Sink or Float?
A Real World Science Lesson Plan

BACKGROUND:
Buoyancy was really important in WWII technology. Large ships moved troops overseas, aircraft carriers were used as landing strips in the middle of the ocean, landing craft carried troops and vehicles from ship to shore, and pontoon bridges transported personnel, supplies, and equipment over water. Even barrage balloons used buoyancy.

Some of these engineering results seem ungainly. What makes things sink or float? Basically, anything that displaces an amount of fluid that has the same mass as itself will float. Another way to put it is that objects will float in a fluid if their density is less than that of the fluid.

OBJECTIVES:
- Students will predict and then observe the buoyancy of objects and substances. They will measure the volume and mass of objects, and of a sample of water, and graph the relationship between mass and volume. They will then compare the position of the points on the graph to the objects' buoyancy.
- Students will test the buoyancy of a ball of play dough, and then make the play dough into a boat that floats. Finally, they will test the buoyancy of that boat by adding mass to it.
- Students will read about the development of landing craft in WWII.

GRADE LEVEL:
5-8 with enrichment activities for advanced students

STANDARDS:
3rd-5th grades:
- Measurements of a variety of observable properties can be used to identify particular materials.
  NGSS PS1.A

6th-8th grades:
- The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.
  NGSS PS1.A

TIME REQUIREMENT:
Measuring the mass and volume of the objects, making the graph, and recording the results of their buoyancy test will take about an hour. This may be faster with older students. Testing the boat and reading the article about Higgins boats will take another hour.

MATERIALS:

Student Handouts: Building the Higgins LCVP, What will float?

First step:

- blocks or cylinders of wood, plastic, cork, and metal
- rulers
- scale
- small plastic cup
- foil baking pan
- water
- graph paper

Second step:

- tennis-ball sized mass of play dough
- pennies

PRIOR KNOWLEDGE:

If they are not good at measuring or graphing, they will need support in that part of the activity.

INFORMATION FOR TEACHERS:

The play dough will get really soft if left in the water too long. Foil can be used in its place, but it's hard to make a ball of foil and then turn it back into a boat. Transforming an object from not-floating to floating will help students understand.

OUTLINE OF ACTIVITIES:

1. Students use **What will float?** as a pre-assessment. It will get them thinking and discussing about buoyancy and density. It will help to surface any prior misconceptions.
2. Students measure and then test objects' buoyancy. Measuring before testing may make less of a mess.
3. Students graph data that they collected on mass and volume and buoyancy.
4. Students test ball of play dough, and then make it into a boat. They then test the limits of the boat.
5. Students read about the development of the Higgins Landing Craft for Vehicle and Personnel (LCVP).
6. Students complete Freyer charts of terms for the lesson.
7. If you wish, you could conduct the parts of this lesson as stations.

ASSESSMENT:

Student responses on **What will float?** will provide a pre-assessment. Student answers on handouts and student discussions can serve as formative assessments of these standards.

EXTENSION/ENRICHMENT:

You can have students take the plan for the LCVP and design improvements. You could also give them another set of unknown materials and have them predict their buoyancy based on measurements before testing them

REFERENCES:

Andrew Jackson Higgins and the Boats That Won World War II. Jerry Strahan, LSU Press, 1998.

STUDENT HANDOUT

What will float?

PT Boat on East Coast of United States in February 1945. The National WWII Museum, 2011.102.274.

Some students are talking about a boat they made in science class. Zoe says that the boat floats because it is lighter than the water. Tomas says that the boat floats because it takes up less space than the water. Kris says that the boat pushes water out of the way and that's why it floats.

What do you think? Build on the ideas the students shared to explain why a boat floats.

STUDENT HANDOUT

Sink or Float?

Measure the objects your teacher gives you and record their mass and volume here. Use the formula **V=LxWxH** for blocks' volume and the scale for their mass.

Object	Volume	Mass	Float or Sinks?

STUDENT HANDOUT

Building the Higgins LCVP

During WWII Andrew Higgins' company made more than 20,000 boats for the military. They were mostly wooden boats, and over 12,000 of them were the landing craft like those used on the beaches of Normandy for D-Day.

In 1938 Higgins was a flamboyant and ambitious owner of a small boat company in New Orleans. His 75 employees at one boatyard made fishing boats for Louisiana fishermen. As war approached, the military was looking for a company to design and build craft that could transport men and troops from large ships onto beaches, reefs, and rocky coasts.

At first they looked to large shipbuilders on the East Coast. These companies had been making boats for the military and industry for quite a while. The landing craft that these companies made didn't do well when tested by the military. They fell apart when traveling fast on waves, or they were stopped by submerged logs and sand bars.

Then they came to New Orleans to see Higgins. He quickly assembled a landing craft for them, modifying the design of his fishing boats which performed well in the shallow waters of swamps and marshes. He took the boats to Lake Pontchartrain and ran them up the seawall to show how well they worked.

Later he designed a different version that had a door on the front that could be lowered to let soldiers off more easily, and so that jeeps and small tanks could be moved to shore. These landing craft were made of plywood, and built quickly and cheaply.

LCPL, LCVP, and barrage ballon on Lake Ponchartrain in July 1944. The National WWII Museum, 2008.379.019.

STUDENT HANDOUT

Building the Higgins LCVP

Andrew Higgins shows all 4 of the important characteristics of people who solve problems.

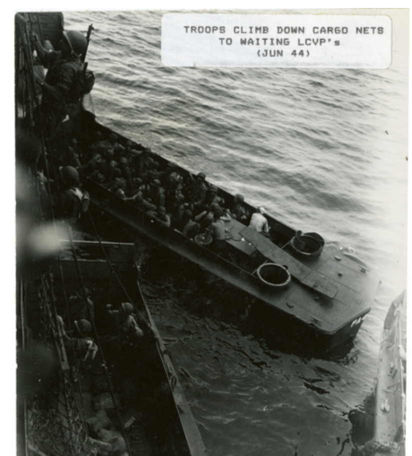
1. He had knowledge— he knew how to make boats that did well in shallow waters, and he knew how to make them quickly and cheaply.
2. He was persistent— when he couldn't get the military to check out his boats, he kept trying. When he didn't have enough space or material so, he found ways to get them.
3. He was creative— he put a door on the front of a boat! He adapted a fishing boat into a landing craft.
4. He was a team builder- his company grew, by 1943, to employ 25,000 workers. They were men and women, of different races, different ages, and some had disabilities.

At The National WWII Museum, there is a replica of one of the landing craft that took men and vehicles ashore on D-Day. This plywood boat, with a big door on the front, is called an LCVP (Landing Craft for Vehicles and Personnel). It is the boat which General Eisenhower said "won the war for us." The LCVPs came to be called 'Higgins Boats' by soldiers and the Marines who rode to battle in them.

Today we face many big problems, and we can solve them in the same way as Higgins did—with knowledge, persistence, creativity, and collaboration.

Andrew Higgins (center) at ceremony celebrating the 10,000th Higgins Boat, Lake Ponchartrain, 1944. The National WWII Museum, 2009.428.035.

A full LCVP in training manuevers at Morro Bay, California, January 1944. The National WWII Museum, 2011.065.068.



LCVPs loading before going ashore in Guadalcanal, March 1944. The National WWII Museum, 2008.354.070

Earn Your Wings

A Real World Science Lesson Plan

BACKGROUND:

Planes were used in WWI, but they took on a huge role in WWII.

Flying so many planes and at such great altitudes really presented many challenges for engineers. One challenge was designing planes with so many different sizes and purposes. Another was protecting pilots in the planes from the dangers of high altitude.

Flying vehicles use Bernoulli's principle to generate low pressure that can be manipulated for lift. This is more challenging at high altitudes.

OBJECTIVES:

- Students will practice the design process, applying it to airplanes.
- Students will explain the lift of planes using Bernoulli's principle.
- Students will explain air pressure, and relate it to the layers of the atmosphere and the relationship between heating, cooling, and pressure.
- Students will read about the use of aircraft in WWII.

GRADE LEVEL:

5-8 with enrichment activities for advanced students

STANDARDS:

3rd-5th grades:

- The effect of unbalanced forces on an object results in a change of motion. **NGSS PS2.A**
- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-1**
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. **3-5-ETS1-3**

6th-8th grades:

- The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter. **NGSS PS1.A**
- 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-ETS1-1**
- Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **MS-ETS1-2**

TIME REQUIREMENT:

Testing plane designs may take one period, but could be shortened with only one model tested. **Bernoulli's Blast** might take one period. **Under Pressure** might take another period. **Catch a Glider** is likely to take about half of a class period, but might take more if you put Freyer charts into it.

MATERIALS:

Student Handouts: Bernoulli's Blast, Under Pressure, Catch a Glider, What's in the Air?, Why do things fly?, Earn Your Wings

Materials for the Plane Design depend upon your chosen plane-making technology. You could make simple paper airplanes, make planes from templates, or make planes from disposable plates. Use the handout **EarnYour Wings** for this activity.

Materials for Bernoulli's Blast depend upon which demonstrations you choose and how you choose to do them. I would suggest

- Ping pong balls and plastic cups—blow across top of cup to get ball out
- Beach Ball—toss it with spin to show curving of trajectory
- Foam plane—show wing profile, and show that planes fly upside-down
- Hair dryer and ping pong ball—lift the ball with just air (be sure to show that it's not just blowing the ball up)
- Fan and beach ball (or balloons)—dramatically larger version of hair dryer
- Bernoulli noise maker—swing to show motion of air through tube
- Ping pong ball and funnel— blow in the funnel and trap the ball

Materials for Under Pressure depend upon which demonstrations you choose and how you choose to do them. I would suggest

- Soda can, boiling water, ice bath—crush the can with air pressure
- Balloon Lung—model of mammalian lung shows how air pressure fills lungs
- Boiling with ice—shows that boiling and vapor pressure are dependent on temperature (I would only use this for middle school students, or groups who are comfortable already with phase change)
- Inverted glass and paper card—the water stays in the glass due to air pressure
- Fountain bottle—fill a two liter bottle with colored water, and put it in a tray. Poke 3 holes at different heights in the side of the bottle to show the effects of pressure
- 2 plungers—wet their rims then compress them together, and then try to separate them
- Tire pump, ball and hair spray—show that compression of a gas generates heat and release of a gas uses heat

PRIOR KNOWLEDGE:

Students may need a review of the design process before making and testing planes. Some students, especially young ones, may not understand that the atmosphere is filled with matter.

INFORMATION FOR TEACHERS:

You'll need to practice the demonstrations and work out a little routine and story line to make them all fit together. The only really complicated one is Boiling with ice, but that's only in its setup.

OUTLINE OF ACTIVITIES:

1. Students use **Why do things fly?** as a pre-assessment. It will get them thinking about and discussing flight and lift. It will help to surface any prior misconceptions.
2. Students make, test, and improve their airplanes. You could read *How People Learned to Fly* by Fran Hodgkins, or another book, or a section of your textbook together to learn more about flying.
3. Students use **What's in the air?** as a pre-assessment. It will get them thinking about and discussing air, air pressure, and matter. It will help to surface any prior misconceptions.
4. Students draw diagrams of, and ask questions about the demonstrations in **Bernoulli's Blast**. Afterwards you might have them make Freyer's charts of vocabulary.
5. Students draw diagrams of, and ask questions about the demonstrations in **Under Pressure.** Afterwards you might have them make Freyer's charts of vocabulary.
6. Students read **Catch a Glider**
7. If you wish, you could conduct some parts of this lesson as stations, especially since some of the demonstrations students could do on their own.

ASSESSMENT:

Student responses on **Why do things fly?** and **What's in the air?** will provide a pre-assessment. Student answers on handouts and student discussions can serve as formative assessments of these standards.

EXTENSION/ENRICHMENT:

You could connect air pressure and the challenges of flight to the structure of the atmosphere. The Fountain Bottle is a good model for the structure of the atmosphere. You can also use technology to test planes. Affix your PocketLab or other probe to a large foam airplane and collect the data. Use it to measure the speed and time in the air of the plane. Can you modify the plane to go faster or stay in the air longer?

In this lesson, students made planes and tested them. They could make generalizations based on their observations (induction). To practice their reasoning, you could have them look at profiles of WWII planes from spotter cards or charts, and have them hypothesize the flight characteristics of the plane from its shape (deduction).

REFERENCES:

Lost in Shangri-La. Mitchell Zukoff, Harper Collins, 2011.

STUDENT HANDOUT

Why do things fly?

B-17s flying in formation over the Mediterranean, 1944 or 1945. The National WWII Museum, 2011.160.030.

Four friends are hanging out in a backyard on a weekend day. They are making paper airplanes and tossing them. "Why do planes fly? I mean, what keeps them up in the air?" says Anna.

"They go fast so that gravity can't pull them down. See how when the plane goes slow it starts falling down?" says Stefan.

"But helicopters can hold still and stay in the air. So can bees and hummingbirds," says Chiara. "I think they push against the air with their wings."

"I think it has to do with the shape of their wings," says Anna. "Some airplanes fly better than others, and I think it is because of how their wings are shaped."

"They are light and that's why they fly!" says Tommy. "After all, elephants and rhinos don't fly. Only light animals like pigeons and butterflies can fly."

What do you think? Do you agree or disagree with the ideas of the the four friends? Explain why things fly.:

STUDENT HANDOUT

What's in the air?

Your cousin is confused about something that happened when she flew to visit her grandmother.

She took a bottle of water on the flight with her, and drank about half of it on the plane, then closed the bottle. When the plane landed and she gathered all her belongings, she noticed that the bottle was all squished and crushed. When she opened the cap, she heard a whoosh and the bottle expanded and looked normal again.

How would you explain what your cousin saw happen with the bottle?

If you turn an empty glass upside down and then hold it in a bowl of water, will the water fill the glass? Draw a diagram and explain what you think will happen.

STUDENT HANDOUT

Bernoulli's Blast!

Your teacher will demonstrate for you some examples of how pressure and changes in air pressure can do some surprising things.

Scientists love to make diagrams of things. For each demonstration, draw a picture of what you or your teacher did. With arrows, labels, and words, explain how it worked.

Demonstration 1:

Demonstration 2:

STUDENT HANDOUT

Bernoulli's Blast!

Demonstration 3:

Demonstration 4:

Give a short definition of Bernoulli's principle:

STUDENT HANDOUT

Under Pressure

Your teacher will demonstrate for you some examples of how pressure and changes in air pressure can do some surprising things.

Scientists love to make diagrams of things. For each demonstration, draw a picture of what you or your teacher did. With arrows, labels, and words, explain how it worked.

Demonstration I:

Demonstration 2:

STUDENT HANDOUT

Under Pressure

Demonstration 3:

Demonstration 4:

Give a short explanation of why air has pressure:

STUDENT HANDOUT

Catch a Glider

1940s map of New Guinea. Courtesy of the United States Army.

In the spring of 1945, the outcome of war was starting to look a little better for the Allies. Germany had surrendered on May 8th, and after some very tough battles in the Pacific, the Allies were getting closer and closer to the mainland of Japan.

New Guinea was taken back from Japan a year earlier, in 1944. An American base at Hollandia (now called Jayapura) had a good port and landing strip. Hollandia had been a Japanese base, and now the Americans used it as part of the supply route for the continuing battle in the Philippines.

The war had been going on for a long time, and everyone worked 6 or 7 days a week even if they were just office workers or supply clerks far from the battlefield. Officers tried to keep up the morale of their workers and soldiers by planning fun events.

On May 13th 1945 Lieutenant John McCollum took a group of 19 people on what he hoped would be a fun sight-seeing flight. To the south of Hollandia were mountains that reached over 5,000 feet in altitude. There was a high valley in those mountains, called Baliem. A more fanciful name had been given to it—Shangri-La.

In 1938 an explorer named Richard Archbold was looking for new animals in New Guinea, and he discovered in the mountains a valley about 20km by 80km, with an altitude of about 5,000 feet. In this valley lived around 200,000 native people. They lived in small villages and kept animals and large gardens.

After the American forces took New Guinea from the Japanese they started flying over the island to Australia, and began mapping the island. When the valley was rediscovered news reporters called the valley Shangri-La after a fictional place in a novel called Lost Horizon. There were wild stories of the people who lived in the valley.

Lieutenant McCollum thought it would be fun to fly some of his people over the valley so that they could see this strange place, and bring back more stories about it. With 4 other crewmen he loaded his passengers, who included some WACs (Women's Army Corps) into a C-47 (a large cargo plane) and headed for the valley.

STUDENT HANDOUT

Catch a Glider


Paratroopers entering a C-47 on training at Fort Benning, GA, June 1944. The National WWII Museum, 2011.065.1293.

Something went wrong, and the plane crashed into the side of a mountain at the edge of the valley. The crash was bad, and only 5 people survived it. Two of those 5 died of their injuries soon after the crash. Corporal Margaret Hastings, Sergeant Kenneth Decker, and Lieutenant McCollom were injured, but left the crash site for the valley floor.

When the plane did not return search planes were sent to look for them. The valley is so large that it took some time to find the survivors. On May 17th they were spotted. Shortly after, two medical paratroopers and 10 other paratroopers were dropped nearby to help the 3 survivors. Other planes dropped food and tents and other supplies.

The southern part of the island was still unexplored, and possibly held Japanese troops. The spot in the valley were the survivors were was hundreds of miles from the base in Hollandia. High mountains and dense jungles separated them from safety. The ground was too rough and covered with plants to make a landing strip. It took 6 weeks for a rescue plan to get them all out of the valley.

Glider troops about to board in Italy, August 1944. The National WWII Museum, 2002.337.825.

The final plan involved another C-47 and a glider. The glider was built of aluminum and balsa plywood frames covered with canvas, and a simple steering system.

The C-47 carried the glider to the valley, and then a glider pilot landed the light craft near the survivors' camp site. The survivors and paratroopers were loaded into the glider, and then came the exciting part.

The C-47 came back by with a cable and latched onto a hook on the glider. The glider was pulled across the rugged valley floor and then lifted into the air. It took a few passes to successfully hook the glider, and then it took several trips to get all of the survivors, medics and paratroopers out.

STUDENT HANDOUT

Catch a Glider - Questions

How would the design of a cargo and passenger plane be different from a fighter plane?

C-47 and glider in a field in Austria around 1945. The National WWII Museum, 2008.321.651.

Why was the glider made of flimsy material like balsa plywood and canvas?

What was daring about the rescue attempt?

STUDENT HANDOUT

Earn Your Wings

You are going to iteratively test and redesign a model of a plane to see how you can change its performance. Decide whether you want to make your plane fly faster or stay longer in the air. Record your results below, conducting at least 3 redesign cycles.

Design 1 (draw diagram):	**Data:**
What are you going to modify?	**Expected Outcome:**

Design 2 (draw diagram):	**Data:**
What are you going to modify?	**Expected Outcome:**

STUDENT HANDOUT

Earn Your Wings

Design 3 (draw diagram):	**Data:**
What are you going to modify?	**Expected Outcome:**

Design 4 (draw diagram):	**Data:**
What are you going to modify?	**Expected Outcome:**

What were your results? Were you able to improve your plane through cycles of the design and testing process?