Energy Engineering Design

Activity Overview

The engineering design process is an iterative series of steps to ideate, implement, test, and improve ideas and their physical manifestations. Professional engineers follow this process developing projects and products, but the steps are simple enough to be applied across a wide range of concepts and industries, even in high school. In fact, the engineering design process is an adaptation of the scientific method. Evaluate the diagram on the next page which demonstrates the difference between the traditional scientific method and the engineering design process, or engineering method.

The engineering design process does not have a universally accepted series of steps. Different groups and different individuals will take a slightly altered approach to the process. However, at the beginning there is a problem, and at the end the solution is communicated. This project is appropriate for individuals and for groups.

Time

This activity is appropriate for project-based learning. As defined by the Buck Institute for Education, project-based learning (PBL) invites students to "work on a project over an extended period of time—from a week up to a semester—that engages them in solving a real-world problem or answering a complex question. They demonstrate their knowledge and skills by developing a public product or presentation for a real audience." You could consider scheduling this activity at the beginning of a unit on energy, the environment, or engineering to challenge students to start thinking about different interdisciplinary issues. Alternatively, you could schedule this project as a "final examination" to assess students' grasp of the material and engagement with the interdisciplinary process. For a different approach, consider scheduling a semester- or year-long project, with routine iterations and presentations. Students' ideas and engineering designs will improve over the scheduled time as they learn more about the concepts and processes involved.

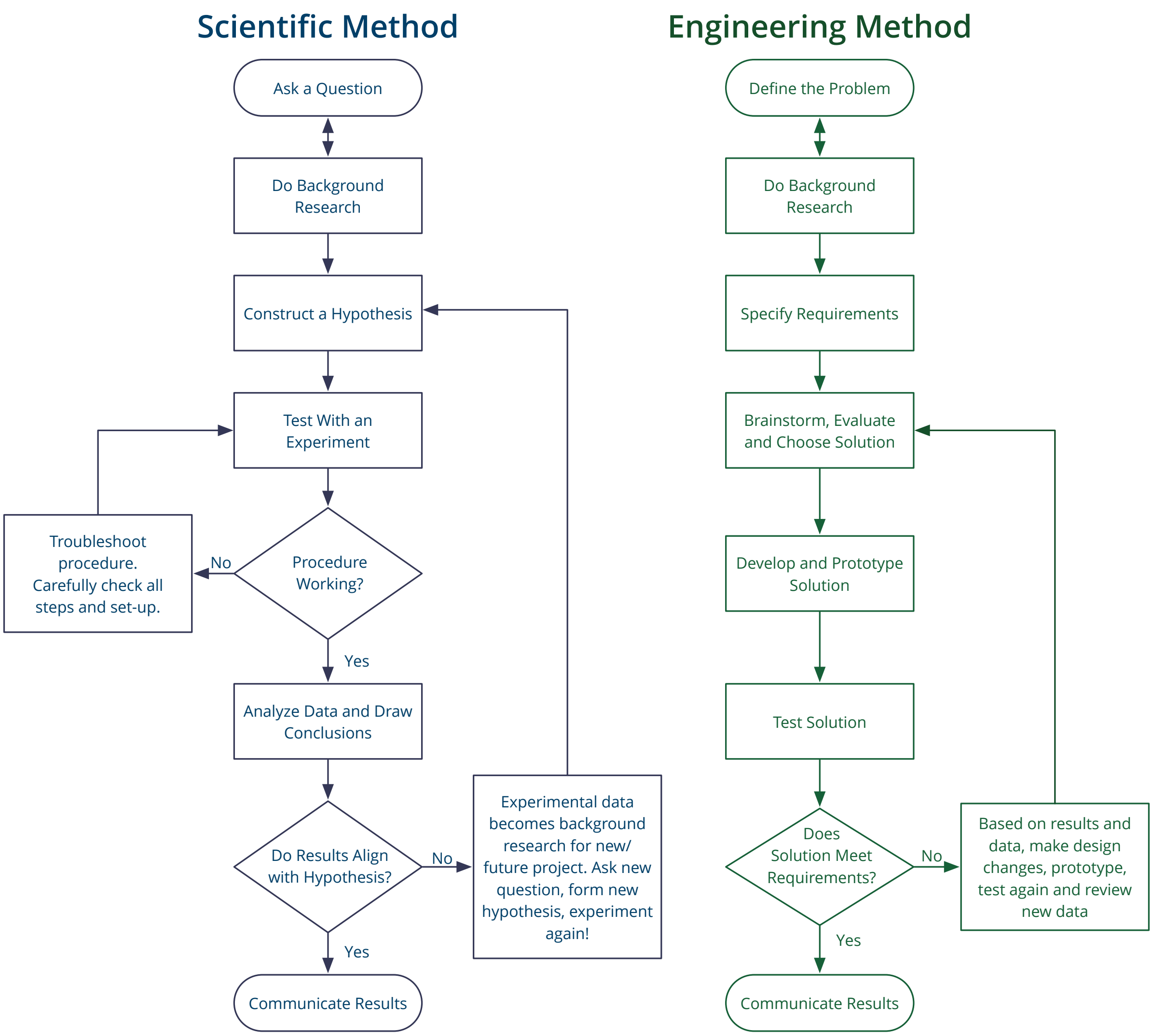
Resources:

The Energy chapter from *Resourcefulness* (*www.stem.guide/lesons/energy*) provides a comprehensive introduction to the different forms of energy and the laws of thermodynamics, which govern the conversions thereof.

The first law of thermodynamics, also known as the law of conservation of energy, states that matter and energy cannot be created or destroyed in a closed system. The second law of thermodynamics, also known as the law of entropy, states that entropy in a system always increases. Entropy in thermodynamic systems manifests in the loss of efficiency in energy conversions. Students project design parameters (and project outcomes) should take these laws of thermodynamics into consideration. The efficiency of many different energy conversions is well documented online, and students should use reputable online and other resources to determine the efficiency of their planned conversions.

Project Statement:

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.



Project Procedure:

Introduce the project statement to students along with an overview of the engineering design process. Explain that students will need to decide on a problem relating to the the project statement and a solution thereto. Students will also define the constraints as appropriate to their problem, and the testing procedures therefore. Finally, students will communicate their project to their peers for evaluation. Each stage of the process can be assessed independently, or the entire project can be assessed holistically.

Evaluation:

Evaluate students' projects according to the following criteria. Excellent project performance for each phase is defined below.

Define a Problem: Student fully understands the project statement and identifies a problem with a measurable solution related to energy conversions.

Do Background Research: Student identifies a succinct list of reputable sources that document the background and context of their identified problem and produces a well composed summary of the problem with few to zero errors in grammar, spelling, or citations.

Specify Requirements: Project specifications should be relevant to the problem and within realistic parameters depending on the context based on researched and documented real efficiencies.

Develop a Prototype: The prototype solution should convert one form of energy to another taking into consideration the project specifications, and all of the features and their relationship to the project requirements should be well documented.

Test the Solution: The prototype, real or theoretical, should be tested to see how it meets project requirements through repeatable, verifiable testing methodologies, which are well documented.

Refine the Solution: Students can proceed through as many iterations as appropriate and should be evaluated whether the changes and repeat tests are documented clearly and completely; it is not necessary for the solution to meet all of the project specifications, as long as this is documented and explained.

Communicate the Results: Students should compile the engineering equivalent of a laboratory notebook, which details the process completely (assessed through criteria listed above), as well as a final summary, which explains how well the final solution fits the functional requirements, where further improvements could be made by another team, and any other relevant project information, composed with few to zero errors in grammar, spelling, or citations.

Alternative: Energy Engineering Evaluation

If your instructional approach does not include creating new knowledge as per the project outlined above, this project may be adapted to evaluate existing knowledge by reconfiguring the project statement. This adaptation of the project may be applicable to some students in upper middle school.

Rather than presenting students with the project statement to "design, build, and refine" a new device, assign a well known energy conversion device to each student or groups of students. Examples include but are not limited to wind turbines, internal combustion engines, and electrical motors. Chapter 4 of Energy Technology and Policy provides many real examples from which to choose.

The adapted assessment criteria are as follows:

Do Background Research: Student identifies a succinct list of reputable sources that document the background, context, and history of their conversion device and produces a well composed summary of the device with few to zero errors in grammar, spelling, or citations.

Evaluate the Solution: Students should be able to extrapolate from their research what problem their device was intended to solve and the functional requirements thereof. Students should evaluate the device's function, efficiency, and other qualities against both historical and modern requirements.

Communicate the Results: Students should compile a short report or presentation to their peers, which details the background, context, and history of their conversion device and their own evaluation of it, composed with few to zero errors in grammar, spelling, or citations.

TEKS

IPC.3F, CHEM.3F, SCI.8.3D, PHYS.2D, IPC.5D, PHYS.6D, CHEM.11B, CHEM.11A, PHYS.6E, PHYS.6B

ELA.9.13A, ELA.10.13A, ELA.11.13A, ELA.12.13A, ELA.9.13B, ELA.10.13B, ELA.11.13B, ELA.12.13B, ELA.9.13C, ELA.10.13C, ELA.11.13C, ELA.12.13C, ELA.9.13D, ELA.10.13D, ELA.11.13D, ELA.12.13D, ELA.9.13E, ELA.10.13E, ELA.11.13E, ELA.12.13E, ELA.10.15A.vi, ELA.11.15A.vi, ELA.12.15A.vi, ELA.9.16A, ELA.10.16A, ELA.11.16A, ELA.12.16A, ELA.9.16B, ELA.10.16B, ELA.11.16B, ELA.12.16B, ELA.9.16C, ELA.10.16C, ELA.11.16D, ELA.12.16D, ELA.9.16D, ELA.10.16D, ELA.11.16C, ELA.12.16C, ELA.9.16E, ELA.10.16E, ELA.11.16E, ELA.12.16E, ELA.10.16F, ELA.11.16F, ELA.12.16F, ELA.12.16G

NGSS

HS-PS3-3, PS3.A, PS3.D, ETS1.A, WHST.9-12.7, MP.2, MP.4, HSN.Q.A.1, HSN.Q.A.2, HSN.Q.A.3