

## World's Most Dangerous Record – Engineering Design Challenge

**Scenario:** Ferrari, known for making high performance cars, has decided to commission a company to build a boat to break the water speed record. This is widely considered the most dangerous record in the world because of the instability of a boat at very high speeds and the fatality rate involved with the record attempts.

Ferrari has issued a call for proposals to companies that can build a small-scale prototype of their record-breaking boat. As one of the top design companies in the world you have accepted Ferraris challenge to design, build, and test a record-breaking watercraft with a focus on safety and stability.

**What will students make:** Students will follow the engineering design process in order to plan, design, and test a small watercraft. They will 3D print the hull that holds a minimum of a small electric motor for propulsion and 2AA batteries. The watercraft should be as fast as possible as tested by the straight-line distance of travel in a 3 to 5-foot container of water.

**Intended grade level and courses:** High School engineering, STEM, or CAD classes. Also scalable to middle school.

**Time frame:** 3 to 5 weeks or 15 to 25 hour-long class sessions



1) Identify the “Big” concept to be covered by the engineering design challenge.

The following are the main concepts this project will address:

- Understand and utilize the full engineering design process to produce and test an object
- Work with a team to develop a project
- Document the development of your project in an engineering notebook (via Pathbrite)
- Learn new techniques using the Fusion 360 CAD software
- Understand and apply principles of aerodynamics to a design such as weight, thrust, lift, and drag
- Justify design decisions verbally, graphically, and in writing
- Further your understanding of the abilities and limitations of 3d printing in design
- Explore the power output of a propeller with an electric motor.

2) Research appropriate learning standards associated with the topic.

- Kansas CTE Engineering Pathway Standards for Engineering Design
  - *Standard 3: Gain knowledge of the design process and implement the process during design challenge*
  - *Standard 4: Identify and demonstrate knowledge in the use of technology*

- *Standard 13: Demonstrate proper techniques used in creating drawings on CAD*
- *Standard 19: Create a Portfolio showing evidence of the skill and understanding of Engineering Design*
- *NGSS Engineering*
  - *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*
  - *HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.*
  - *HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.*

3) Identify and discuss the different types of problem solving and declarative/procedure knowledge needed.

Declarative Knowledge	Procedural Knowledge
Aerodynamic forces in general and in water specifically	Techniques and effective workflow in Fusion 360
What makes something fast?	Applying EDP to a design challenge
How does a propeller move air?	Moving through the phases of EDP effectively
Deeper understanding of Fusion 360	3D printing an object (when to use supports, how to slice it, etc)
Why is the water speed record so dangerous?	Planning, testing, and analyzing results
Different types of hulls in watercraft and their advantages/disadvantages	What constitutes effective documentation and how to do it.

4) Explore objectives and ancillary concepts/content covered by the project.

Due to the open nature of this project there are a number of ancillary concepts that could be explored on a whole class or group level, these may include:

- Bernoulli principle
- Material properties (both 3d printing material such as PLA vs. ABS vs real world material such carbon fiber)

- Gear ratios and power sources (Giving teams the chance to add a higher power motor and/or experimenting with more or different batteries)
- Planes vs boats – basic fluid dynamics and what it means for vehicle design
- Surface tension of water – how a 200mph crash in the water is like hitting a wall of concrete
- Lots of other concepts and directions to explore...

5) Identify possible activities

The 5e structure or something similar could be effectively used for activities within this project.

Engage	<ul style="list-style-type: none"> <li>○ Intro to scenario</li> <li>○ Youtube video of the world water speed record</li> <li>○ Why do you think it is so dangerous discussion?</li> <li>○ Would you attempt the record if you could? What would need to be in place for you to attempt this record?</li> </ul>
Explore	<ul style="list-style-type: none"> <li>○ Different hull designs of speed boats</li> <li>○ Propulsion methods</li> <li>○ Factors influencing boat manufacturers</li> <li>○ 3d printed boat examples</li> <li>○ Perhaps bring in an RC boat and have students drive</li> </ul>
Explain	<ul style="list-style-type: none"> <li>○ Discuss CAD techniques for boat design</li> <li>○ Discuss aerodynamics and/or formalize the results of exploration phase</li> <li>○ Construction of decision matrix/Gantt chart etc.</li> <li>○ Students formalize their project plan – this is essentially the ‘ideate’ phase of the process</li> </ul>
Elaborate	<ul style="list-style-type: none"> <li>○ Students go from sketching designs and coming up with a plan to CAD design</li> <li>○ Students use what they learned in the previous phases to design their boat. Each group member designs a different boat design testing in the next phase</li> </ul>
Evaluate	<ul style="list-style-type: none"> <li>○ Students test their boats – gather their data using a collection method</li> </ul>

	<ul style="list-style-type: none"><li>○ Students iterate by going back to previous steps and changing if necessary</li><li>○ Students showcase their work in either a presentation, demonstration, brochure, sales pitch, etc...</li></ul>
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6) Select the best activity for your classroom

From a project planning perspective, one of the things I need to decide is do I have the students focus on designing the boat alone, or experimenting with different propeller designs and 3d prints.

I think that the propeller design would make a nice addition and extension, however, giving students premade or similar propellers would make the focus more on the boat design.

In general – the activity that would bring this all together is a small scale (maybe 2 to 4” max) boat design. Students will use what they learned to design a boat that can move as fast possible in a container that is about 2 to 4 feet long. They will also take factors such as safety and aesthetic into consideration. Students will gather data, iterate, and present their findings in the form of a sales brochure for the Ferrari company. The goal is to be the company ‘chosen’ to produce the boat. Students must justify why they made the design decisions they did.