Tips for Leading Service-Based Engineering Projects

Summary

Service-learning fosters both civic responsibility and scholastic abilities through the integration of academic instruction and community-based service. Service-based engineering design projects involve finding clients in the community with specific community-based needs and designing projects to fulfill those needs. By engineering for a specific community need, students can gain a greater understanding that engineering is directly linked to helping people. Service-based projects positively impact students' academic performance, leadership skills, and understanding of the social context of their work.

Engineering Connection

Engineering is essential to our health, happiness and safety. By designing a project that has direct community involvement, students learn valuable engineering skills and gain a sense of pride for contributing something beneficial to their community or for a specific person. The engineering project can be as complex or as simple as desired, as long as it is geared towards fulfilling a specific need for a person or community.

Pre-Requisite Knowledge

This project is an application of the complete engineering design process, so it is best if the students have gone through the process before. It is recommended that students experience this through a brief design activity before starting the full project. See TeachEngineering's Creative Engineering Design unit for guidance on conducting design projects with high school students.

Learning Objectives

After this activity, students should be able to:

- Explain that engineers design, create and build things for the benefit of society.
- Explain in their own words the steps in the engineering design process.

Time Required Variable. These projects tend to take a significant amount of time and are best conducted during the course of a semester or at least several weeks. Projects often take 20% longer than anticipated due to inevitable setbacks and redesigns.

Group Size 4

Expendable Cost per Group Variable. Depends on nature of the project.

Materials List

Materials vary depending on the project. Unlike traditional engineering projects, which may have a clearly defined set of materials, each service-based project can require a unique set of materials. One approach is to set up a list of available building materials for the prototype *in advance*, from which student teams may select (such as wood, foam core, dowels, PVC pipe, tape, glue, screws and wire). Another approach is to have students create a materials list during the project design phase, which can be purchased. If you do the latter, plan to make multiple supply trips throughout the course of the project.

Introduction / Motivation

Can anyone explain what an engineer does? (Designs machines, roads, bridges and buildings, vehicles, medical devices, digital games, satellites, all kinds of products, etc.) Who do you think designs the devices that keep our water clean, help people live more comfortably, and keep playgrounds safe for children? Those are engineers too! A big part of being an engineer is designing devices for the benefit of society. Engineers do a lot more than work on bridges and cars. Without their work, many of a community's needs would not be met. Can you think of some ways that the work of engineers directly benefits people? (Sanitation, shelter, etc.) During this project, we're going to engineer something to

benefit our community (or a specific individual). By doing this, we're going to make the community a better place (or make the individual's life better).

Procedure

Before the Activity

- Find a community client. Clients can be found from a variety of sources such as special needs students at your school or nearby schools, centers for disabled adults, community centers, and volunteer organizations. The ideal client:
  - Is a part of the local community
  - Proposes a project that may be completed in the given time frame and within a reasonable budget
  - Proposes a need that, if filled, improves his/her overall quality of life
  - Provides a clear set of requirements for the project
  - Is willing to interact with the students before, during and after the project
- Meet with the client to discuss project expectations.

With the Students

1. **Introduction and brainstorming** – Introduce the project to the class. Describe the client and give a general idea of what s/he would like the project to accomplish. Have the class brainstorm a list of questions to ask the client when they meet. These could include inquiries to get an understanding of basic requirements (differentiated from bonus features), constraints, how the product will be used, etc.
2. **Background research** – Give students some time to research the problem at the library or computer center. Direct students to look for information on the local environment, medical condition (if applicable), and any related technologies that already exist in the market or through patent searches.
3. **Meet with the client as a class** – Set up a meeting between the class and the client. Have the client explain his/her problem and have students ask the questions they previously brainstormed. If possible, hold a mini-brainstorming session while the client is still present to make sure students are moving down the correct path of design. If the client is unable to meet with the class, videotape a short segment in which the client introduces him/herself and presents the problem. The goal is to give a human element to the project so students fully realize that they are designing for a specific person.
4. **Define the problem** – As a class, discuss the parameters of the problem. Decide what elements of a solution are critical and which are extraneous.
5. **Divide into groups and brainstorm solutions** – Give each group the task of brainstorming ideas for the entire project. Give each group a sheet of butcher paper and encourage students to write down all their ideas. Encourage wild ideas as well as building upon each others' ideas.
6. **Present solutions to class** – Have groups present their favorite solutions to the class; require them to explain why they chose the idea and why they think it will work. Ask each group about some potential difficulties in their idea. Have other groups provide feedback to the presenting group during discussion or by using small slips of paper or sticky notes.
7. **Decide on a final design** –After groups are done presenting their ideas, have them use the feedback to refine their designs. Remind students that the designs they commit to may not be the perfect product, but are the one design that their team is pursuing the feasibility of creating.
8. **Detailed design and materials list** – Have group create detailed plans of their final designs. This can include to-scale posters or drawings and/or small-scale models using simple materials, such as Popsicle sticks and cardboard. It is helpful to have these detailed design plans presented to the teacher or a panel in the form of a brief design-review. If possible, have the client return to provide input at this stage. Set a deadline for drafting initial materials lists; go over the lists with groups to make sure that the buyer understands exactly what they need.
9. **Building** – The length of time needed for constructing the project varies depending on the project complexity. Expect that the project will take about 20% longer than initially planned.

10. **Progress review** – Have each group give progress reports at pre-determined time intervals. This can be done at the end of every class, at the end of every week, or at the teacher's discretion depending on the timescale of the project. Progress reports ensure that groups stay on task during the work period.
11. **Mid-project client meeting** – If possible, have the client come in and observe a day of building. Have students explain their designs to the client and show them current progress. Also have the students explain problems they encountered previously and the work that remains to be done.
12. **Redesign** – During the building process, obstacles will arise and groups will be forced to redesign parts of their projects. As a teacher, be flexible when it comes to redesign; be prepared to make multiple trips to the store for additional supplies.
13. **Client presentation** – When the project is finished, have the students present the finished product to the client. Have them describe the initial designs and how they expected them to work. Then have them present the final design and explain how and why it differed from the original. Finally, have the students explain what else they would change given more time and/or funds/materials.
14. **Reflection** – An important part of service-learning is the process of reflection. This step allows the students to examine the design project experience and how it relates to the course objectives, implications of the project on societal and community issues, the role of engineering in societal issues, and how the experience impacted their own values and impressions of engineering. This step is also referred to as *metacognition*. Engage students in reflection through oral presentations, journal entries, small class discussions, or guided questions (see the Assessment ideas section [below] and the associated Example Reflection Questions handout).

If creating one project for the whole class, include the following steps:

15. After presenting possible ideas to the class, **decide on one final design as a class and divide the project into sub projects.** To do this, after each group is done presenting its ideas, lead a class discussion to evaluate which ideas are the most feasible to combine and build**.** As a class, decide how to divide the project, making sure that the work is evenly distributed. Assign groups to each sub-project to make sure that everyone has something to work on, since the entire class cannot work on the same part of the project at the same time. To create teams, one option is to have each student write down his/her top three choices for which sub-projects s/he would like to work on; then assign groups based on these preferences (as much as is possible).
16. **Compatibility checks** – As each sub-project starts to take shape, have the groups collaborate to make sure all elements fit together. Make this an ongoing process throughout the building phase.
17. **Final assembly** – When all of the sub-projects are completed, assemble the entire project. This can be an ongoing process, as certain elements will be finished before others. During final assembly, last-minute changes can be made to ensure that all the parts are compatible with each other.

Safety Issues

- Power tools may be needed to complete this project. Make sure students know how to use the tools safely, and supervise them while they use the tools.

Troubleshooting Tips

Often, the final product ends up being more of a prototype than a fully-functional working product. It is important that clients understand that this is a distinct possibility.

If allowing students to determine materials, be prepared to make multiple trips to the supply store for additional materials as designs evolve and change during the building phase.

Assessment Ideas

Pre/Post Quiz: Prepare a short concept inventory quiz with topics pertinent to the class's service-based engineering project. Before beginning the project, have students complete the quiz. At completion of the project, have students take the same quiz, comparing their results to their pre-project scores to gauge their knowledge gains.

Engineers Help the World by...: Have each student write "Engineers help the world by…" at the top of a sheet of paper, and then list some things that engineers design and build for the benefit of society. Call on students to share some of their ideas with the class. Talk about how engineers design things for the benefit of society and create things that directly help people live better lives.

Design Review: At regular intervals, have each group give the class a progress report. Have them explain what they had accomplished since the last report and what they plan to accomplish during the next time period. Give the class a chance to comment on and critique what was presented.

Project Reflection: Have the students answer the following questions in an oral presentation, small group discussion, or a journal entry:

1. What did you design and build, and why?
2. What was your role in the group? What were the other roles in the group?
3. What would you change about your design if you had more time and materials?
4. What aspects of engineering did you learn about during this service-learning project?
5. What have you learned from the person/people in the community that you were serving?
6. What have you learned about your own views and abilities during this project?
7. Should engineers be active in their communities? Why or why not?