# BUILD A BETTER BOAT

## Overview

Book: *Breakthrough* by Jack Andraka

Grades 6-12

Jack loved kayaking and often thought of problem-solving while he was on the water. He also knew that he had to try many different approaches to any challenge he took on. In this PBL, students will create prototypes of boats to determine which style and materials will hold the most weight.

## Standards

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| W.6-8.7 | Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate. |
| W.9-12.7 | Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. |
| WHST.6-12.2 | Write informative/explanatory tests, including the narration of historical events, scientific procedures/experiments, or technical processes. |
| MS-ETS1-3 | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. |

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| MS-ETS1-4 | Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. |
| HS-ETS1-2 | Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering |

## Objectives

Students will research the various types of hulls and keels on boats.

Students will design and create 3 prototypes with different hulls and keels.

Students will test the prototypes for stability and ability to hold weight.

Students will revise designs to enhance chances of success.

Students will write a narrative about the process.

## Materials Required

Internet or library access
Large tub or trough to hold water
Various building supplies that might include cardboard, foil, duct tape, aluminum pans, Styrofoam, craft sticks, toothpicks, chenille stems, cardstock, non-hardening craft clay, plastic cups/plates, empty water bottles, scissors, glue, and masking tape.
Chart paper and markers
Paper
Pencils
Set of gram weights, coins, marbles, or other items that can quantitatively provide a consistent weight amount.
Hand held egg beater (optional)

## Vocabulary

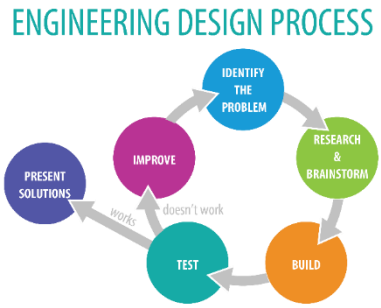
Hull – the main body of a ship or other vessel, including the bottom, sides, and deck

Keel -the longitudinal structure along the centerline at the bottom of a vessel's hull, on which the rest of the hull is built, in some vessels extended downward as a blade or ridge to increase stability.

Profile - a vertical cross section of a structure.

## Procedure

1. Review the engineering design process.




2. Go over the vocabulary terms with students.
3. Tell the class they are going to create at least three prototypes of boats to determine which is the most stable and will hold the most weight.
4. Divide the class into groups.
5. Have students brainstorm all the different types of boats that they can think of and write the names on the chart paper.
6. Research the different types of hull and keel structures for the various types of boats. Here are a few sites that are helpful.
   https://sites.google.com/site/moricsep/home/designing-sailing-ships/hulls
   https://cdn.education.com/files/174901_175000/174979/keep-the-boat-afloat-1.jpg
   https://media1.britannica.com/eb-media/90/1890-004-52F26B90.jpg
   http://portbusan.go.kr/eng/img/new/page_yacht_02_a.gif
7. Have students draw the various profiles of the hull and/or keel that matches the types of boats they have written on their chart paper.
8. Ask students to note on the chart paper, whether the hull design is mainly for stability, speed, weight bearing, agility, etc.
9. Have students decide on three designs of hulls and/or hulls with keels. Students should first draw a design of these combinations.

10. Depending on your tub size and amount of materials, you may want to set a limit on boat size. A suggestion would be no larger than 6 inches.
11. Provide plenty of time for students to build their prototypes following their planned designs.
12. Test the prototypes in the water. Gradually add weight until the boat begins to sink or until you have used the heaviest weight.
13. Have students record the amount of weight each prototype could hold.
14. Discuss some of the following questions.
    Was the success or failure due to hull/keel design?
    Were the materials selected a good or poor choice?
    Did the overall execution of the build affect the result?
    What changes could increase the chance of holding more weight?
    What kind of hulls/keels are used on the ships that carry the most weight? (such as tankers and barges)
15. Give students time to redesign **one** of the prototypes and test again.
16. Have students write a report about the success/failure rate of each of the prototypes. Students should include how the one prototype was changed and why those changes were made.

## Extensions

1. Use a handheld egg beater to create turbulence in the water. Have students document the effect this has on their prototypes.
2. Let each group build an additional boat, using what they have discovered. Hold a contest to find the boat that will hold the most weight.
3. As a class, create a boat that will hold a student. Test this in a shallow pool, stream, river, or lake using proper safety precautions.
4. Have students create a drawing of a boat they would like to have or sail on. Have students create an inset of the profile of this boat, too.
5. Ask students to create a montage of film clips where the structure of the ships/boats played an important role. (Examples: *Titanic, The Perfect Storm, All is Lost*).

## Rubric

| RUBRIC | Exceeds (3) | Meets (2) | Partially Meets (1) | Does Not Meet (0) |
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| Chart | Chart lists 6 or more types of boats | Chart lists 5 types of boats | Chart lists 2-4 types of boats | Chart lists 1 type of boat |
| Hull design | Hull profiles were included for 5 or more boats | Hull profiles were included for 3-4 boats | Hull profiles were included for 1-2 boats | No hull profiles were included |
| Sketches | Four or more sketches were made in the design process | Three sketches were made in the design process | Two sketches were made in the design process | One or no sketch was made in the design process |
| Prototypes-hulls | Hull and keel configurations were different on all three prototypes | Hull configurations were different on all three prototypes | Hull configurations were different on two prototypes | All hulls had same configuration |
| Prototypes - construction | Construction was very precise with superior attention to the design concept | Construction was well done with attention to the design concept | Construction was sloppy with some attention to the design concept | Construction was poor with no attention to the design concept |
| Revision | | Revision directly reflects concepts learned during testing. | Revision somewhat reflects concepts learned during testing | Revision does not reflect concepts learned during testing |
| Written Report | Report contains precise details about the design | Report contains basic details about the design, all | Report contains vague details about design, all | Report contains very few details about any of the |

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| | process, all prototypes, and explains revisions. | prototypes, and explains revisions | prototypes, and explains revisions – or some elements are missing | phases and many elements are missing. |
| Total n/20 | | | | |