San Antonito STEM Fair:

Engineering Project Guide

Table of Contents

What is an Engineering Project?

An Engineering Project solves a problem in the real world. The project will involve asking a question, imagining a solution, planning a solution that meets your design requirements, creating prototypes, and improving those prototypes. In the "Which Should I Choose" video (https://www.youtube-nocookie.com/embed/uIV031bnmFA?playlist=uIV031bnmFA&autoplay=1&iv_load_policy=3&loop=1&start=), the Engineering Project example was "I need a Bird Feeder to Attract More Birds to My Yard." Other examples of Engineering Projects are: "Design a hoverboard to help me go get the mail" or "Build a door handle adaptor that helps people open doors more easily."

Computer science projects fall into the Engineering Project category too! In these projects, your prototypes are the computer program or code that you write and you'll still use the engineering design process to improve your program.

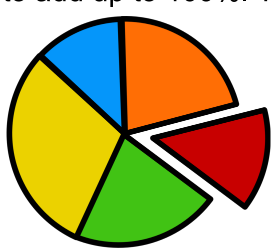
What is the Engineering Design Process?

The Engineering Design Process is the series of steps, or procedures, that engineers like you use to answer engineering questions. All of your steps should be recorded in an engineering journal! You can use blank paper or a notebook - but it's important to write down your steps and research and especially your data. Keep all your writing together.

- Ask:
    - The first step in your engineering project is to ask a question. In our example video, the engineering design question was "How can I build a bird feeder to attract more birds to my yard?"
- Imagine:
    - Once you have your question, you can start thinking about possible solutions.
    - This step of the process should also include research! Have other people tried to solve this problem before? How did they solve this problem? Read about your topic, take note of any new engineering words you learn. You might even want to interview someone who is an expert in your field, or someone who might use your finished product. Keep track of all the books, articles, websites you read and people you talked to.
        - When you're getting ready to present your engineering project, you will need to create a **bibliography**. This is a list of all the books, articles, websites, and people you have used for research. Use the Calvin Library site (https://www.calvin.edu/library/knightcite/) to help you create your bibliography. It is okay for young students to cite in resources in age appropriate ways, for example "I talked to a scientist/my mom/an expert…" or "I read a book that said…."
    - The final part of this step of the Engineering Design Process is to develop **design criteria**. Design criteria are the things the design needs to do in order to be successful. Criteria might be things like "holds more than 100 pounds" or "is durable enough to be reused 10 times." These are the "goal posts" for your project. **Design constraints** are the limitations of the design. Constraints might include a limit to costs, materials or time you have available, or even size. You will judge each future prototype against these criteria and constraints, so you need to write them down.
- Plan:
    - Now you get to design your first prototype! Planning your first prototype might include writing a first draft of a computer code or drawing a diagram of what you want your finished product to look like. You should include as many details as possible, such as size, shape, materials, so that creating the prototype is easier. It should be like a recipe to follow!
    - At this stage, you might be thinking about other options or prototypes. That is great! You should be! Write these down too. Make sure you take pictures of your diagrams for your project board.
- Create:

- Now it’s time to build your prototypes! Gather your materials and get to work. Make sure to take pictures along the way.

- Improve:
  - After you’ve made your first prototype, it's time to **evaluate** it against your design criteria. To evaluate means to tell whether or not you were successful in meeting that guideline. Write down your observations to evaluate each of your design criteria.
  - Now, go back to the “Plan” step! Yes, that’s right - you have to go back and do it again. The Engineering Design Process is like a loop. You have to keep going back to PLAN - CREATE - IMPROVE over and over again until your prototype successfully meets all of your design criteria. Make sure you evaluate your prototypes against your design criteria every time. This will help you know what you need to work on to improve your design.
  - Your evaluation might include collecting **data**. Data are the observations, numbers, measurements or other information that should be collected as you do your project. It is best if you can collect data in addition to observations! This might be data to answer your initial question, such as “How many birds visited my yard?” or “How much weight did my bridge hold?”
  - It is best to organize your data in a way that is easy to read and understand. You might also need to use your data to create a **graph.** Here are some types of graphs you might want to use:
    - **Pie graphs** are good to use if you are showing percentages of groups. Remember that you can’t have more than 100% and all the pieces need to add up to 100%. This type of graph is useful if you are doing a survey.



    - **Bar graphs** are good to use if you are comparing amounts of things because the bars show those amounts in an easy to read way. This way the judges will be able to tell your results at a glance. The x axis (horizontal) is where you label what is being measured (for example, type of food) and the y axis (vertical) is label to show the unit being measured (for example, number of birds that visited each food)

- **Line graphs** are good to use if you are showing how changes occurred in your experiment over time. The x axis is labeled with time increments and the y axis is labeled to show what you are measuring.

- Reflect:
  - Finally, it is time to write your conclusion. Engineers must communicate their results to others! Share your data and/or observations about each prototype. Were any of your prototypes successful? Why or why not? Would you change anything about your design if you had more time? Was there limitations to your prototypes because of materials or anything else? What did you learn from doing this?
  - It's also important to share if you are now curious about something else that you've learned by completing this project. Is there another engineering question you might want to pursue next?

Writing a Good Engineering Question

The first step in starting an engineering project is coming up with a good question. If you're stuck on deciding on an overall topic, check out some of the links in the "Getting Started" Guide. Once you have a topic, it's time to write a question. The question is the focus of your project and possibly even the title on your display board. Your question should be able to be designed or built. Take a look back at the "What is the Engineering Design Process?" section to make sure your question is one that is able to be tested following this procedure.

Here are some types of questions to help you get started:

Engineering or Technology Question:

Can I design a ________________________(adjective)_____________________(noun)?

* Example:

Can I design a birdhouse that is more attractive to birds?

Can I build a _____________________ to help do __________________________?

*Example:

Can I build a door handle to help people with disabilities open doors more easily?

Developing Design Constraints

One of the most important parts of an engineering project are the design criteria and constraints. A thoroughly developed set of criteria to measure your prototype against helps you discuss the success of your prototype. Constraints are the limitations you set in place to solve your problem.

Design Criteria: How will you judge your design as successful? Your design criteria! Design criteria are the guidelines that you want to design to be able to meet. Here's some examples:

- For a structural project:
  - Can hold a minimum of 100 pounds
  - Is aesthetically pleasing
- For a design project:
  - Able to perform a task
  - Is durable enough to be used repeatedly
- For a computer programming project:
  - Is fun for kids to use

Design Constraints: Design constraints are your project's limitations. These are the "rules" you must follow for your project to be successful. Here are some examples:

- For a structural project:
  - Cost of materials is less than $
  - The finished structure is smaller than a 10 inch cube
- For a design project:
  - Cost of materials is less than $X
  - The product is made of only recycled materials
- For a computer programming project:
  - Run time is less than X
  - Uses X type of code

Timeline for Completing Your Project

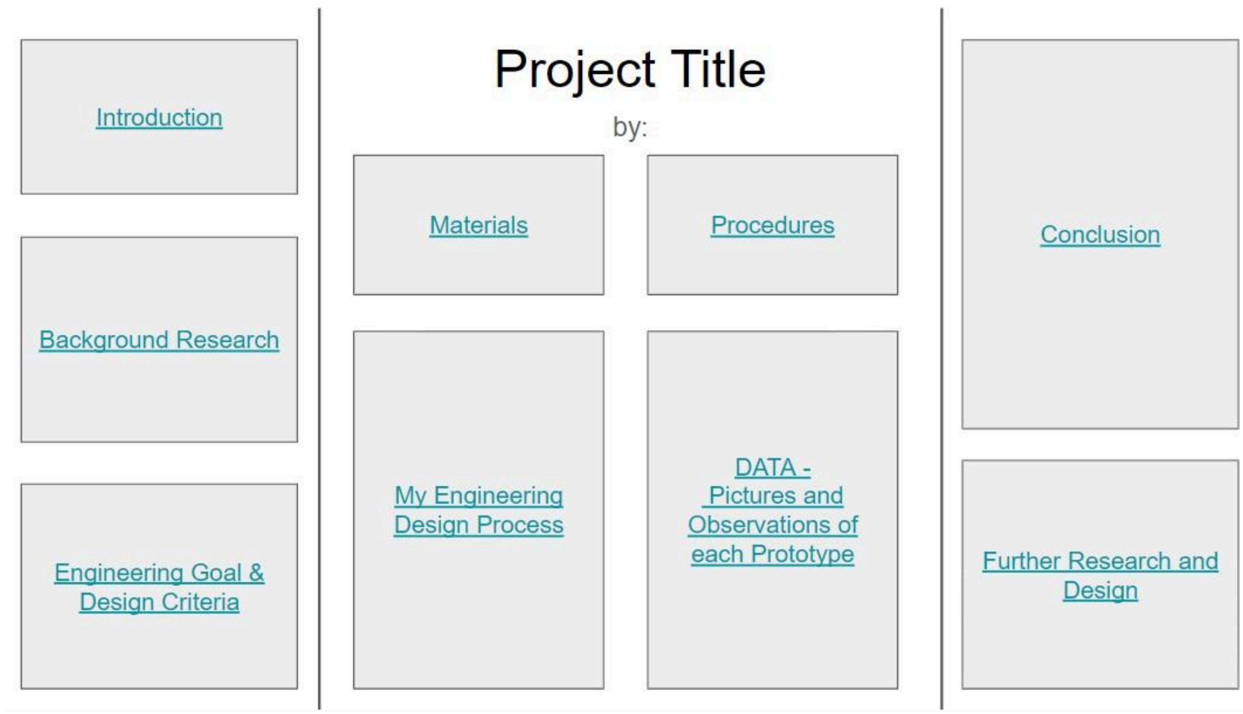
Engineering & Computer Science Projects

Project Part	“Due” Date
Question: Decide on your engineering question	October 27
Background Research: Research your topic! What have others done related to this topic? Edit your question if you need to.	November 10
Design Constraints: Decide what your design requirements will be. How will you know if your prototypes are successful?	November 24
Build your Prototype: Remember, you should do multiple prototypes for an engineering project! Collect your data and/or make observations following your design requirements.	December 8
Improve: Identify challenges with your plan, go back and edit your plan if needed. Collect additional data or observations.	December 22
Conclusion & Next Steps: Make your final prototype and observations about that prototype. Draw conclusions about how it works or could still be improved. What would you do in the future?	January 5
STEM Fair Presentation: Create your STEM Fair Board and practice your verbal presentation you will make to the judges	January 17 - DROP OFF YOUR PROJECT TO BE JUDGED ON THE EVENING OF 1/17

Template For Your STEM Fair Board

After you are finished your experiment, it is time to put it all together in a STEM Fair Board. This is a visual presentation of what you did and should include all the parts of the engineering design process. Your poster should be easy to read, interesting and also tell the most important parts of your project to the judges. You should include pictures of your process, graphs to share your data and physical prototypes if you have them. You can use the template on the school STEM Fair webpage to help you. Additionally, there is a great online course, “Student Researcher Training Modules” through UNM STEM-H Learning Lab (they also put on our regional STEM Fair), which can be found here: https://hsc.unm.edu/stem-h/programs/learning-lab/.

Here is a brief overview of what your board should include:



Preparing for Your STEM Fair Presentation

Presenting to the judges is an important part of your project. You should take some time to practice how you will talk to the judges about your STEM Fair project. This video shows you how to prepare for your presentation and below are some additional tips.

- Practice talking about your STEM Fair project ahead of time. You can practice speaking out loud to yourself in front of a mirror, to your grown up, a friend, or a sibling.
- On the day of the STEM Fair, wear nice clothes.
- Use good manners and introduce yourself to the judges.
- Don't be afraid to say "I don't know." or "I haven't thought about that yet."
- Include graphs, photos and actual prototypes with your STEM Fair Board. Use these to help you explain your project.
- Relax, smile and have fun!

Here are some questions the judges might ask you. You should think about these questions to help you prepare for your presentation.

- Where did you get this idea?
- What made you choose this project?
- What would you do differently next time?
- What was the hardest part for you?
- What research did you do for this project?
- Why did you do your testing more than once?
- Why are your findings important?
- Why should this project/topic matter to other people? What impact does this have on others?
- What is the most important thing you learned from this project?
- Who helped you? (This sounds like a trick question because you were supposed to do your own project - BUT no scientist or engineer works in isolation. Acknowledge your parents, teachers, friends, and anyone else that gave you advice, equipment, helped you find materials, or other help.)

Rubric

A rubric is the guidelines by which your project will be judged. As you go through your project, read the rubric to make sure that you have included all the necessary parts and judge yourself to see how well you think you would do. This is a good way to reflect on your board and presentation to see how you might improve.

Engineering Project Rubric

Topic	1 (Developing)	2 (Approaching)	3 (Meeting)	4 (Exceeding)
Research Problem Engineering need or problem to be solved	Description of a practical need or problem is vague, incomplete or missing.	A practical need or problem to be solved is described but is missing relevant detail.	Complete description of a practical need or problem to be solved.	Complete description of a practical need or problem to be solved that includes criteria for proposed solution as well as explanation of constraints.
Design & Methodology	No prototype is provided and/or no design for solution is included.	A design for a solution is included, including a prototype. No alternative solutions are presented or design details are limited.	Clear design for solution including a prototype. Design details are included. Alternative solutions are presented.	Clear design for solution including a prototype. Includes specific design details. Alternatives are presented and clear rationale for why alternatives will or will not meet the criteria.
Construction & Testing	Prototype is missing or does not match design.	Prototype mostly matches design but has some differences. Testing of prototype is incomplete or unclear.	Prototype is complete and demonstrates intended design. Prototype has been tested.	Prototype clearly demonstrates intended design. Demonstrates engineering skill and completeness. Prototype has been tested in multiple conditions/trials
Creativity Demonstrating imagination and inventiveness and/or offering different perspectives that open up new possibilities for experimentation.	Does not demonstrate creativity in any of the above 3 criteria	Demonstrates creativity in **1** of the above 3 criteria	Demonstrates creativity in **2** of the above 3 criteria.	Demonstrates creativity in **all 3** of the above criteria

Presentation (Board) How readable, logical, and appealing is the board	Display board has limited eye appeal or is not easily readable. Display has limited organization, or has confusing visuals. Contains multiple spelling and grammatical errors that are not grade-appropriate.	Display board has a combination of confusing and readable parts. Some visuals are confusing and others are helpful. A few spelling and grammatical errors that are not grade-appropriate.	Display board is appealing, neat, and readable. It is organized and clear, uses understandable visuals. Spelling and grammar are grade appropriate.	Display board is logical, neat, attractive, and creative. Makes striking use of inventive and eye catching visuals. Supporting documentation displayed. Spelling and grammar are grade-appropriate.
Presentation (Interview) How thoroughly does the presenter understand their project and can they discuss their project.	Student partially answered questions. Does not demonstrate independence in understanding the project. Poor understanding of the project and no mention of how their project impacts others.	Student can answer some questions regarding the project. Limited degree of independence in conducting the project. Cannot speak about the project beyond what is presented on the board and does not mention how their project impacts others.	Student can answer most questions. Adequate understanding of interpretation and limitations of results and conclusions. Satisfactory degree of independence in conducting the project. Able to provide some information and answer some questions that are not already represented on the board. Briefly or superficially mentions the impact of their work.	Student demonstrated clear, concise, thoughtful responses to questions. Thorough understanding of interpretation and limitations of results and conclusions. High degree of independence in conducting project. Excellent understanding of the project and quality ideas for further research. Can thoroughly answer questions that are not represented on the board as well as how their project impacts others and why the work is meaningful.