HANDS-ON ACTIVITY

Design Step 2: Research the Problem

Quick Look

Grade Level: 9 (9-12)
Time Required: 1 hour
The time required to complete this design process step is adjustable to as little or as long as the teacher deems appropriate. We suggest a minimum of 60 minutes and a maximum of three class periods.
Expendable Cost/Group: US $0.00
Group Size: 4
Activity Dependency:
Design Step 1: Identify the Need
Subject Areas: Science and Technology
NGSS Performance Expectations:

HS-ETS1-2

Summary

Through Internet research, patent research, standards and codes research, user interviews (if possible) and other techniques (idea web, reverse engineering), students further develop the context for their design challenge. In subsequent activities, the design teams use this body of knowledge about the problem to generate product design ideas. (Note: Conduct this activity in the context of a design project that students are working on, which could be a challenge determined by the teacher, brainstormed with the class, or the example project challenge provided [to design a prosthetic arm that can perform a mechanical function]. This activity is Step 2 in a series of seven steps that guide students through the engineering design process.)
This engineering curriculum aligns to Next Generation Science Standards (NGSS).

Background research is an important step of the engineering design process.

Engineering Connection

Developing a thorough knowledge base of existing products related to a need or problem is important for all engineering design projects. This step helps the engineering team determine if a similar product already exists or whether any regulatory and standards issues (such as intellectual property, safety or environmental issues) must be considered in the product design. Engineers often design modifications or incremental improvements to existing products, so one way to learn more about a product is to purchase and take apart similar, competing products.

Learning Objectives

After this activity, students should be able to:

- Gather and organize background information related to a design challenge.
- Conduct an information search to find existing solutions or products related to a problem.

Educational Standards

- NGSS: Next Generation Science Standards - Science
- International Technology and Engineering Educators Association - Technology

Materials List

Each group needs:

- Design Challenge Project Description (created in Activity 1), or use the attached Example Design Challenge Project Description
- blank paper and pencils
- Idea Web Example
- 2 worksheets of the following four, for each team's selected two types of background research: Patent Search Worksheet, Standards and Codes Search Worksheet, Reverse

Engineering Worksheet and User Interview Worksheet

For the entire class to share:

- computers with internet access
- (optional) small video or audio recorders for user interviews

Worksheets and Attachments

Example Design Challenge Project Description (docx)
Example Design Challenge Project Description (pdf)
Idea Web Example (docx)
Idea Web Example (pdf)
Patent Search Worksheet (docx)
Patent Search Worksheet (pdf)
Standards and Codes Search Worksheet (docx)
Standards and Codes Search Worksheet (pdf)
Reverse Engineering Worksheet (docx)
Reverse Engineering Worksheet (pdf)
User Interview Worksheet (docx)
User Interview Worksheet (pdf)

Visit [www.teachengineering.org/activities/view/cub_creative_activity2] to print or download.

Introduction/Motivation

Today we are continuing to work on our engineering design project for this class. Similar to real-world engineers, we must develop a thorough knowledge base of the information related to our design to determine if a similar product already exists or if any regulatory and standards issues (such as intellectual property issues, safety or environmental issues) exist that must be considered in the design of the product. We do this by conducting a variety of information searches and compiling all the information in a useful way. Can anyone think of a way to get useful information about our project?

Sometimes it is hard to know what information we need to find before we have a product design. One way to identify what information we should be looking for is to break down our problem statement or "need" into an idea web. An idea web starts with the main need or problem in the middle of a piece of paper. Then the team draws branches from the main problem to represent different parts of the problem, such as audience, requirements, constraints, and questions. Each engineer on the team may choose to or be assigned to focus on addressing one particular part of the problem or the team may work together to establish the knowledge base. Often, new questions arise, requiring the team to do additional background research in order to answer them

A patent search is another way to find existing information about a related product. This type of search is often done by engineers in the beginning stages of product design and is really helpful for avoiding designs that infringe on an idea that has legal protection. Many websites offer information on existing patents, including the US patent and Trademark Office (https://www.uspto.gov/) and Google patent search (https://www.google.com/?tbm=pts).

Standards and codes developed by industry or federal, state or local governments are also important to know for product design. Standards are any agreed-upon common criteria, item or process that helps to ensure the safety and interchangeability of a product. For example, having standard bolt sizes helps designers communicate to manufacturers located elsewhere exactly which bolt to use in making a product. A code is a collection of standards that are mandatory for use in the development of a particular item. For example, building codes specify the height and area limitations for certain types of buildings in a city. Can anyone think of why we would need to know the standards and codes related to our product design? Some other examples might include the chemical properties of the materials used in a product or process, the environmental impacts of the product, and the safety of the user interfaces.

Reverse engineering an existing product is another way to learn about technologies that relate to the design of a new product. When possible, engineers test competitor's products to determine how to make their new design even better. They take products apart to figure out how they work, and then they often reassemble them to see how the parts interact. Reverse engineering requires careful observation, disassembly, documentation, analysis and reporting.

Lastly, user interviews can give us valuable insight into a product design. We have already identified our target population, and, when possible, interviewing members of that population about our product can be extremely helpful. Since the customer ultimately determines whether a product is a success or failure, it is important to communicate often with the user during the design process. It is useful to use props during the interviews to watch how a user interacts with a product. Sometimes how the user uses the product is more telling than what they say about it. Gathering initial data from the user helps the engineering team identify which aspects of the problem are the most important to address for its audience.

Back to our engineering project—today we will focus on conducting as much background research as possible on our problem in order to generate a common knowledge base for our team as we begin to brainstorm possible engineering solutions.

(Note: After conclusion of this activity, proceed to the next activity in the series, Design Step 3: Brainstorm Possible Solutions.)

Procedure

Before the Activity (Teacher Prep)

- Base this activity off of an existing project with a Design Challenge Project Description (See the first activity of this unit, Design Step 1: Identify the Need). This can be a challenge

determined by the teacher, brainstormed with the class, or the Example Design Challenge Project Description attached to this activity.
- Make copies of the attached Idea Web Example, one per team.
- Make copies of the Patent Search Worksheet, Standards and Codes Search Worksheet, Reverse Engineering Worksheet, and User Interview Worksheet. Teams are asked to complete *at least two* of these four knowledge-base handouts.
- Student teams should continue with the same 3-5 members each, as determined in the first activity of this unit, Design Step 1: Identify the Need.

With the Students

1. Review the steps of the engineering design loop as described in the pre-activity assessment. Discuss any questions as a class.
2. Review the Design Challenge Project Description as a class.
3. Use the Investigating Questions to lead a class discussion about the role of background research in engineering problem solving.
4. Give each team a blank sheet of paper. Review an example idea web with the students to illustrate how to start thinking about what background research they need to conduct. Have student teams each create an idea web of the design challenge.
5. Have students choose at least two of the following methods for developing their knowledge base: patent research, standards and codes research, reverse engineering, and user interview. Have student teams complete their worksheets in sub-group pairs. Provide assistance as questions arise. Conduct the activity-embedded assessment (as described in the Assessment section) to discuss students' responses to the worksheet.
6. Conduct the post-activity assessment to help students share their new knowledge base within their team and their class. This assessment asks them to create a list of the main points that they discovered and plan to use to inform their design. Then, the students reflect on the research process and ask if any questions are still unanswered.

Vocabulary/Definitions

code: A set of mandatory minimum standards or rules. For example, a building code, a safety code, a fire code, the UL code, etc.

engineering design loop: A specific and iterative set of steps that engineers use to evaluate and refine potential solutions to problems or challenges. The steps: The steps: ask to identify the need and constraints, research the problem, imagine possible solutions, plan by selecting the most promising solution, create a prototype, test and evaluate the prototype, and improve and redesign as needed. Also called the engineering design process.

patent: An official document given by a state or government that allows exclusive right or privilege to an inventor for a specified period of time.

standard: Something set up and established as a rule for the measure of quantity, weight, extent, value, or quality. For example, standardized bolt sizes. See http://standards.gov/standards_gov/standards.cfm.

target population: The population, clients, or subjects intended to be identified and served by a particular program.

Assessment

Pre-Activity Assessment

Engineering Design Loop Review: The engineering design loop is a specific set of steps engineers use to organize their ideas and refine potential solutions to engineering challenges. Ask for student volunteers to identify and define each step of the design process. (Note: The steps of the design loop include ask to identify the need and constraints, **research the problem**, imagine possible solutions, plan by selecting the most promising solution, create a prototype, test and evaluate the prototype, and improve and redesign as needed.)

Activity-Embedded Assessment

Worksheets: Using the attached four worksheets, have each team complete two of the following methods for developing their knowledge base: patent research, standards and codes research, reverse engineering, and user interview. Review and discuss the worksheet answers with the entire class. Use the answers to gauge students' mastery of the subject.

Post-Activity Assessment

A Common Knowledge: Have students work with their team to develop common, shared background knowledge related to their design problem. Have each team develop a priority list of the main points they plan to consider as they begin to generate ideas for their product design. Lastly, ask each team to share two or three of their research findings with the entire class.

Reflecting on the Process: Have the teams work together to reflect on the background research that they conducted. Have the teams consider:

- Have we researched the most important information related to our project?
- What do we know now that we did not know before?
- Do we have any unanswered questions that surfaced as a result of our research?
- Do we need to do any follow-up research to answer those questions?

Investigating Questions

Use the following discussion questions to help students gain understanding of an important aspect of engineering problem solving: **background research**.

- **Why do engineers conduct background research before they design a new product?** (Possible discussion points: To find out if similar products already exist, to discover any regulatory and standards issues, such as intellectual property issues, safety or environmental issues, that are pertinent to the new product design.)
- Many types of background research can be conducted. **What are some examples of background research?** (Possible discussion points: Basic search for existing similar products, talking to the target audience(s), patent searches, codes and standards searches.)

Activity Extensions

Patent Searches: Give students one of the following products (or generate your own list) and have them complete a sample patent search. Require students to make a list of patents they find that ar e associated to the product. This extension activity demonstrates the wide variety of patents that re late to a single "common" product. Possible items: shower head, headphones, skateboard, backpac k.

"Standard" Communication: Have students explain in their own words why common standards exis t for the measure of quantity, weight, extent, value, or quality of an item. Have them research a real situation or describe a fictional scenario in which standards are not used. Ask students to share thei r explanations with the class.

Additional Multimedia Support

Direct students to look for patents on the US Patent and Trademark Office's website; see: https://www.uspto.gov/patents-application-process/search-patents

For a complete description of the engineering design process, see https://www.teachengineering.org/engrdesignprocess.php

References

- Yowell, J.L. and Carlson, D.W., Eds., Introductory Engineering Design: A Projects-Based Approac h, Third Edition, Textbook for GEEN 1400: First-Year Engineering Projects, Integrated Program, C ollege of Engineering and Applied Science, University of Colorado at Boulder, Fall 2000. http://itl l.colorado.edu/index.php/courses_workshops/geen_1400/resources/textbook/ Accessed April 8, 2 010.

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