Engineering Design

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Experience the Engineering Design Process

Design an Electric Vehicle

What is Engineering Design?

Science is the study of the natural world. This study often identifies patterns. The study and use of patterns is basically the definition of "mathematics." What is discovered can be applied "to solve problems and extend human capabilities". That is the definition of "technology." The process of developing technology is called "engineering."

Engineering Design is the process of applying knowledge of the natural world and its patterns to solve a problem. It is not discipline specific or limited to a particular age group or gender. It is, can, and should be conducted by all students regardless of academic ability or career aspirations. Engineering Design can be as simple as the informal development of a schedule to complete all of the tasks required for getting ready for school in the morning and arriving on time. It can be as complex as operating a rover on Mars.

For the past several decades, the general understanding is that an increased interest in and understanding of mathematics and science will improve our ability to solve problems leading to new inventions and innovations. The intended outcome is a stronger economy, increased national security, and an elevated standard of living. This is the foundation of current interest in STEM (science, technology, engineering, mathematics) educational programs.

Why is Engineering Design Important?

Begin the workshop by asking your teachers what they want their students to know and be able to do in their discipline 5 to 10 years after graduation. The math teachers will most likely produce a list very similar to the Mathematics Practices listed below. The science teachers will differ somewhat, but much of what they write will be connected to the NGSS practices. Teachers from other disciplines will generate lists that will be easily connected to the potential of this engineering design process. Lead a short discussion (no more than 10 minutes) connecting their lists to the explanation given as to why engineering design is important. In this case, and throughout this workshop, ask the teachers to tell you information, do not tell them. Ask how the math and science practices compare to their lists of what is important. Do not tell them why it is important. Let them tell you.

The ***Common Core State Standards for Mathematics*** call for "an understanding of mathematics." One way this is achieved is through the full integration of Mathematics Practices throughout the curriculum. These practices consist of:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

The ***Next Generation Science Standards*** (NGSS) include Science and Engineering Practices as an integral part of a comprehensive science educational program. These practices include:

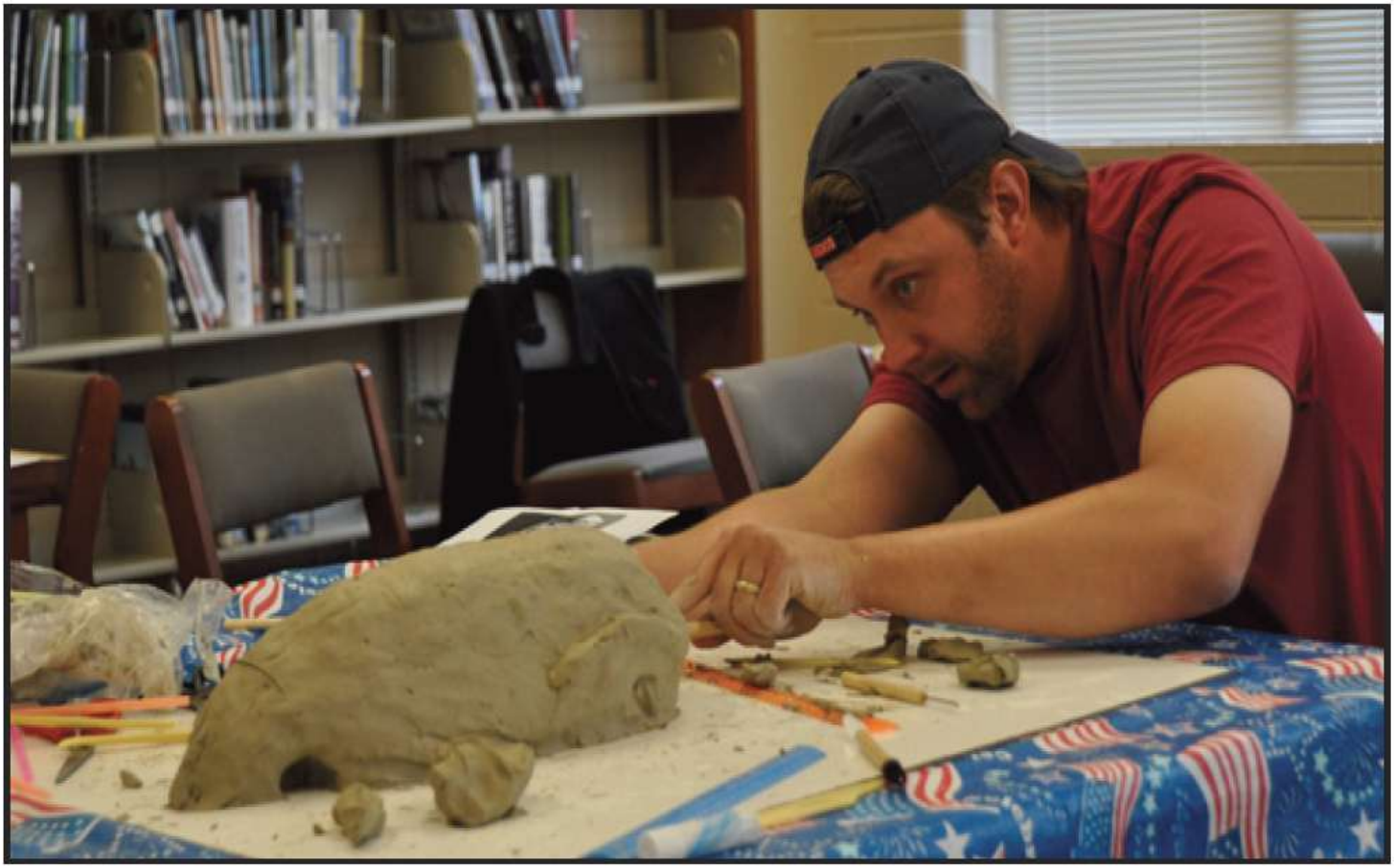
1. Asking questions and defining problems
2. Planning and carrying out investigations
3. Analyzing and interpreting data
4. Constructing explanations and designing solutions
5. Obtaining, evaluating, and communicating information
6. Developing and using models
7. Engaging in argument from evidence
8. Using mathematical and computational thinking

Educational standards for Technology and Engineering disciplines are not so clearly defined or as widely adopted as those for mathematics and science. The ***Standards for Technological Literacy*** include engineering design and the application of the design process. They also call for an understanding of "the relationships and connections between technology (engineering) and other fields of study."

It is clear that a well-designed and well executed activity in engineering design can address important concepts in all STEM disciplines. It is also possible to utilize the design activity to address content in other disciplines, particularly art and social studies. English and Language Arts concepts and skills can also be addressed.

Introduction

Throughout this professional development experience, you will be learning the value of utilizing engineering design challenges as an integral component of instruction. Initially you may be thinking of design challenges as "just another fun activity that we do not have time to do." Instead, please consider how the design challenge provides a framework for teaching important content and the motivation for learning it.



Divide the participants into teams of 3-4 teachers each. Each team should have a designated area to work. Make sure that each team member has a copy of the manual and that each team has an Engineering Journal. Tell them that eventually they will need to name their vehicle, but that is not the first task. Show them where the materials are stored and instruct them to get started. DO NOT READ THE INSTRUCTIONS TO THEM OR TRY TO EXPLAIN THE PROCESS UP FRONT. They will figure it out as they go.

Problem/Task

Your team will design an electric vehicle to be used on land. Do not design a boat or airplane. All decisions must be recorded and supported by mathematics (as much as possible and practical).

Define the Design

The engineering design process is not nearly as linear and sequential as diagrams and maps seem to indicate. It does, however, start with the definition of the problem.

1. Make some decisions of what type of vehicle you want to design. These are the Requirements of the design.

- What is the purpose of the vehicle?
  - Around town for errands. Haul groceries, children, etc.
  - Commute in town
  - Commute between towns
  - Long distance travel
- How many people will the vehicle carry?
- What cargo capacity will be necessary?
- Does it need to be suitable for all weather conditions?
- How does it compare to other electric vehicles?