Float That Boat!

Unit Summary

After investigating density, displacement, and buoyancy in hands-on experiments, students take on the role of designers to create boats for We B Toys. Students create brochures or multimedia slideshows to persuade We B Toys to consider their boat designs for a new line of toy boats.

Curriculum-Framing Questions

- **Essential Question**
  How can we explain the things that happen around us?
- **Unit Questions**
  Are there rules that affect the ways things move?
  What rules affect whether an object floats or sinks?
- **Content Questions**
  How are density, buoyancy, and displacement related?
  How can you measure volume of irregular solids?
  Which objects float and which objects sink?
  What happens to liquids when objects float or sink?

At a Glance
Grade Level: 3-5
Subject: Science
Topics: Properties of Matter
Higher-Order Thinking Skills: Problem Solving, Generalizing, Investigating
Key Learnings: Density and Buoyancy, Experimental Design, Measurement, Persuasive Speaking
Time Needed: 3 weeks, 45-60 minutes daily
Background: From the Classroom in Texas, United States

Assessment Processes

View how a variety of student-centered assessments are used in the Float That Boat Unit Plan. These assessments help students and teachers set goals; monitor student progress; provide feedback; assess thinking, processes, performances, and products; and reflect on learning throughout the learning cycle.

Things You Need
Assessment
Standards
Resources

Instructional Procedures

Posing Questions and Eliciting Prior Knowledge

Introduce the Essential Question, *How can we explain the things that happen around us?* Ask students to brainstorm their thoughts, examples, and ideas, and record their responses on a chart. Keep this chart to refer to as the unit unfolds. Then ask students to consider the following questions:

- *Are there rules that affect the ways things move?*
- *How can we find out?*

Guide students in a class discussion highlighting scientific method and engineering process components as they arise. Do not worry about having all components during this initial discussion. The following chart is for reference and can be used as a template for anecdotal notes for recording student ideas or given as a handout after the discussion.

The Scientific Method	The Engineering Process
State the question	Define the need
Conduct background research	Conduct background research
Formulate hypothesis, identify variables	Determine design criteria
Design experiment, determine procedure	Prepare initial designs
Test hypothesis by conducting an experiment	Build and test a prototype

Analyze results and draw conclusions	Test and redesign as necessary
Present results	Present results

Introduce the topic of the unit by asking, *Why does a huge ship float but a nail sink? What rules affect whether an object floats or sinks?* Ask students to discuss their hypotheses/ideas in groups and record them in their unit journals. Tell students that they will be investigating these hypotheses throughout the unit to help them design boats.

Review student journals to assess prior knowledge students have about buoyancy and density. Differentiate instruction based on student hypotheses. Periodically throughout the unit, review the journals to assess how well students understand the content, and redirect teaching as needed.

Background Information
Tell the students that today they will start to investigate some of the rules that affect whether an object floats or sinks.

Have students start to investigate some of the rules that affect whether an object floats or sinks.

For each group, provide a big tub of water and several objects that float and sink (wood, rocks, coins, nails, crayons, polystyrene cups, eraser, paper clip, marble, small piece of plastic, and so forth). Ask students to predict which of the items will sink and which will float. Then test the waters. Have students record in their journals in a simple T-chart the items that float and those that sink. Brainstorm as a class the properties of objects that float and objects that sink, and record on a chart. Introduce the word *density* to describe the differences. Whether an object sinks or floats depends on the density of the object in relation to the water. The heaviness of an object compared to its size is called its density.

Water Displacement and Buoyancy Activities
Ask students, *What happens to liquids when objects float or sink? Is there a difference? How can we measure what happens?*

Lead a discussion of ideas and then demonstrate measuring volume of a liquid using graduated cylinders and measuring volume of an irregular solid using volume displacement. The standard experiment uses a rock that can be suspended from a string or slid into a graduated cylinder. When the rock sinks, it pushes some of the water out of the way (displaces the water). The volume of the water displaced is equal to the volume of the rock. Graduated cylinders are generally used to measure how much water is displaced. The amount water rises when a rock is added shows the volume of the rock.

Have students practice measuring the volume of irregular solids using volume displacement. Provide each group a container of water, graduated cylinders, and the sinker objects they tested for the floating and sinking activity (marbles, coins, nails, rocks, and so forth). Ask students to record their measurements in their unit journals.

Bring students together and discuss how they just measured the displacement of water with objects that sink. Introduce the Displacement worksheet by asking, *What happens to liquids when objects float? Is water displaced?* Ask the students to make predictions and then work with a partner to complete the activity.

Based on their observations and measurements, lead the class in a discussion of the relationship between density and displacement. Introduce the word buoyancy as students describe their observations. Look at Buoyancy Basics* for a good demonstration of this concept. As a wrap-up for the day, ask the students to answer the question in their journals, *How are density, buoyancy, and displacement related?* Read journals to check for student understanding. If many students are struggling with understanding the concepts, use time the following day to continue investigating these concepts with the class.

Liquid Densities
Ask students if all liquids are the same. Have them explain how they differ. Using the Liquid Densities worksheet, ask students to explore liquids with different densities.

In groups, ask students to consider the question, *Will different liquids have an effect on whether an object floats or sinks?* Have each group share their thoughts and reasoning with the class. Provide each group with a small piece of wood, small piece of plastic, nail, and eraser from the floating and sinking activity as well as the jars they just created in the Liquid Densities activity. Ask students to return to their T- charts to find which objects floated and which sank in water. In a new table, ask them to write down which objects are more dense/less buoyant and which are less dense/ more buoyant than water. Have students drop the objects in the liquids and record their observations in tables. An example table follows.

Density and Buoyancy Comparison

	Water	**Oil**	**Corn Syrup**

Wood	Less dense/ more buoyant		
Eraser			
Plastic			
Nail			

Have groups report to the class about one interesting discovery.

Pose the question, *Will ocean water or bubble bath affect buoyancy?* Provide tubs of liquids—one with salt water, one with bubble bath, and one with plain water. Also provide several objects that float and sink. Ask students to compare the results with plain water to see if the density of these liquids affects buoyancy. Have students add their observations to their tables.

Wrap up the day by asking students to record their answers to the Unit Question, *What rules affect whether an object floats or sinks?*

Lead the class in a discussion of the rules they have discovered that affect whether an object sinks or floats. Record the rules on a T-chart. Have students return to their initial hypotheses and discuss in groups any that have not been answered. Have groups share hypotheses that still need to be tested and add these to the other side of the T-chart. Circulate through the room as groups discuss, taking anecdotal notes. Refer to these notes to help students needing further clarification or additional instruction. Lead a discussion emphasizing the scientific method they have used so far and the engineering processes that still need to be investigated to answer some of their remaining questions.

Foil Boats Activity
Shape will probably be one of the questions the students would still like to consider. In the Foil Boat activity, have students observe additional properties of buoyancy as they experiment with foil to create a shape that will float.

At the conclusion of this activity, tell students that they can continue to answer some of their remaining hypotheses for extra credit because the class is now going to move on to the challenge. As homework, ask students to explain in their unit journals why a huge ship floats but a nail sinks.

Introducing the Challenge
Introduce the challenge for the unit by describing the following We B Toys scenario:

> *We B Toys just completed their annual customer satisfaction reviews of their toy boat line. They have learned that customers have complained that their boats tend to sink. They are looking for new toy boats and are offering to purchase $1 million worth of merchandise from the company that produces the best boat. Your job is to design a new boat that will float and prepare a proposal for a new toy boat line.*

Assign students into heterogeneous groups and introduce them to the following project steps:

1. Brainstorm types of materials as well as designs to create a toy boat.
2. Use the brainstormed list to create a few prototypes that display the best ideas using the Design That Boat! worksheet.
3. Redesign and construct new boats based on tests.
4. Analyze the prototypes and select the best model to present to We B Toys.
5. Form "companies" with a company name and marketing theme.
6. Develop a brochure or multimedia presentation to present to We B Toys representatives.
7. Use the marketing checklist and project rubric to guide the process.

Discuss the requirements and assessment criteria, and check for student understanding. Allow time for teacher and peer conferences while student groups are working to receive feedback to strengthen their projects. Have students use the collaboration rubric to assess the group’s collaboration skills.

Invite guests from local toy stores or from the school community to the presentation as "representatives" of We B Toys. Assess the presentations using the project rubric.

Wrapping Up
At the end of the unit, revisit the Essential Question, *How can we explain the things that happen around us?* Ask students to record examples from their testing and experimentation in their unit journals as they explain what they have learned during the unit of study.

Prerequisite Skills

- Basic mass and volume measurement skills
- Working knowledge of desktop publishing software and multimedia slideshow software
- Working knowledge of word processing skills

Differentiated Instruction

Resource Student

- Allow extended computer use
- Provide a brochure template
- Break assignments into small, manageable segments and write them on a checklist
- Use a teacher assistant or instructional aide
- Arrange partnering with another non-resource student

Gifted Student

- Challenge the student to master complexity within applications as well as analyze and synthesize learning
- Enlist the student to use leadership skills to organize and focus the group
- Encourage the student to include more advanced technical attributes in the brochure
- Have the student exchange correspondence with a toy or boat building company
- Encourage the student to make arrangements for a guest speaker
- Have the student complete a class Web site that showcases class learning

English Language Learner

- Pair the student with native English speakers to assist in project work
- Use visual aids
- Allow for work to be done in the student's first language and then get a translation

Credit

Teresa Kester participated in the Intel® Teach Program, which resulted in this idea for a classroom project. A team of teachers expanded the plan into the example you see here.

From the Classroom

Can you design a boat that is seaworthy AND so appealing that a national toy store chain agrees to sell it? With this challenge, Teresa Kester's fourth graders at Galatas Elementary School in The Woodlands, Texas are launched into learning. Through many experiments in density and buoyancy, students learn what it takes for a boat to float reliably. Next, they practice the art of persuasion as they develop a winning marketing campaign for toy conglomerate "We B Toys".

Float that Boat! Is just one example of how project learning is on the move at Galatas Elementary. A school of 800, Galatas serves students in kindergarten through fourth grade. The fourth grade is departmental, with some teachers responsible for language arts instruction, and others focusing on science and social studies. Ms. Kester and her colleagues have been using technology and project learning in their instruction for quite some time. Several years ago, students used Hyperstudio to author "All About Me" projects. Since then, twenty Galatas teachers have participated in the Intel® Teach to the Future training, and are integrating technology in a myriad of new ways in their classrooms.

In a recent project addressing 4th grade geography standards, students studied the major regions of Texas. A Texas Regions Webquest gave kids entrée into the topic, and the teachers focused online research by packaging relevant Web page links into folders. Students used Publisher to produce enticing travel brochures that informed visitors about Texas landforms, rivers, cities, climate, and more.

Teresa says new methods of research and communication bring the work to life for students. "Kids can't get excited about traditional research. Once they get to the computer they're really happy." She says students work longer at hard tasks when they are aided by technology. Teresa recognizes that students who find pencil and paper activities difficult often find it easier to produce their work on computers. She also sees an increase in motivation and cooperation among all her students.

Teresa enjoys the change in her role as well. "When kids work together on projects I assign a facilitator to each group to solve immediate problems. I also assign an editor, who checks through the work to make sure it is complete and polished." Having students in these roles frees her up for other tasks, such as monitoring progress and solving the most difficult problems.

Assessment Plan

Assessment Plan

Assessment Timeline

Before project work begins

- Chart
- Unit Journals
- Questioning

- Anecdotal Notes

Students work on projects and complete tasks

- Unit Journals
- Questioning
- Anecdotal Notes
- Marketing Checklist

- Project Rubric
- Conferences
- Peer Feedback

After project work is completed

- Project Rubric

- Collaboration Rubric
- Reflection

Assess students throughout the unit using questioning strategies and taking anecdotal notes of responses and behaviors. Review questions posed at the beginning and end of activities in the students' unit journals and adjust instruction as necessary. Circulate through the room as students participate in group discussions and activities, monitoring understanding, probing thinking, and gathering information on individual and collaborative skills.

Provide the marketing checklist to give students an opportunity to brainstorm ideas and ensure all required elements are present. Ask students to refer to the project rubric as they develop their presentations, and use both teacher and peer feedback to provide each group with information to revise their projects before the final presentation. Assess the presentations and brochures with the project rubric for content, presentation, and organization. Students use the collaboration rubric to provide feedback on their group members' collaboration skills. As a final assessment, review student answers to the Essential Question, *How can we explain the things that happen around us?*

Content Standards and Objectives

Targeted Content Standards and Objectives

Texas Essential Knowledge and Skills for Science

- Conducts field and laboratory investigations following home and school safety procedures and environmentally appropriate and ethical practices
- Uses scientific inquiry methods during field and laboratory investigations
- Uses critical thinking and scientific problem solving to make informed decisions
- Knows how to use a variety of tools and methods to conduct science inquiry
- Knows that matter has physical properties

Student Objectives

Students will be able to:

- Understand the properties of density, buoyancy, and displacement
- Measure volume of irregular objects through displacement
- Develop and test hypotheses about variables that affect the buoyancy of boats using the scientific method and engineering process
- Analyze data and draw conclusionsUse various written and visual presentation tools to effectively communicate learning
- Use persuasive speaking to convince audiences of the superiority of a product
- Work cooperatively in small groups

Resources

Materials and Resources

Printed Materials

- Buegler, M. E. (1988). *Discovering density* (grades 6-9). Berkeley, CA: University of California at Berkeley, Great Explorations in Math and Science (GEMS) Project.
- Gibson, G. (1995). *Making things float and sink*. Brookfield, CT: Copper Beech Books.
- Glover, D. (1993). *Flying and floating*. New York: Kingfisher Books.
- Science and Technology for Children (STC). (2002). *Floating and sinking.* Burlington, NC: Carolina Biological Supply Company.

Supplies

- Several objects that float
- everal objects that sink
- Beakers (or other containers) of water
- Graduated cylinders
- Aluminum foil
- Paper clips
- Film canisters
- Small masses (such as coins, marbles, nails, rocks, and so forth)
- Balances or scales
- Several sinks or containers for water
- Cooking oil
- Corn syrup
- Bubble bath
- Salt
- Red and blue food coloring
- Various materials that could be used to build boats

Internet Resources

- ExploreLearning, Gizmos
  www.explorelearning.com*
  Interactive density labs
- MadSci Network
  www.madsci.org/experiments/archive/869327658.Ph.html*
  Buoyancy lesson
- NYU: Science Teachers Enhancement Model, Exploring Density
  www.nyu.edu/projects/mstep/lessons/density.html*
  Background information for teacher
- Bill Nye's Buoyancy Lab
  www.billnye.com/episode_pdfs/episodeguide5.pdf* (PDF; 1 page)
  Episode on buoyancy under physical science

Technology—Hardware

- Computers for conducting research and creating multimedia and publishing documents
- Projection system to share multimedia presentations with We B Toys representatives
- Digital cameras to take pictures of prototypes

Technology—Software

- Desktop publishing for designing brochures
- Encyclopedia on CD-ROM for accessing information about vocabulary and boats
- Image processing to process pictures for presentation
- Internet Web browser for conducting research
- Multimedia for designing multimedia presentations
- Word processing for creating written work

Marketing Your Boat

Company Name: ______________________________________

Production Team: ______________________________________

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____

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Boat Name: ______________________________________

Marketing Jingle/Theme:

Brochure or multimedia marketing tool to use with We B Toys representatives includes all of the following elements:

_____ Company name

_____ Company logo

_____ Product name

_____ Digital image of the boat

_____ Rationale of how the boat design makes your product superior

_____ History of your product design (include findings from experimental foil boats and initial prototypes regarding buoyancy, density, and so forth)

_____ Marketing theme/logo

Float That Boat Project Rubric

	4	3	2	1
Content and Understanding	• I effectively describe the history or sequence of events that led to the boat design (experimentation with density, buoyancy, and construction of boat). • My rationale is clearly supported by data I collected during the experimentation of my toy boat design. • I use a wide variety of technology and writing skills to complete the project. • I make important connections and offer unique ideas between the concepts I learned and the toy boat design.	• I describe the history or sequence of events that led to the boat design (experimentation with density, buoyancy, and construction of boat). • My rationale is supported by data I collected during the experimentation of my toy boat design. • I use a variety of technology and writing skills to complete the project. • I make connections and offer unique ideas between the concepts I learned and the toy boat design.	• I describe the history or sequence of events that led to the boat design (experimentation with density, buoyancy, and construction of boat) with some errors. • My rationale has limited support with data I collected during the experimentation of my toy boat design. • I need some assistance in choosing technology and writing skills to complete the project. • I make few or no connections and offer some ideas between the concepts I learned and the toy boat design.	• I do not describe the history or sequence of events that led to the boat design (experimentation with density, buoyancy, and construction of boat). • My rationale has no support or data. • I need assistance in choosing technology and writing skills to complete the project. • I need assistance to make connections and do not offer ideas between the concepts I learned and the toy boat design.
Oral and Written Presentation	• I communicate effectively and persuasively. • I convey clear, focused main ideas that are supported by well-chosen details and examples. • I design my presentation to match the topic, audience, and purpose. • I use my brochure or presentation to effectively communicate my information to the audience.	• I communicate completely with some persuasion. • I convey main ideas that are supported by important details and examples. • I design most of my presentation to match the topic, audience, and purpose. • I use my brochure or presentation to communicate my information to the audience.	• I communicate some without much persuasion. • I convey a main idea but I do not support it effectively. • I design a presentation that does not effectively match the topic, audience, or purpose. • My brochure or presentation does not clearly communicate my information to the audience.	• I communicate in a limited manner. • I do not present or support main ideas. • I do not match my presentation to the topic, audience, or purpose. • My brochure or presentation does not communicate my information to the audience.

Organization and Mechanics	• I present my information in a clear and logical order. • I make understandable connections and transitions among ideas or topics. • I use formatting consistently throughout the presentation. • I show clear evidence of proofreading. • I have no noticeable errors.	• I present my information in order. • I connect ideas. • I use different styles of formatting, but it does not interfere with the presentation. • I show evidence of proofreading. • I have a few errors that do not detract from my presentation.	• I present some of my information out of order. • I usually connect ideas but some ideas are not connected. • I use inconsistent formatting that detracts from the presentation. • I show some evidence of proofreading. • I have some errors that detract from my presentation.	• I present my information in a disorganized way. • I do not connect ideas. • I use inconsistent formatting that interferes with the presentation. • I show little or no evidence of proofreading. • I have many errors that significantly detract from the meaning of my presentation.

Collaboration Rubric

4	3	2	1
We paraphrase what others have said in our group to clarify understanding. We ask probing questions. We encourage and value the ideas and opinions of our group members. All of us can express our opinions and positions without hurting the feelings of others in our group. Our differences are appreciated—we seek out diverse opinions and try to come to common understanding.	We respond verbally to the ideas of others in our group and may ask for clarification. We are interested and curious about the ideas of others in our group. Our opinions are communicated without passing judgment, such as using “I” versus “you” messages. We can extend our discussions beyond our initial thoughts and ideas. Differences that we have are resolved.	We acknowledge the ideas of others. Occasionally, we acknowledge or indicate support for the ideas of others in our group. Sometimes, we have a difficult time responding to the ideas of others in our group. We pay attention to the consequences of what we say or do at times, but taking turns or accepting suggestions from others is difficult. Our differences are sometimes ignored and, when acknowledged, can be left unresolved.	We offer feedback only if requested. We have difficulty responding to questions. Our contributions are neither acknowledged nor responded to. We do not pay attention to the consequences of what we say or do. Our differences are usually suppressed or ignored and sometimes result in arguments.

 # Name ________________________ **Date ______________**

What happens to liquids when things float on them?

A. Fill a beaker about half-full with water and adjust the water level so that it comes to a line marked on the beaker.

B. Put an empty film canister with the lid on into the beaker of water without splashing the water. What happens to the film canister? What happens to the water?

C. Remove the canister and add 10 paper clips. Then close the lid and observe carefully as you place it into the water. Describe what happens to the film canister and what happens to the water.

D. Keep repeating step C, adding 10 more paper clips each time until you can't add any more. Describe what happens to the film canister and the water each time:

1. Film: ______________________ Water: _________________________

2. Film: ______________________ Water: _________________________

3. Film: ______________________ Water: _________________________

4. Film: ______________________ Water: _________________________

5. Film: ______________________ Water: _________________________

6. Film: ______________________ Water: _________________________

E. Discuss your observations with your partner and write a statement about what happens to a liquid when things float.

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Name ______________________________ Date ______________

DENSITY: ARE SOME LIQUIDS MORE DENSE THAN OTHERS?

Density describes the amount of matter packed into a certain space.

A. Use a graduated cylinder to measure 100 ml of cooking oil. Pour the oil into a tall, clear plastic jar.

B. Use the other graduated cylinder to measure 100 ml of water. Add one drop of blue coloring to the water and stir to mix. Tilt the jar and slowly pour the blue water down the side of the jar. Set the jar down. Observe what happens to the liquids. Make a drawing of what you see and label it.

C. Measure 100 ml of corn syrup. Add one drop of red food coloring. Stir to mix well. Tilt the jar again. Slowly pour the red corn syrup down the side of the jar. Set the jar down. Observe what happens to the three liquids in the jar. Make a drawing of what you see and label it.

D. In what order did you add the liquids to the jar?

1. ____

2. ____

3. ____

E. What was the final position of the liquids in the jar from top to bottom?

1. ____

2. ____

3. ____

F. From your results, what can you conclude about the density of the liquids?

____

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____

G. List the liquids in order from the least dense to the most dense.

1. ____

2. ____

3. ____

H. Give the meaning of “density.”

____

____

#____ Name ____________________ Date ________________

FOIL BOATS

1. What happens to a square of aluminum foil when placed in water? Record your observations: ____

____

____

2. What happens when you crush a square of foil and place it in the water? Record your observations: ____

____

____

3. Form a square of foil so it will float on the water. Place the "boat" on the surface of the water and put paper clips on it one at a time until it sinks. Record the results in the table. Redesign your boat and repeat the procedure.

WILL IT FLOAT? HOW MUCH WILL IT HOLD?

Draw your three best boat designs	Length, Width, Height	Mass of Cargo
a.		
b.		
c.		

4. Make inferences about **why** your boat floats. ______________________________

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5. Did your boat support the same number of paper clips the first two times? ____
What might have caused it to support more, less, or the same number of paper clips? Explain: ____

____

____

6. What happened when the boat was redesigned? Did it support more weight? Explain why: ____

____

____

7. Tell why your best boat design is so special. What makes your boat hold more than others? ____

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____

8. What happened to the waterline on the outside of the boat as the paper clips were added? ____

____

9. If you doubled the size (area) of the foil (from 4”x4” to 4”x8”) predict how much more weight (how many more paper clips) you think that your boat will support. Explain: ____

____

____

Bonus: Could other materials be used to make boats? Find out what kinds of materials modern boats and ships are made of today. ____________________________

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Designing Your Company Boat

Select a Boat Design

- Share with your team your answers to questions 4-8 from your Foil Boat handout.
- Record similar findings among team members here:

- Come to agreement on 2-3 boat designs based on your team's findings (this includes agreeing on the types of materials to use to build the boats). For each design, draw a diagram and write a brief description.

Create Prototypes and Test Them

Create and test the team's prototypes. Record your data below.

Boat #	Did it float?	Could it support any weight? If so, how much?	What changes can you make to improve the boat?
1			
2			
3			

Modify your prototypes and try again. How did this revised prototype fair against the original?

Boat #	Did it float?	Could it support any weight? If so, how much?	How did the revised prototype fair against the original?
1			
2			
3			

Select Your Best Boat

As a production team, select your best boat. Record why the selected boat is the best boat. Think about what makes the boat design so special. What makes your boat hold more than other boats?

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Think about the target age group for your boat. How will you persuade you target audience that they want to have your boats in their bathtubs?

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So Much Fun!

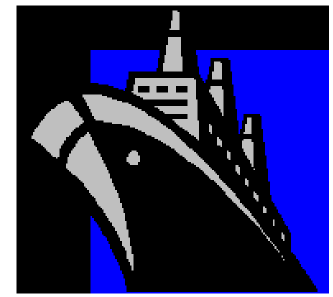
The boat is also very fun to play with. It doesn't sink in any type of water because we tested it. The children can open up the egg carton to put the play people or cars or animals or anything they want inside. Then they can make it crash through waves or even fall over and it will not sink.

It can be a transport ship, an ocean liner, a houseboat, or a pleasure boat—wherever the children's imagination takes them. You can also order a sail that attaches to the top of the Wave Breaker. The boat is so light that even a slight breeze will catch the sail and have it racing across a pond in no time.

Fanta Sea Company

Brought to you by the
Fanta Sea Company

Makers of high quality children's toy boats



The Wave Breaker

The unsinkable toy boat.

Brought to you by the
Fanta Sea Company

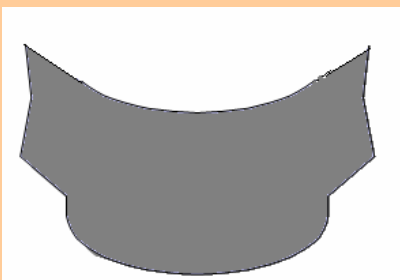
SHANE
ANTONIO
LAVONNE

The Wave Breaker

DESIGN PROCESS

We have conducted many experiments and tests to make sure that the Wave Breaker is buoyant, not very dense, and will float in pond, ocean, or bathtub water.

We wanted our boat to be buoyant and watertight. When we were making foil boats, we found that they tipped over if we weren't careful in our design. After many tests, we think the best design was one where most of the foil touched the water, but the sides were pretty tall so the water couldn't get in. Even this was tippy when we added the paper clips, so we had to make the bottom a little curvy so most of the paper clips stayed in the middle. It still sank when the water got in. The sketch shows our best foil boat design:



So we started thinking about what would be the best materials to use to keep our boat watertight. We knew from our experiments, that plastic bottles filled with air were the most buoyant material. They don't displace very much water and they are long so they float very well. Also, every time we pushed down on them they would pop right back up to the surface. So we knew we wanted to use plastic bottles in our boat design.

How could we make our boat stable? Plastic bottles are round and very tippy, so we knew we had to add other materials. We didn't want to add anything dense like rubber or metal that would weigh it down, and we had discovered that wood floats very well. So we thought we would make a wood platform out of popsicle sticks to connect the bottles together.

This design didn't work very well because the boat turned over and the popsicle sticks fell apart. The glue didn't hold it together. Plus, it was tippy because the wood was out of the water and only the bottles were touching the water.

FINAL BOAT

We decided to use a polystyrene egg carton to hold the bottles together and we used electrical tape instead of glue. This design worked very well because most of the surface of the boat is right on the water, and it uses two very buoyant materials. The two bottles act like pontoons and give the boat lots of stability. The tape is waterproof, so it won't fall apart. This is a picture of the Wave Breaker:

WHAT WE LEARNED

If we were to take the plastic in the bottles and scrunch it up, the plastic would sink. This is because the plastic would be more dense than the water. Because we've used the plastic in a long shape that we can fill with air, it is less dense than water, and it floats.

After we added the egg carton to our boat, we noticed it floated higher in the water—it displaced less water, than the wood one. We think this is because there is more area touching the water. The more water that pushes against the boat, the better it is able to float—the more buoyant it is. Our new boat has two bottles and the egg carton touching the surface of the water, so it is very buoyant.

When we filled our boat with weights, it floated lower in the water, but it didn't sink. It started taking on water, but the bottles still kept it afloat. This means that our bottles are more buoyant than the weight of the egg carton filled with water and that means it's a really good boat!

We had many hypotheses about what would make a good boat design. We tested our hypotheses out and kept changing them a little bit after every test. Now we know that the most important criteria for making a good boat are buoyancy, stability, and being watertight.