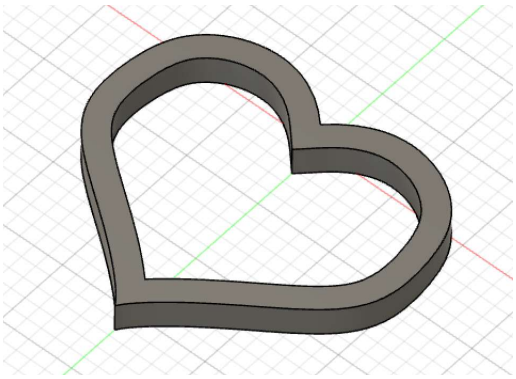
“Projects with a Purpose” Unit Plan



A Philanthropy-Inspired Engineering Design Project

Summary

Philanthropy can be defined as the practice of giving time, talents, and treasure (the 3T’s) to help make life better for other people. In this project, students use the concept of philanthropy as an inspirational springboard to create their own designed solution that solves a problem for someone or satisfies a human need. Students are provided **time** to define, develop, and work on their “project with a purpose”. Their **talents** include their knowledge of engineering tools and techniques, their problem-solving abilities, and their creativity and imagination. Their “**treasure**” is their makerspace-style engineering lab resources. Students follow the **engineering design process** as they identify needs, generate ideas, select potential solutions, design and create their solutions, test their solutions, and improve their solutions.

Learning Objectives

Student will be able to follow the engineering design process as they apply their knowledge and creativity to define and solve an open-ended problem.

1. Identify a problem to be solved, the criteria for success, and any constraints on the solution. Describe how the problem and its solution are connected to the idea of philanthropy.
2. Research what has been done to solve similar problems in the past.
3. Brainstorm to generate ideas for possible solutions.
4. Select a feasible solution. Adjust the project scale to satisfy constraints of time, technology, and materials.
5. Design the solution using computer-aided design tools.
6. Fabricate the design using available resources (such as a 3D printer and/or laser cutter)
7. Examine and test the resulting product to see if it meets the criteria for success.
8. Iterate and redesign to address issues and/or make improvements.
9. Communicate the design process and end results orally and/or in writing.
10. Reflect on the project experience to identify what went well, what could be improved, and what was learned throughout the process.

Educational Standards

NGSS Science and Engineering Practices (ngss.nsta.org)

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)
- Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)
- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

Equipment and Materials List

Equipment:

- 3D-Printers
- Laser Cutter or CNC Machine (optional)
- Digital Calipers (for making measurements)
- Hand tools for cleaning up 3D prints (small needlenose pliers, assorted files, flush cutters)

Computer Software:

- Fusion 360 Computer-Aided Design Software (or other software such as Tinkercad, SolidWorks, etc.)
- Slicer Program for 3D Printer
- Control Software for other optional equipment

Materials:

- 3D Printer Filament
- Blank cuttable/engravable materials for laser cutter or CNC

Documents and Attachments

- Engineering Notebook Template (Electronic – Google Slides or PowerPoint)
- Client Feedback Form (Word Doc – Print one for each student)
- Assessment Rubric (Word Doc)

Prerequisite Knowledge

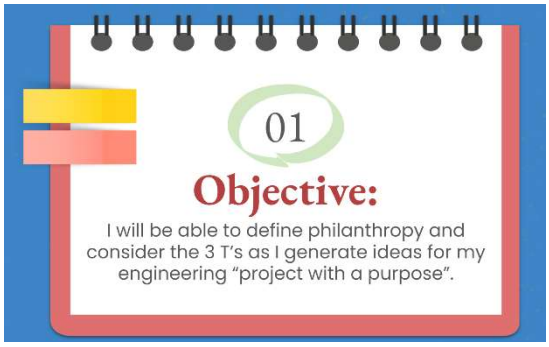
Prior to the start of this project, students should be able to create designs using computer-aided design software such as Fusion 360. They should be able to create 3D prints and/or laser-cut designs using their available maker equipment.

Procedure

Note: The specified pacing for this unit (Day 1, Day 2, …) assumes 45-minute class periods. Pacing may vary substantially depending on the grade level of the students and the previous design and fabrication experience of the students. The engineering notebook template is provided so that students can follow the engineering design process at their own pace. It guides students through the steps of the engineering design process and encourages them to document their progress as they go. A paper notebook could be kept, but an electronic notebook has several advantages. It is easy to paste images from design software into an electronic notebook using the “snipping tool” or other screen capture software. The teacher can easily monitor progress throughout the project while students are working. Also, the electronic notebook is much less likely to be misplaced or lost.

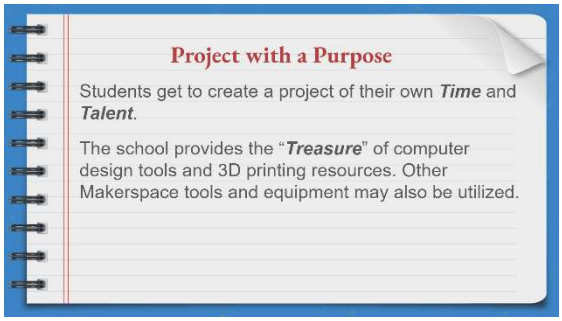
Day 1: Introduction to Philanthropy

1. Discuss the question, "What do you think *philanthropy* is?" with students. Ask students if they have heard the word before. Students may have heard the word and they may have heard of some famous philanthropists.



2. Show students the definition of philanthropy and introduce them to the idea of the 3T's (time, talent, treasure).

3. Explain that students will get to create a project of their own time and talent to help someone else. The school is providing the "Treasure" of computer design tools and makerspace resources.

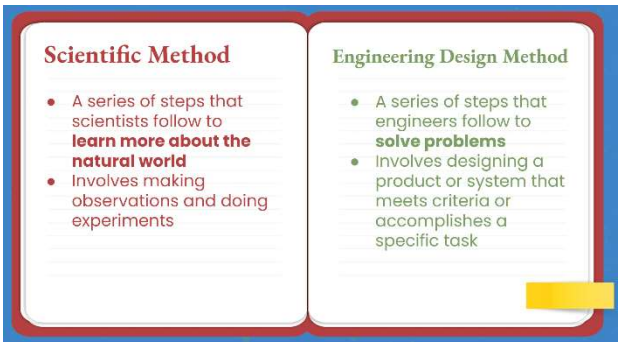


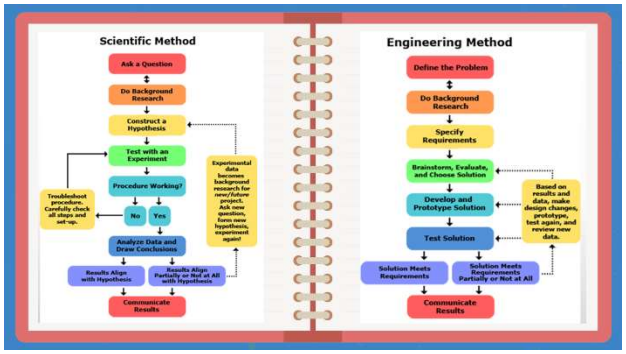
4. *Optional:* Ask students to select an inspiring philanthropy-related quote and use computer-aided design software to 3D-print or laser-cut that quote. This simple activity can help students get into a "philanthropy mindset" while also practicing the use of the available design and fabrication tools. It is also a great way to use up scrap material! The example quote at the right is laser-cut into a small piece of acrylic. Quotes could be researched online by students or selected from a list that you provide. Quotes taken from literature studied by your students in your school's curriculum can provide cross-curricular connections. There are many relevant quotes related to philanthropy in the OtterCares "High School Microlearnings" document (https://myprojectheart.org/images/default/PHHS_Microlearning.pdf).

5. *Optional:* At this time, you could consider using additional resources from OtterCares Project Heart https://myprojectheart.org/ to explore philanthropy in a bit more depth before launching into the engineering design portion of the project.

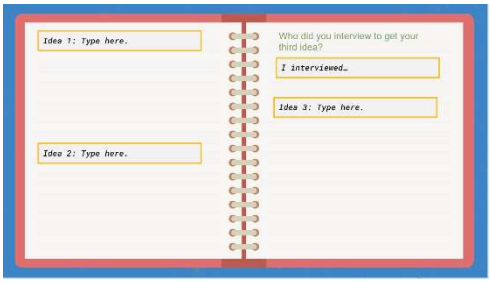
Day 2: Introduction to the Engineering Design Process

1. Provide a digital copy of the Google Slides Engineering Notebook for each student. Distribution can be done on Google Classroom (using the "Make a copy for each student" feature or the notebook can be distributed using another method.)
2. If students are not already familiar with the engineering design process, explain that the engineering design process is a series of steps that engineers follow to solve problems. It may be helpful to compare the engineering design process to the familiar scientific design method.





3. The first step in the engineering design process is to "Define the Problem" or "Identify the Need". Students should use a brainstorming process to identify problems that could be solved or needs that could be met with the technologies and resources that they have at their disposal. Ask students to think independently and come up with ideas in their electronic engineering notebook. Students should then share their ideas with their classmates. Capture all of the ideas (on the board, on sticky notes, or electronically using a Google form) so that students can see their ideas as well as the ideas of their classmates. The goal at this stage is to generate many ideas so that students have many options for problems that could be solved.



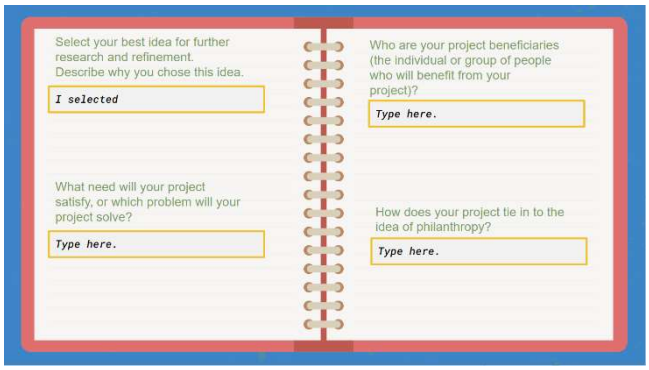
4. For homework, students should conduct an interview with an adult in their community, such as a parent, relative, teacher, coach, or other community member. Students should ask the adult being interviewed to provide one or more ideas of a problem that could be solved that relates to philanthropy and giving.

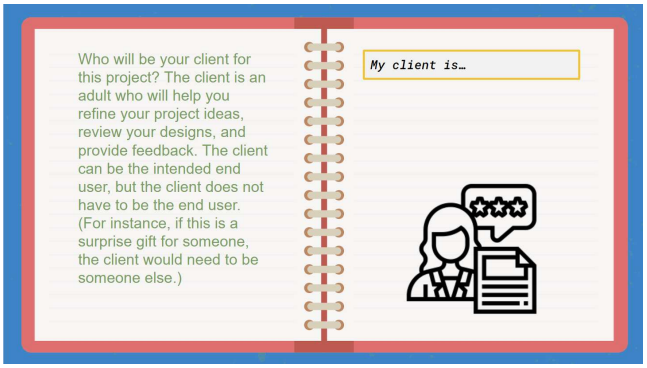
Day 3: Asking Questions and Selecting a Problem to be Solved

1. Ask students to share the project ideas that they have generated from their interviews with adults.
2. Ask students how they might go about deciding which problem to select for their project. Some important questions to be considered are:

a. What are the constraints on the problem solution (including material limits and maximum size of the object which can be created)?
b. What is the difficulty of the proposed project solution? Is the project too difficult or too easy for the time available?
c. Which project solution potentially has the most impact and provides the most "good" for the available time, talent, and treasure?
d. Will the project be an individual project or a group project? If it is a group project, can the project tasks can be divided into parts such that everyone has a role and everyone has a component of the final solution to design, develop, and test? [The teacher can specify that projects must be individual or group. If projects may be completed by groups, careful attention must be given to the partitioning of the group projects to identify roles and accountability for group members.]
e. Who will be the client for the project? All students are required to select an adult to be the client. The primary role of the client is to provide feedback at various stages of the project, including design, test, and redesign.

3. *Optional:* At this point, some students may be very sure of the problem that they would like to solve for their project. Other students may be undecided or feel overwhelmed by the various options. This may be a good time to introduce the concept of a **decision matrix**. A decision matrix is a tool used by people in business and engineering to evaluate options with clarity and objectivity. Criteria for making the decision (such as difficulty of solving the problem, interest level of the designer, and impact on the end user) are given numerical weights and each project option gets a score. Sometimes a decision matrix is overkill and a decision is clear without a detailed analysis, but an analytical approach can be helpful when a decision is not immediately clear. It could be helpful to create a decision matrix together as an entire class to give students a feel for the analysis process. For more information, search online for "decision matrix".
4. Ask students to record their thoughts and make updates in the engineering notebook. Students should explain why they chose their idea, who will benefit, and how the idea ties in with philanthropy. Students should also identify the client who will provide feedback at various checkpoints during the project. Some students may be ready to proceed with their project while others may need a little more time to finalize their decision.



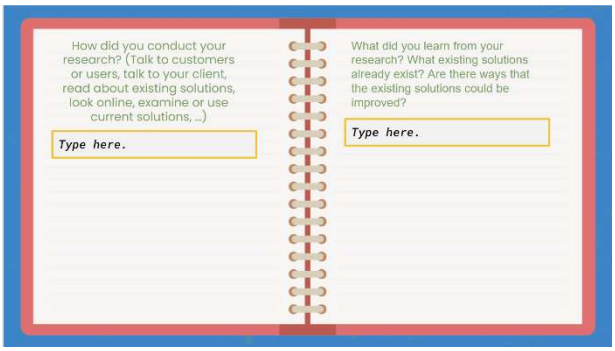


Day 4: Research, Specify Requirements, and Generate Ideas

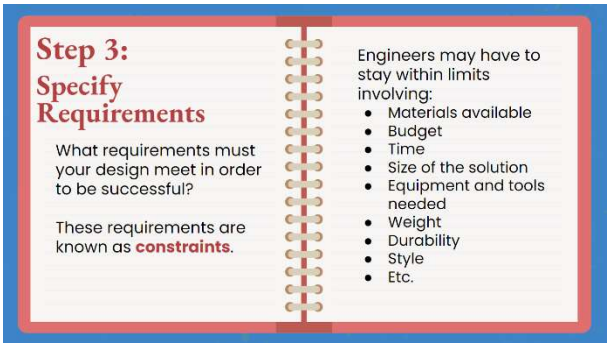
1. Students may be ready to jump in and create their first design to solve their problem. If the teacher does not insist that the students complete these steps and document the results, students are likely to skip them completely. It is helpful for the teacher to take the time to explain the purpose of each step so

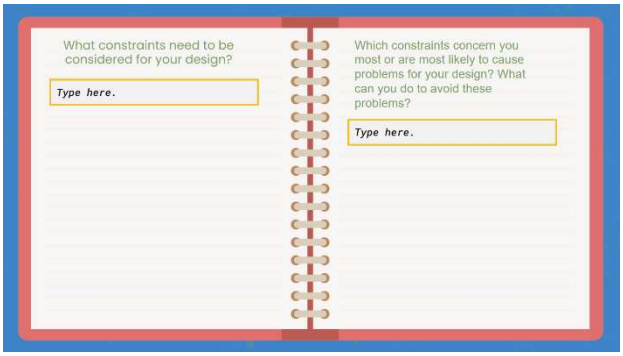
that students understand the “why”. In the end, these steps may save the designer time and aggravation and they may also help the designer create a better solution.

2. It is recommended that students research and examine existing designs first to learn what has already been done. The research gives students one or more base ideas on which they can make improvements, adaptations, and/or personalization for the intended end user. It is not necessary to reinvent the wheel! To do the research, students could talk to customers or users, talk to the client, read about existing solutions, look online, examine current solutions, or use current solutions.

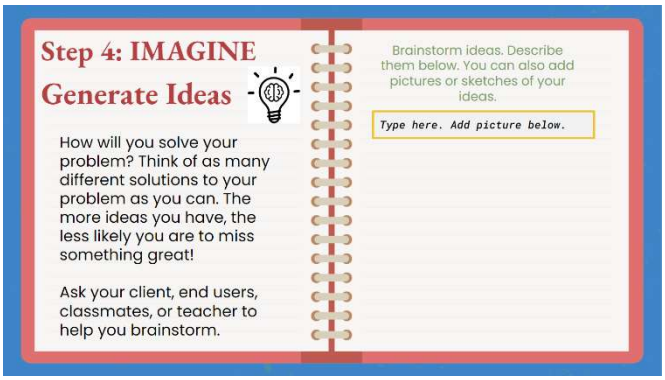


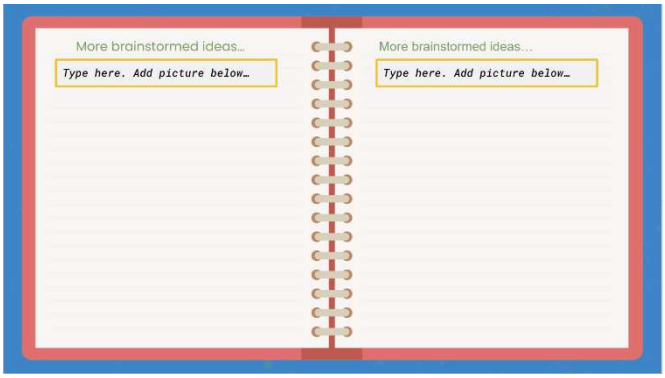
3. Before creating a design, it is important for the designer to understand the requirements for a successful design and record those requirements for future reference. Examples of constraints include materials available, budget, time available, maximum or minimum size of the solution, equipment and tools needed to create the solution, maximum or minimum weight of the solution, the required level of durability of the solution, etc. Some constraints will be specified by the teacher. For example, there may be a limit on the amount of the 3D printer filament which may be used or the amount of time that it takes to create the 3D print. Other constraints might be specified by the client. A client may require the solution to be a certain size. A common issue with 3D printing is that certain parts may need to fit correctly with other parts. Students should talk with their teacher and client to identify the relevant requirements and constraints. The requirements should be recorded in the engineering notebook.





4. Students may be tempted to quickly create the first design that comes to mind. However, it is likely that there is more than one way to solve the problem. A brainstorming process can be very helpful at this stage. Generating a list of different ways that the problem could be solved improves creativity and helps the designer consider various options. It is helpful to brainstorm ideas with classmates, teachers, and the client.

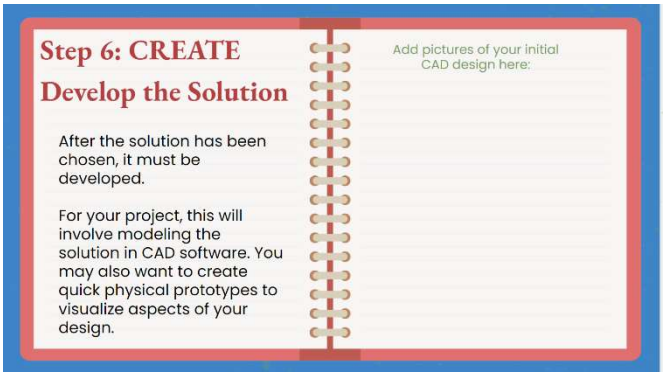




Days 5-7: Plan and Create

1. Students select their best solution idea from their brainstormed ideas. They should be able to explain why they selected the solution that they chose over other possible solutions.

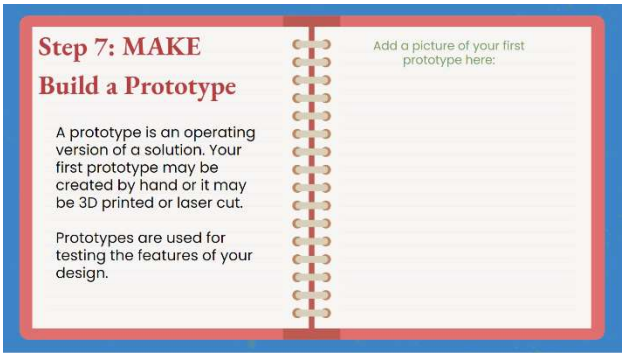
2. After the solution has been chosen, it must be developed. For this project, developing the solution will involve modeling the solution in computer-aided design software. For some complex projects, it may also be appropriate to create quick physical prototypes out of paper or cardboard to visualize aspects of the design.



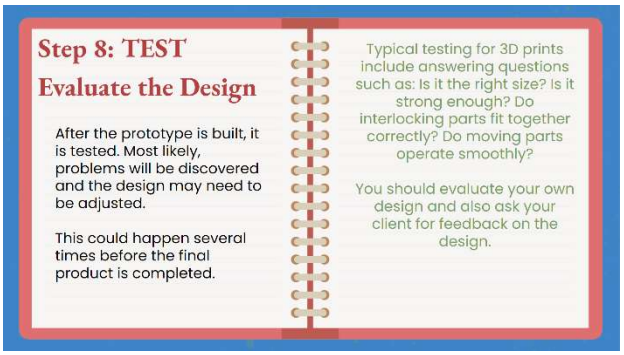
3. After the design is modeled in software, the student should ask the client to look at the design and provide feedback. This should be done before the design is fabricated on a 3D printer, laser cutter, or other equipment. Students should use the client feedback form and get a client signature before proceeding to the fabrication ("make") stage.

Days 8-9: Make and Test

1. It's time to make the first prototype! Students will use a 3D printer, a laser cutter, a CNC machine, or other available equipment to create their designs. Students should put a photo of the initial prototype into the engineering notebook.

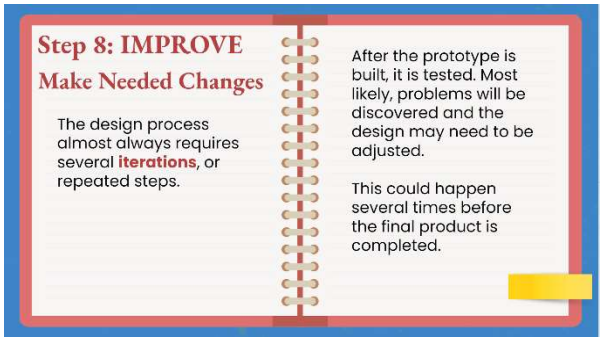


2. After the first prototype is built, it is tested and evaluated. Most likely, problems will be discovered and the design may need to be adjusted. This could happen several times before the final product is completed. Typical testing for 3D prints include answering questions such as: Is it the right size? Is it strong enough? Do interlocking parts fit together correctly? Do moving parts operate smoothly? Resolution issues are also common with both laser cutters and 3D printers. Students sometimes put very fine details into their designs which are too detailed for the equipment to reproduce. Adjustments to the design will need to be made if the design details are too small for the resolution of the equipment.

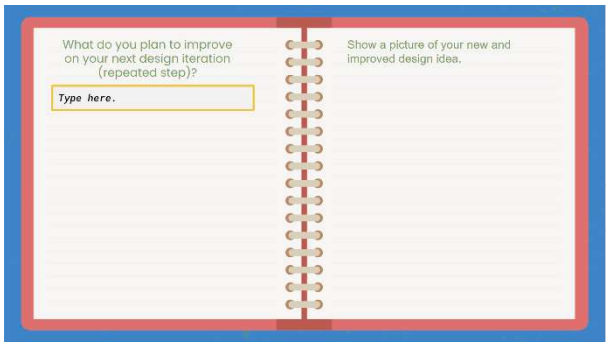


3. Students should also show the client the first prototype and ask the client for feedback. The client feedback should be documented on the client feedback form.

Days 10-13: Improve



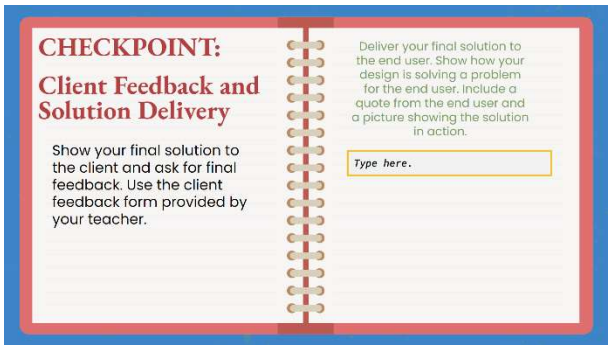
1. The design process almost always requires several iterations, or repeated steps. After the prototype is built, it is tested. Most likely, problems will be discovered and the design may need to be adjusted. This could happen several times before the final product is completed. Students should revisit any steps in the engineering design process that are necessary to make improvements in the design.



2. Students should document their plans to make design improvements, based on their own testing and the feedback received from their client.

3. It can be very challenging for teachers to have all of the students finish at approximately the same time. Here are some common situations that may need to be addressed at this stage.

    a. Sometimes, students do not feel that any improvements are needed and their project solution is perfect “as is” (or maybe it is just “good enough”). Their project is done even though it seems to involve minimal effort relative to other projects in the class and the student easily finishes the project early. Does the project meet or exceed the original requirements? Does the client agree that the solution is good enough? If the student finishes the original project early, the student may have time to tackle a second project (either related or unrelated). Students should be aware that they one of the 3T’s is time, and if they have extra time, they have an opportunity to do more good with their talents and treasure!
    b. Sometimes, students try to tackle a problem that is much more difficult than originally anticipated and they may be having a great deal of difficulty. In this case, the teacher can work with the student to try to find a solution to the problems. Is it necessary to adjust the scope of the original project by eliminating or modifying some of the project requirements? Sometimes, simplification is required. Any changes in scope should be reviewed by the client. Students can also be frustrated if they are running into unanticipated technical difficulties. Teachers can help students work through the difficulties and lead them to a place where they can be successful, even if the original plan needs to be modified substantially.



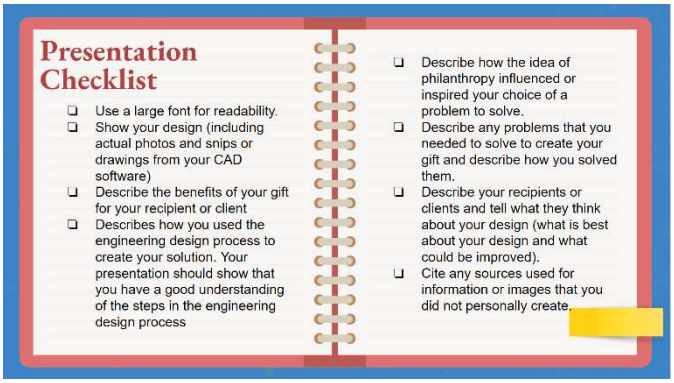
4. Once the project is completed, the student should show the final solution to the client and ask for final feedback. The student should ask the client to fill out the last part of the client feedback form. The student should also deliver the final solution to the end user. For documentation purposes in the engineering notebook, the student should show how the design is solving a problem for the

end user. The students should include a quote from the end user and a picture showing the solution in action.

Days 14-16: Communicate Results

1. Students should create a few slides (3-5) to share the final results of their engineering design project with their classmates. The slides could be inserted directly into the engineering notebook, or a separate presentation could be created if the teacher prefers.

2. A presentation checklist is provided within the engineering notebook. Students should refer to the checklist when preparing their presentation.
3. Once the slides have been prepared, students should briefly present their project to the entire class. Celebrate all of the good that has been accomplished!



Assessment

A project assessment rubric is provided. There are spaces provided for both the student and teacher to assess the student's performance. The designed solution, the engineering notebook, and the end-of-project presentation provide the basis for the evaluation. Students are assessed on connecting their project to philanthropy, asking questions and generating solution ideas, developing a solution, constructing and testing a prototype, and improving and evaluating their solution.

Acknowledgements

The development of this project was inspired by OtterCares Project Heart (https://myprojectheart.org/). The engineering design process details were adapted from Science Buddies (https://sciencebuddies.org/) and STEM in the Middle (https://www.teacherspayteachers.com/Store/Stem-In-The-Middle).