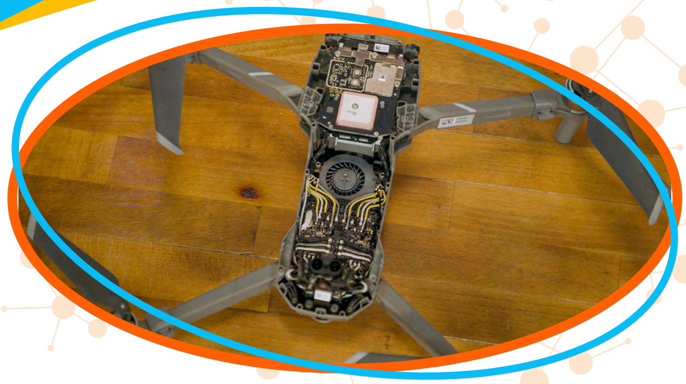
GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.



TEACHER GUIDE

ENGINEERING DESIGN PROCESS
GRADES 6-8

COMMON MISCONCEPTIONS

- **Engineers sit behind a computer all day.**
  The field of engineering is diverse with many different areas of specialization. Engineers choose which field they would like to specialize in and navigate their own career path within the broad field of engineering. Although there are some engineering jobs that may require sitting at a desk, design engineers typically work on solving problems and designing new products. Engineers also work alongside other professionals such as architects to engineer new buildings, scientists to engineer new medical devices, and mechanics to engineer new car engines.

- **Engineers are not creative.**
  Engineering is one of the most underrepresented creative career fields. The key component of an engineer's work is coming up with creative ideas to solve the world's problems. The engineering design process helps structure how engineers visualize and develop ideas that could be potential design solutions to the problems they are trying to solve.

- **Engineers must be good at and enjoy math.**
  Although math is an important part of an engineering student's curriculum, it is not necessary to be a mathematical genius to pass these courses. Students will need to put in the time and work to learn math concepts, but students who struggle with math can still succeed in the field of engineering. The key is persistence and determination. If students are enthusiastic about becoming an engineer, then their journey will be well worth the effort once they reach their destination.

ENGINEERING DESIGN PROCESS

The engineering design process is a series of steps that engineers follow to come up with a solution to a problem. There are many versions of the engineering design process with a varying number of steps. However, all engineering design processes have three main phases in common. The first phase is when engineers define the problem. Usually a problem statement is written, and all of the criteria and constraints are listed. During the second phase, engineers develop possible solutions. This phase may consist of brainstorming, sketching, modeling, testing materials, interviewing experts, or doing anything that can help inspire ideas for a possible design solution. The third phase is optimizing the design solution. Often this phase will go on for long periods of time as prototypes are built, tested, and improved. A prototype will eventually be considered to be complete when it provides a design solution that successfully meets all of the criteria and constraints. Although there are three phases, engineers will jump around and repeat steps within these phases as necessary. The process is considered iterative because steps are repeated and not necessarily used in a linear order.

TYPES OF ENGINEERS

Engineering is a vast field of specialized engineers who design solutions to problems. Depending on the field of specialization, engineers integrate knowledge and ideas from applied mathematics, science, or technology and work with other specialists from these fields to collaboratively design solutions to problems. Typically, engineering is broken down into branches, subdisciplines, and specialties. For example, ecological engineers are a type of specialized engineer found within the subdiscipline of environmental engineering. Ecological engineers design, monitor, and construct ecosystems, while the broader subdiscipline of environmental engineering solves problems related to the improvement and protection of the environment. These are both found within the branch of civil engineering, which focuses on designing, constructing, and maintaining physical and naturally built environments.

ENGINEERING DESIGN CHALLENGES

Engineering design challenges are often used in education to build skills and engage students in science and engineering practices. A design challenge is provided for students to emphasize one or more different aspects of the engineering design process and to develop students' ability to engage in and use the science and engineering practices. For example, students may be asked to come to consensus on criteria and constraints in order to define the problem. Or students might obtain, evaluate, and communicate information from online resources and use it as the research related to the problem or possible design solutions. Students may develop models to communicate design solution ideas or conduct investigations to test and improve prototypes of their design solution.

TEACHER TIPS

Students may need you to provide support or scaffolds when they are new to participating in engineering design challenges. Guiding questions are useful to help lead students into thinking about or using science ideas to help develop their design solutions. Although possible, it is not necessary to include all of the science and engineering practices into every design challenge. Intentional and purposeful integration of certain practices and science ideas into the design challenge will help you focus on students' development of skills and science ideas.

ABOUT THIS LESSON

This lesson was created by the National Science Teaching Association (NSTA) to pair with the Generation Genius video and support *NGSS*.

They have requested we provide the following background with this lesson:

The Next Generation Science Standards (NGSS) are the national standards on how students learn science, and they are based on contemporary research presented in *A Framework for K–12 Science Education (the Framework).* The shift in science teaching and learning required by the Framework is summarized in this infographic: [A New Vision for Science Education].

At the start of each Generation Genius lesson, students are presented with a phenomenon, then they try to explain it. Students will notice they have gaps in their knowledge and ask questions, which motivates them to build ownership of science ideas they need in order to explain how or why the phenomenon occurred. The way students build ownership of science and engineering ideas is through active engagement in the science and engineering practices (SEPs). This process of sensemaking, or doing science to figure out how the world works, is one of the major shifts the *Framework* encourages.

To engage in the SEPs, students should be part of a learning community that allows them to share their ideas, evaluate competing ideas, give and receive critiques, and reach consensus. Students can start by sharing ideas with a partner, then with a small group, and finally, with the whole class. This strategy creates opportunities for all students to be heard, build confidence, and have something to contribute to whole-class discussions. Each Generation Genius lesson provides conversational supports to facilitate such productive student discussions to contribute to sensemaking.

Excited to continue your shift toward the new vision for science education? Check out the Generation Genius Teacher Guide page on the NSTA website for resources and strategies to engage every student in your classroom in **doing** science.