AOE IED Integrated Unit: Ship Shape

Lesson 3.1

World Geography

Boats Far and Wide

In this lesson, individual students or groups of students are assigned a specific region of the world. They will research the physical geography of their region, specifically focusing on the major waterways and how civilizations have historically used those waterways for trade and expansion.

This lesson is expected to take two class periods. (Additional time may be necessary to conduct research and prepare presentations.)

Lesson Framework

Learning Objectives

Each student will:

- Identify significant waterways in a region of the world and discuss their importance to the local culture.
- Discuss the history of seafaring associated with their assigned region.

Academic Standards

- Students read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. (NCTE Standards for the English Language Arts, Standard 1)
- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. (NCTE Standards for the English Language Arts, Standard 8)
- How to Use Maps and Other Geographic Representations, Tools, and Technologies to Acquire, Process, and Report Information From a Spatial Perspective. (NGS National Geography Standards, Standard 1)
- How to Analyze the Spatial Organization of People, Places, and Environments on Earth's Surface. (NGS National Geography Standards, Standard 3)
- The Physical and Human Characteristics of Places. (NGS National Geography Standards, Standard 4)
- How Culture and Experience Influence People's Perceptions of Places and Regions. (NGS National Geography Standards, Standard 6)

- The Characteristics and Spatial Distribution of Ecosystems on Earth's Surface. (NGS National Geography Standards, Standard 8)

Assessment

Assessment Product	Assessment Criteria
Region report on social, economic, and cultural impact of local waterways	None provided
Summary poster of region report	None provided

Prerequisites

- None

Instructional Materials

Teacher Resource

- Teacher Resource 3.1.1—PowerPoint Presentation: Ships Around the World

Student Resource

- Student Resource 3.1.1—Handout: Ship Research Assignment

Equipment and Supplies

- Computer lab with Internet access
- Poster paper
- Clip art and photographs of boats and ships from around the world

Lesson Steps

Step	Min.	Activity
		CLASS PERIOD 1
1	**10**	**Brainstorm: Ship Similarities** Show photos or clip art of several types of boats and ships from around the world and ask students if they recognize any of them. Use the Ships Around the World presentation as a starting point. Ask what different craft have in common and how they are different.
2	**Varies**	**Research Project: Regional Ship Research** Pass out the Ship Research Assignment handout. Assign each student or group of students a different region of the world. Their assignment is to research the maritime history of that region and the types of boat and ship designs that emerged over time. Students will compile their research into a report and summary poster. Students should complete their research and prepare their presentations as homework. If students are working in groups, you may wish to give them a little time to prepare their posters during class.
		CLASS PERIOD 2
3	**20**	**Gallery Walk: Regional Ship Displays** Each student, or group of students, should prepare a poster presentation of their research. Have each group hang their poster in the room. Give students 20 minutes to walk around the room and examine each poster. As they walk, students should fill out a minirubric for each poster.
4	**30**	**Class Discussion**

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Lesson 3.1

Boats Far and Wide

Student Resource

Resource	Description
Student Resource 3.1.1	Handout: Ship Research Assignment

Student Resource 3.1.1

Ship Research Assignment

Humans have always tended to live near water, and it is natural to make use of things that float. Logs or bundles of reeds can be lashed together to form rafts; hollow trunks can be improved to become dugout canoes. Once the principle of a watertight hull is understood, an infinite number of designs become possible. Boats of all kinds have been made around the world and throughout history, from the technologically primitive communities to the modern day.

Your task is to research the maritime history of your assigned region of the world and prepare a presentation for the class, including:

1. A map of your region with all major countries and bodies of water labeled. Sometimes the political map of region has altered significantly over time. Include extra maps showing past political boundaries if they are relevant to the history of seafaring.

2. A history of seafaring originating from your assigned region of the world. Include a description of the importance of seafaring to the development of the local culture and/or the region's political dominance.

3. A general time line of important seafaring events of your region, if any.

4. Depictions of historical ships built in that region.

5. Description of any design features of regional boat types that arose from the characteristics of the bodies of water being sailed or the technology available to builders.

AOE IED Integrated Unit: Ship Shape

Lesson 3.1

Boats Far and Wide

Teacher Resources

Resource	Description
Teacher Resource 3.1.1	PowerPoint Presentation: Ships Around the World

Teacher Resource 3.1.1

PowerPoint Presentation: Ships Around the World

In order to open the presentation, right-click on the image below and then select Presentation Object/Open from the menu.

AOE IED Integrated Unit: Ship Shape

Lesson 3.2

Introduction to Engineering Design

Hull Design

In this lesson, students are given the design brief for their culminating project. Students research various hull shapes common to a specific type of boat or ship, and create a design for their own hull using 3D modeling software.

This lesson is expected to take at least 2 class periods (variable)

Lesson Framework

Learning Objectives

Each student will:

- Use the engineering design process to design a hull that fulfills a specific set of design constraints.
- Explain what constraints are and why they are included in a design brief.
- Generate dimensioned multi-view drawings from a simple CAD-modeled hull.

Academic Standards

- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (ITEA Standards for Technological Literacy, Standard 4)
- Students will develop an understanding of the attributes of design. (ITEA Standards for Technological Literacy, Standard 8)
- Students will develop an understanding of engineering design. (ITEA Standards for Technological Literacy, Standard 9)
- Students will develop abilities to apply the design process. (ITEA Standards for Technological Literacy, Standard 11)

Assessment

Assessment Product	Assessment Criteria
Hull Drawings	None provided

Prerequisites

- Working knowledge of Autodesk Inventor software
- Isometric sketching skills
- Working knowledge of buoyant force calculations
- Completion of IED curriculum up to Lesson 2.2

Instructional Materials

Teacher Resources

- Teacher Resource 3.2.1—Reading: Background Information

Student Resources

- Student Resource 3.2.1—Handout: Ship Shape Design Challenge
- Student Resource 3.2.2—Handout: Speed Boat Design Brief
- Student Resource 3.2.3—Handout: Life Raft Design Brief
- Student Resource 3.2.4—Handout: Amphibious Assault Vehicle Design Brief
- Student Resource 3.2.5—Handout: Container Ship Design Brief

Equipment and Supplies

- Engineering notebook
- Isometric grid paper
- Computer with AutoDesk Inventor software
- Aluminum foil
- Flexible straws
- Paper clips and tape

Lesson Steps

Step	Min.	Activity
		CLASS PERIOD 1
1	**10**	**Design Challenge: Ship Shape** Pass out the Ship Shape Design Challenge handout. Pair students up and have them select their design challenge. **Note:** Students will build and test these boats as part of Lesson 3.4. That lesson is designed around the use of aluminum foil as the primary building material. You may choose to have students make more elaborate scale models with a wider range of materials. If so, you will need to edit the Ship Shape Design Challenge handout and provide students with information about the mass and/or density of the materials they have available.
2	**Varies**	**Design Process: Research** Provide the students with some time for basic research about the type of ship they have selected for their design challenge, to do some individual brainstorming, and to sketch at least three possible solutions to the design challenge on isometric grid paper.
		CLASS PERIOD 2
3	**Varies**	**Design Process: Explore and Select an Approach** Have the pairs of students come together and share their ideas and designs. Together they should pick a final design to work on, using Inventor to create all the necessary parts of their design solution, including fully dimensioned, multi-view drawings.
4	**20**	**Gallery Walk: Ship Designs** Have each student group post their drawings, and conduct a mini–poster walk around the room. Have students individually select their two favorite designs, not including their own.

AOE IED Integrated Unit: Ship Shape

Lesson 3.2

Hull Design

Student Resources

Resource	Description
Student Resource 3.2.1	Handout: Ship Shape Design Challenge
Student Resource 3.2.2	Handout: Speedboat Design Brief
Student Resource 3.2.3	Handout: Life Raft Design Brief
Student Resource 3.2.4	Handout: Amphibious Assault Vehicle Design Brief
Student Resource 3.2.5	Handout: Container Ship Design Brief

Student Resource 3.2.1

Ship Shape Design Challenge

Design challenges provide opportunities to apply skills and knowledge in unique and creative ways. Designers are often asked to come up with solutions to problems that exist. Their supervisor or board of directors may give them a few constraints to adhere to and then ask the designers to solve the problem.

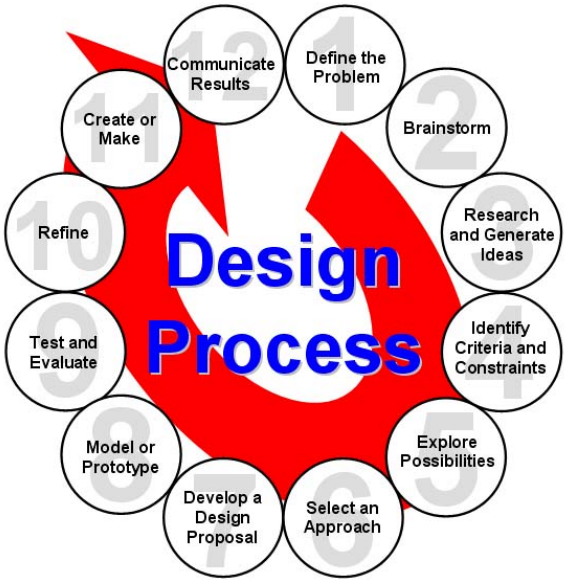
Designers are sometimes put together to form a team and asked to collaborate to create the solution. When you are a one-person design team, the task of effective communication is rather simple. However, what happens when you must communicate your ideas to others or when the responsibility for a team's solution falls on the shoulders of the entire team? This increases the level of responsibility significantly and requires the development of effective teamwork skills.

Materials

- Engineering notebook
- Isometric grid paper
- Computer with AutoDesk Inventor

Building Materials

- Aluminum foil
- Flexible straws
- Paper clips
- Tape



Procedure

This project gives you the opportunity to work in teams of two. Your team will need to come up with a solution to a stated problem. Use the Project Lead the Way design process.

1. Study the four design briefs located on the following pages.
2. Come to a consensus with your partner about which design brief you wish to work on.
3. Using the steps in the design process, your team will come up with a solution to the problem.
4. Use isometric grid paper provided for your team to sketch ideas and possible solutions.
5. Create three possible solutions.
6. Discuss your solutions with your partner and choose a final design.
7. Create a complete set of working drawings. (Check with your teacher on the deliverables needed.)
8. Create with your team a three-fold brochure marketing your solution to the design problem.

Student Resource 3.2.2

Speedboat Design Brief

Client Company	Offshore racing boat company
Target Consumer	Wealthy recreational boaters
Background	**Cigarette,** or **go-fast,** boats are high-performance offshore racing boats of a characteristic design. These boats have a distinctive long and narrow appearance. At rest, these boats usually sit low in the water. To reduce resistance through the water, the bow is very pointed and the hull typically has a deep V cross section. With powerful engines, cigarette boats are capable of traveling over 100 mph.
Design Statement	Design a scale model of a boat for maximum speed and minimum resistance through the water.
Constraints	1. Must have length-to-width ratio of at least 4:1. 2. Must have a pointed bow. 3. Must have a V-shaped hull. 4. Must have load capacity (and seating) for at least two passengers (100 g). 5. Must have a maximum freeboard of 2 cm when loaded.

Student Resource 3.2.3

Life Raft Design Brief

Client Company	Sea rescue company
Target Consumer	Small ship owners
Background	Life rafts can be designed either to be a stable platform where occupants can safely await rescue or can be a vehicle capable of sailing to a place where a rescue is more likely (or conceivably to land). Inflatable life rafts are generally collapsible, stored in a heavy-duty fiberglass canister, and equipped with high-pressure gas that allows automatic inflation to the operational size. The compact design of an inflatable life raft makes it a good choice for smaller ships and boats. Life rafts usually do not have a motor.
Design Statement	Design a scale model of a life raft intended for a rescue wait, rather than travel. (Design does not need to “deflate.”)
Constraints	1. Must have capacity for nine people (450 g). 2. Must have a flat-bottomed hull. 3. Must minimize use of materials. 4. Must have a minimum freeboard of 3 cm when loaded. 5. Must include a boarding ramp.

Student Resource 3.2.4

Amphibious Assault Vehicle Design Brief

Client Company	Military
Target Consumer	Military troops
Background	Amphibious landing of troops on a defended beachhead is among the most complex of all military maneuvers. Designing a transport for troops and vehicles for use in an amphibious assault requires consideration of some distinctive constraints. The tanks need to be able to roll right out of the transport, and troops cannot waste time clambering over the edge. Also, the draft of an amphibious assault transport needs to be extremely shallow to avoid possible undersea mines.
Design Statement	Design a scale model of an amphibious assault transport.
Constraints	1. Must have maximum length-to-width ratio of 3:1. 2. Must have a blunt (ramp) bow. 3. Must have capacity for 12 people (600 g). 4. Must maintain minimum draft.

Student Resource 3.2.5

Container Ship Design Brief

Client Company	Cargo company
Target Consumer	Commercial industries
Background	Container ships are large cargo ships that carry their entire load in truck-size containers. These ships are designed to carry the maximum amount of cargo with the minimum amount of effort. Container ships have become increasingly large over the years. One constraint on size depends on whether the container ship will be traveling through any narrow or shallow passages. Major international shipping lanes include transit through three constraining passages: the Panama Canal, the Suez Canal, and the Straits of Malacca.
Design Statement	Design a scale model of a container ship designed to maximize possible cargo weight.
Constraints	1. Must have length-to-width ratio no greater than 7:3. 2. Must have a deck to carry at least 400 g of cargo above the hull of the ship. 3. Must be stable in the water when loaded. 4. Must have maximum draft of 2.5 cm when fully loaded. 5. May have maximum width constraints.

AOE IED Integrated Unit: Ship Shape

Lesson 3.2

Hull Design

Teacher Resource

Resource	Description
Teacher Resource 3.2.1	Reading: Background Information

Teacher Resource 3.2.1

Reading: Background Information

For more information, see http://www.globalsecurity.org/military/systems/ship/hull.htm and http://www.boatus.org/onlinecourse/ReviewPages/BoatUSF/Project/info1b.htm.

The general body of a watercraft is typically a **displacement hull**, which displaces (pushes away) water equal to its total weight. If its total weight is equal to the weight of the water that it's displacing, the boat will float. If, on the other hand, its weight is more than the weight of the water that it displaces, the boat will sink.

Another type of hull is the **planing hull**. This type of hull has a deep V cross-section and is designed for speed. When a planing hull is stationary or moving very slowly it is, in effect, a displacement hull. As power and speed increase, however, a planing hull lifts itself up on top of its own bow wave. This causes the boat to displace much less water. As a result, there is a much smaller wet surface on the hull bottom, meaning much less friction as well. The speed of the boat thus increases at a great rate. With this hull, the more horsepower added, the faster the boat will go. The advantage of a planing hull is that it is capable of much greater speed. Just keep adding horsepower and away you go! However, a disadvantage is that the boat is no longer going through the waves, but is "leaping" from one wave top to the next. Consequently, as the waves get larger, the pounding of the boat increases. This makes for a rough ride—one that at worst can injure passengers and cause considerable damage to the boat's hull and equipment.

AOE IED Integrated Unit: Ship Shape

Lesson 3.3

English Language Arts

Sea Stories

In this lesson, students will write both **creative stories** and **technical reports** that demonstrate how different writing techniques are used for different purposes. Students will write a creative short story meant to entertain that describes an adventure aboard the boat they have designed for their culminating project. Students will also write a technical report describing their experiences during the design and production of the boat.

This lesson is expected to take three class periods.

Lesson Framework

Learning Objectives

Each student will:

- Write a vivid short story describing a sea adventure using various literary devices to engage the reader.
- Write a technical report describing the design and manufacture of a boat model.

Academic Standards

- Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. (NCTE Standards for the English Language Arts, Standard 4)
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes. (NCTE Standards for the English Language Arts, Standard 5)
- Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts. (NCTE Standards for the English Language Arts, Standard 6)

Assessment

Assessment Product	Assessment Criteria
Short story sea adventure set on the boat built for the culminating project	Teacher Resource 3.3.1—Rubric: Sea Short Story
Technical report describing the design and manufacture of the culminating project	Teacher Resource 3.3.3—Assessment Criteria: Technical Report

Prerequisites

- Working knowledge of the characteristics of short stories
- Working knowledge of literary devices
- Experience with peer review

Instructional Materials

Teacher Resources

- Teacher Resource 3.3.1—Rubric: Sea Short Story
- Teacher Resource 3.3.2—Presentation: Technical Report Writing
- Teacher Resource 3.3.3—Assessment Criteria: Technical Report

Student Resources

- Student Resource 3.3.1—Writing Assignment: Sea Short Story
- Student Resource 3.3.2—Worksheet: Peer Review
- Student Resource 3.3.3—Writing Assignment: Technical Report

Equipment and Supplies

- None

Lesson Steps

Step	Min.	Activity
		CLASS PERIOD 1
1	**50**	**Writing: Short Stories** Tell students now that they have started working on their culminating projects, they can be creative in imagining what kind of events might take place on the vessel they are designing. Using the skills they learned in Lesson 1.3, assign students to write a short story describing events that could occur on a full-size version of the boat they've designed for their culminating project. Students can choose the events as they see fit, but they should be appropriate for the setting. Give students some time to brainstorm in class and start writing. Ask students to write a draft for homework and to bring in four copies of their short story to class.
		CLASS PERIOD 2
2	**50**	**Peer Review: Short Story Workshop** Remind students of the characteristics of a good narrative: • Focuses on a clear, well-defined incident or series of related events. • Develops plot, character, and setting with specific detail. • Orders events clearly. • Uses description and dialogue as appropriate to develop setting and character. • Shows events rather than just telling them. • Establishes and maintains a tone and point of view. • Uses a logical and effective pattern of organization, such as chronological order, flashback, or flash-forward. • Uses transitional words and phrases to maintain coherence and to establish sequence within and between paragraphs. Divide students to groups of three or four. Have each student read their short story aloud while the others follow along on their copy of the story. Each student should react to the story by recording their comments on the Peer Review worksheet (Student Resource 3.3.2). Have each student in the group share at least one positive comment and one suggestion for improvement. Each student should collect the comment forms at the end of the class and use them to edit/rewrite their short story before turning in a final draft to the teacher.

Step	Min.	Activity
		CLASS PERIOD 3
2	**45**	**Direct Instruction: Technical Writing** In contrast to their creative writing, tell students that engineers tend to produce an entirely different kind of writing at the conclusion of a project. For example, they are often requested to produce a report for the client that summarizes the work that has been done. In fact, engineers often have to write technical reports at many stages of a project. This type of technical writing is quite different from creative writing, whose purpose is entertainment. With technical writing, the primary purpose to convey information clearly. Introduce the elements of technical writing using the Technical Report Writing presentation (Teacher Resource 3.3.2) as a guide. Students' reports will be less extensive.

3	**5**	**Writing Assignment: Ship Shape Technical Report**
		After reviewing the important elements of a technical report with the class, assign students to write a technical report that describes their own culminating project.
		• Front Matter
		  o Title page—name of report and author
		  o Abstract—short summary that provides an overview of the **purpose**, **scope**, and **findings** contained in the report
		  o Table of Contents—lists the titles and page numbers of each section of the report
		  o List of Figures and Tables—lists the titles and page numbers of any figures or tables
		• Main Text
		  o Introduction—introduces the **subject**, **purpose**, and **scope** of the report
		  o Methods, Assumptions, and Procedures—describes the **methods, assumptions, and procedures** used in the design process so that the reader can understand why different design decisions were made
		  o Results and Discussion—describes what was learned during the design process and how the boat performed and discusses what went wrong if the boat did not perform as expected
		  o Conclusions—restates results and includes any concluding remarks
		  o Recommendations—if you were to redo the project, what would you do differently?
		• Back Matter—may include a bibliography, but otherwise no back matter is may be necessary

AOE IED Integrated Unit: Ship Shape

Lesson 3.3

Sea Stories

Student Resources

Resource	Description
Student Resource 3.3.1	Writing Assignment: Sea Short Story
Student Resource 3.3.2	Worksheet: Peer Review
Student Resource 3.3.3	Writing Assignment: Technical Report

Student Resource 3.3.1

Writing Assignment: Sea Short Story

Assignment

Write a 600- to 800-word short story that uses and incorporates the six primary components of any good short story: characters, setting, conflict, plot, point of view, and theme.

You are free to choose the genre of your story—realistic, adventure, fantasy, mystery, etc. Also, the plot is up to your discretion, but your story must be set on the ship you've designed in your Introduction to Engineering Design course.

Your story should demonstrate your understanding of the key elements of short fiction by using those elements and literary devices to create a compelling and enjoyable tale.

Audience

You will share your short stories in literature circles with your classmates.

Checklist for Success

- The story features a well-defined main character or characters who take part in the action.
- Appropriate details are used to describe a particular time and place (setting).
- A conflict, or problem, is introduced, developed, and resolved.
- The plot describes a succession of events, incorporating changes in time and mood.
- The story contains a central theme, idea, or message.
- The chosen point of view is consistent, appropriate, and effective in telling the tale and conveying its ideas.
- The writing and language are concise, clear, and colorful. Adjectives, similes, metaphors, and other figures of speech help the story come alive in the reader's mind.
- The text is free of spelling, punctuation, grammar, and formatting errors.
- The story's title is gripping and engaging, and suggestive of its theme, message, or motif (controlling image).

Student Resource 3.3.2

Worksheet: Peer Review

Directions

Listen carefully as each group member reads his or her short story aloud. On your copy of the story, circle any spelling, punctuation, or grammatical errors. Write down comments about each of the following questions:

1. What did you like best about the story?

2. Was the start of the story exciting? If so, what made you want to hear more? If not, what could have been improved?

3. What was the setting of the story? Did the setting play an important role in the story?

4. Did the flow of the story make sense? What, if anything, was confusing?

5. Could you identify examples of figurative language in the story? Give an example.

6. What is good about the writing? What should not be changed? Why is it good?

7. What specific suggestions for improvement can you make?

Student Resource 3.3.3

Writing Assignment: Technical Report

Assignment

Write a technical report on the design, manufacture, and performance of your boat model. Your report should include all the basic elements of a good technical report.

Audience

You are writing to inform your “client” from the design brief how your boat prototype turned out.

Checklist for Success

- A title page with the report’s name, author’s name, and date
- One paragraph abstract summarizing the report
- Table of contents with correct page numbers
- Description of your design process including all of the designs you considered, and how you decided on the final design
- Description of boat model’s expected performance (including calculations for buoyancy), and how it actually performed
- Comparison of the expected and actual performance and explanation of any differences
- Suggestions for how to improve the model or how to change the process in the future
- No spelling, grammatical, punctuation, or formatting errors

AOE IED Integrated Unit: Ship Shape

Lesson 3.3

Sea Stories

Teacher Resources

Resource	Description
Teacher Resource 3.3.1	Rubric: Sea Short Story
Teacher Resource 3.3.2	Presentation: Technical Report Writing
Teacher Resource 3.3.3	Assessment Criteria: Technical Report

Teacher Resource 3.3.1

Rubric: Sea Short Story

Student Name: _____ *Date:* _____

Grading criteria

The grade, out of 25 possible points, will be based on the following (each category is worth 5 points):

_____The tale contains a well-developed story arc that introduces and resolves a conflict.

_____Multiple methods of characterization are used to create a compelling character or characters.

_____The story's language is concise, clear, and colorful and uses figures of speech effectively.

_____The setting and selected point of view are effective in developing and moving the plot forward.

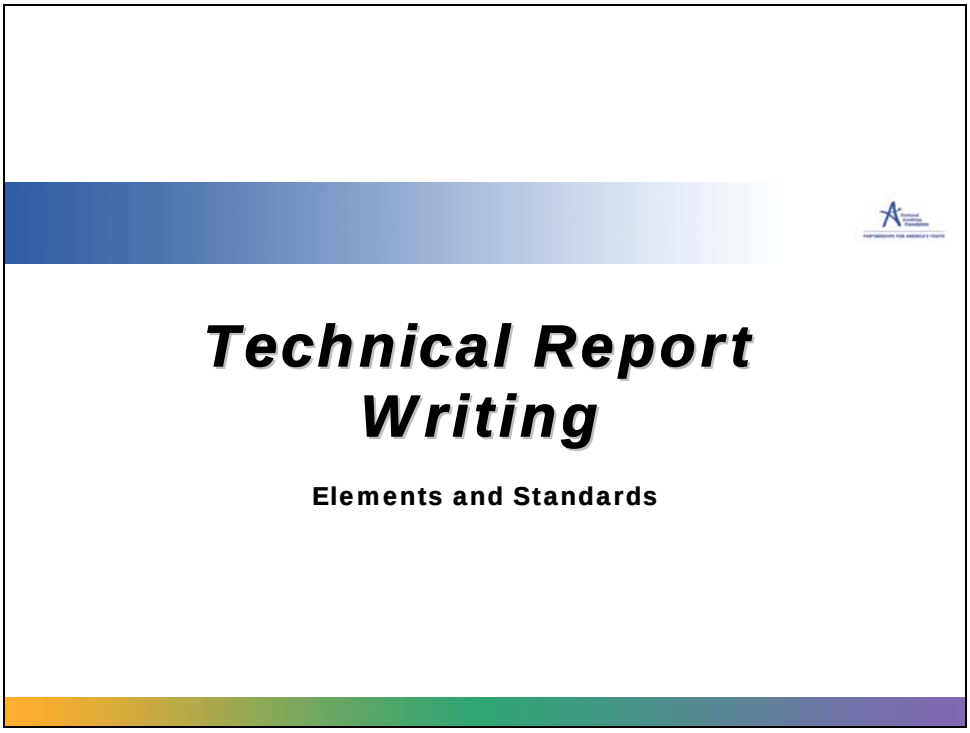
_____The lead grabs the reader's attention; the ending leaves the reader with an idea or message to think about; and the title is gripping, engaging, and suggestive of the story's theme or dominant image.

Teacher Resource 3.3.2

Presentation: Technical Report Writing

Directions

Right click on the slide below and select Presentation Object/Open to open the PowerPoint presentation.



Teacher Resource 3.3.3

Assessment Criteria: Technical Report

Student name(s): _____

Date: _____

Using the following criteria, assess whether the students met each one.

	Met	Partially Met	Didn't Meet
Front matter includes title, author, date, abstract, and table of contents.	☐	☐	☐
Introduction provides summary of report.	☐	☐	☐
Main text includes description of the design process and team decisions while designing and building the model.	☐	☐	☐
Main text includes discussion of how the boat performed and anything that went wrong with the design or performance.	☐	☐	☐
Main text includes suggestions for changes in the future.	☐	☐	☐
Report is free of spelling, grammatical, punctuation, and formatting errors.	☐	☐	☐

Additional Comments:

_____

_____

_____

_____

AOE IED Integrated Unit: Ship Shape

Lesson 3.4

Introduction to Engineering Design

Launch Day

In this lesson, students build and present their culminating projects. Their designs are tested for seaworthiness and measured for fulfillment of design constraints.

This lesson is expected to take two class periods (plus more for building in class, if time allows).

Lesson Framework

Learning Objectives

Each student will:

- Apply knowledge of density and volume to design and build a buoyant boat or ship model.

Academic Standards

- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, Sound Reasoning. (ITEA Standards for Technological Literacy, Standard 10)
- Students will develop an understanding of and be able to select and use transportation technologies. (ITEA Standards for Technological Literacy, Standard 18)
- Students will develop an understanding of and be able to select and use construction technologies. (ITEA Standards for Technological Literacy, Standard 20)

Assessment

Assessment Product	Assessment Criteria
Seaworthy boat design	None provided

Instructional Materials

Teacher Resources

- None

Student Resources

- Student Resources from Lesson 3.2—Handouts

Equipment and Supplies

- Heavy duty aluminum foil
- Flexible straws
- Paper clips
- Tape
- ¾–10 hex nuts
- Electronic scale
- Tanks of water (for boat testing)

Lesson Steps

Step	Min.	Activity
		CLASS PERIOD 1
1	**50**	**Construction: Boat Building** Have students build a boat based on their design. Demonstrate the basic building techniques using the straws and paper clips as the frame and aluminum foil as the primary hull material. You may allow students to use different materials but you will need to determine the density or mass of those materials so that students can make the appropriate calculations. Provide one class period for building. *This should not be done as homework,* to prevent students from testing their designs ahead of time.
		CLASS PERIOD 2
2	**40**	**Competition: Launch Day** Have all groups bring their boat models to the front of the room. Place boats from the same design challenge together. Call each group up to give a short presentation on their design process, explaining how they settled on their design and describing any difficulties they encountered. Students should also provide a prediction for how their boat model will perform (e.g., how much it should be able to hold or how deep the boat's draft will be). Check that each boat model fulfills its design constraints before placing in the water. You may want to have each group prepare a poster that presents their boats and describes its attributes. After all boats from a single design challenge have been tested, you may choose to identify a "winner".
3	**10**	**Reflection: Redesign Considerations** Once all testing is complete, have students reflect on the performance of their boat. Did it hold as much mass as they anticipated? Was the boat's draft as they predicted? Have each student write a paragraph that addresses the following questions: • Did your boat perform as you expected it to? If not, what went wrong? • If you were going to design and build your model again, what would you change, and what would you keep the same? Remind students that this type of reflection should go into their boat's technical report under the Recommendations section in the main text.