12 Key Steps to Building an Inquiry-Based STEAM Challenge

1. Prepare the STEAM Challenge around a topic you will be teaching.
For example, 8th grade science students might be studying physical and chemical changes, types of chemical reactions, and acids and bases. The student math objectives include computational fluency and solving linear equations. This combination allows teachers to blend some math and science content so kids can actually see how the two subjects interconnect.

2. Connect that topic to a real world problem.
Easier said than done. In this example, teachers might explore the problem of airbags. A simple and safe chemical reaction takes place between acetic acid (vinegar) and sodium bicarbonate (baking soda). This produces a gas (carbon dioxide) that might be used to expand airbags.

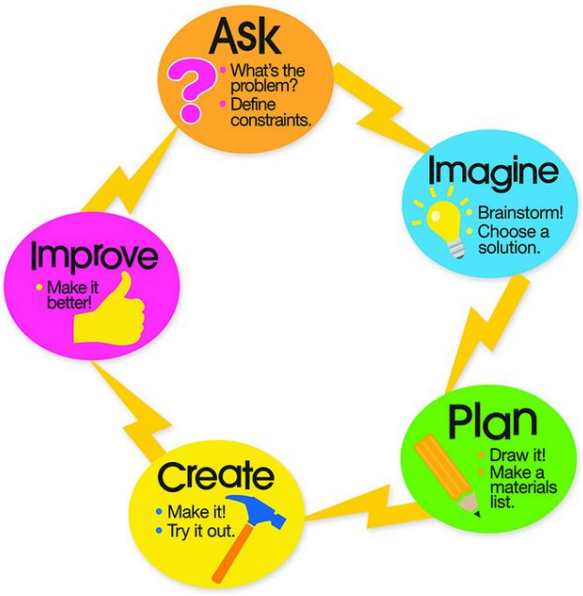
3. Clearly define the STEAM Challenge students will tackle.
In this example, the challenge might be: Design a cost-effective airbag from nonflammable chemicals that will inflate quickly and prevent injury.

4. Decide what success looks like.
How might students test the effectiveness of their air bag in preventing injury. Using a boiled egg as a passenger is a popular way of doing this. Exactly how will they conduct this investigation, and what measurements will they take?

5. Use the engineering design process for planning.
Teach students about the engineering design process that they will use in their planning.

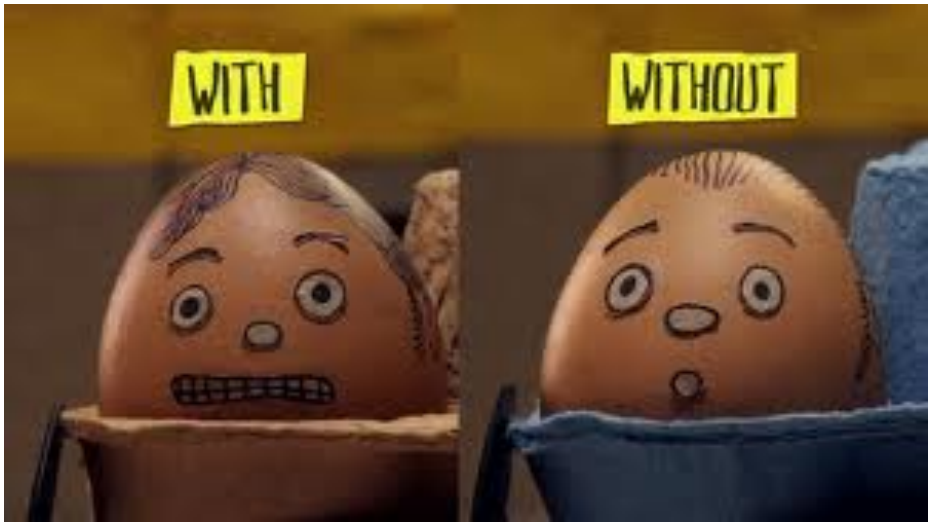
Steps in the Engineering Design Process:

- **ASK**: Identify the problem or need and do background research
- **IMAGINE**: Generate alternative solutions and then choose a solution you wish to test
- **PLAN**: Draw out your solution and make a materials list
- **CREATE**: Create a model or prototype. Then test and evaluate
- **IMPROVE**: Tweek your design to improve it



And then the process begins all over again!

6. Help students identify the STEAM Challenge.
Set up a scenario that captures the students' interest and lays out the problem. YouTube videos are often helpful. Use a skit or some other attention-getter. Be sure the students understand their challenge and actually *feel* challenged.



New Zealand Egg Crash Video (https://vimeo.com/14374385)

7. Involve teams of students in researching the content for the challenge.
Involve the students in learning through videos, reading, hand-on experiments, or websites that provide interactive diagrams, about any or all of the following:

- balancing chemical equations
- learning about acid-base reactions by experimenting with the chemicals
- learning about air bags

8. Encourage teams to develop their own ideas about how to solve the problem. Before you turn students loose to brainstorm ideas and solutions, you'll want to establish some criteria and constraints. For example, one *criterion* might be that their air bag should be cost effective. Exactly how much of each chemical will they need to produce enough gas to fill the air bag (a plastic sandwich bag) to the optimal level? A *constraint* might be that they have only a certain amount of acetic acid and sodium bicarbonate to work with.

Most importantly, let students generate **multiple ideas** for solving their problem. One thing they need to learn is that there are usually multiple solutions for problems – not "one right answer." This idea separates authentic STEAM learning from cookie cutter lab experiments.

After students get some ideas on the table, they can select one to try. (In this case, teams might muck around with the chemicals and come up with their own proportions for inflating the airbag. If students will be using a boiled egg in their investigation, they will need to engage in another round of brainstorming – how will they attach the passenger to the airbag? As they work together, monitor how their teamwork is going. Is everyone participating? Sharing? Being respectful?

9. Guide teams to choose one idea to test and then create their prototype.
In this example they might select the airbag system they think has the most cost-effective ratio of chemicals and a device they think will best transport the passenger egg. Let them dive into building a prototype of their air bag system.

10. Facilitate the process of prototype testing and evaluation.
Teams should test their prototypes and collect data on how well they worked. This may involve one test or many tests, depending on what kind of data they will collect. Then teams should analyze their data and decide how well their prototypes met the criteria.

11. Involve teams in communicating their findings.
The teams might display their data and then make decisions as a whole class about which airbag system worked best and why.

12. Redesign if there's time.
Once teams have time to learn from one another, they can then redesign their airbag systems and improve them.

Key Curricular Concepts:

- Provide lots of guidance. but few instructions.
- Mistakes and design failures are good methods of learning.
- The STEAM process is not linear – the sequence of events may change, and the process is usually recursive.
- Students work in teams to solve STEAM challenges.
- Work with colleagues if possible to write and implement STEAM lessons. If it's not possible, then go for it anyway!