ProjectEngin™
Engineering for Your Classroom

Module1: The Designed World

The world you know is highly engineered and designed. Pretty much everything around you can be classified as "technology" or the application of scientific knowledge to solve our problems and make our lives easier. Most of the time, this designed world gets little direct attention in our classrooms. But it should.

"Perhaps the most compelling reason to include engineering design throughout K–12 education is the need for students to develop an understanding of the designed world they live in. The Committee on Technological Literacy, National Academy of Engineering (NAE), and NRC (2002) stress the need for increasing technological literacy, which they define as "an understanding of the nature and history of technology, a basic hands-on capability related to technology, and an ability to think critically about technological development" (pp. 11–12). We live in a world where countless technologies, from simple pencils to autonomous cars, have been engineered to fulfill our needs, solve our problems, and improve our lives. As educators, we have a responsibility to educate the students who are in our classrooms today in preparation for a highly engineered and complex future." ***(Designing the Future, p. 3)***

When laying out the background for the Next Generation Science Standards, the National Research Council clearly identified Engineering Design as being crucial to the education of young people who understand the world that they live in. At-home learning provides a unique opportunity to make the designed world part of your "classroom" resources. Use some or all of the activities described in the table below to engage students in the final project that asks them to re-design an everyday object. Resources and worksheets at the end of this document and as separate files in the project folder. Worksheets that are in PDF have been formatted to allow students to fill them in.

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EXPLORING THE DESIGNED WORLD

Introductory Activities

Choose one or more to provide background understanding and to engage your students in the exploration of the designed world.

REVERSE DESIGN	Good designs always start from understanding constraints and criteria that frame the challenge. Without an understanding of limitations and goals, you really do not have a starting point. Activity 1 in this series asks students to "reverse" their understanding of this design space by identifying the constraints and criteria that may have led to the creation of an object in their homes (chairs, bikes, cell phones, etc.). A worksheet template can be found in the project folder, along with an example of constraints and criteria. As part of the follow-up discussion, it is helpful to ask students how that object might look or function differently if they removed on or two constraints or criteria.
USELESS INVENTIONS	Introduce some fun by having students investigate the design of useless objects. There is a great TED Talk by Simone Gertz that will work for middle and high school students. Students of all ages will enjoy exploring Japanese "chindogu" or un-useless inventions. Some resources related to this can be found in the project folder. You can further engage students by asking them to design their own "chindogu" and creating an online class gallery.
DESIGN AROUND US	This activity can be used for either groups of students or individuals. It provides a multi-disciplinary opportunity to include social studies, ELA, and art. Give each student or group a common object and ask them to research the history and design process for each. They can summarize their findings in a timeline, animated presentation (like PowToons), video, or infographic to be shared with the rest of the class. Objects, sites for information about them, and links to some presentation resources can be at the end of this document. Worksheets to guide student research and discussion for high school and middle school are also provided in the project folder.
ACCIDENTAL INVENTIONS	Another great activity is to use the approach outlined above but shift the focus to "accidental" inventions. PostIts, the Slinky, and a host of other everyday objects were developed from mistakes and accidents. This is a great way to promote growth mindset and the value of learning from failure. Resources for this can be found at the end of this document. In our experience, students in Grades 5 and up find this to be a highly engaging and informative activity.
ERGONOMICS: How Math Makes Us Comfortable	Objects designed for human use generally follow ergonomic guidelines that make them comfortable and safe for use. Furniture, stairs, pencils, and toothbrushes are good examples. If you are a Math teacher, exploring ergonomics and having students measure and survey objects around them can be the basis for scale-model drawings, statistical analysis, and interesting online discussion. Using themselves and the objects around them, students can identify measurements that might be important for any given type of object and them collect relevant data for 4-6 dimensions of that object. They can then compare their results to published standards. Good resources for learning about ergonomics and standard measurements can be found at the end of this document.

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Final "Project" – Redesign an Everyday Item

We use the short project outlined below quite a bit. Everyone can relate to it – think of what really annoys you every day - socks that get "divorced" in the dryer to the mysteriously topless Tupperware or perhaps that dishwasher that never gets emptied (or filled). It is a great way to introduce young "engineers" to idea of understanding the end-user and addressing their "pain points" (engineering and marketing jargon for those things that really bother you). It also allows students to focus on basic steps of the Engineering Design Process without being overloaded with technical information. They can identify constraints and criteria based on user interviews, brainstorm solutions together, and develop ideas for prototypes. They can even "test" their ideas by getting feedback on a marketing "pitch". It is fun and it can easily be adapted to an online format. In lieu of physical prototypes, students or groups can create a marketing "poster" or a short advertisement using PowToons or any video format. Feedback can be provided by classmates who can "vote" on whether they would buy or use it. Who knows? Maybe the "next best thing" may come out of this current crisis!

Note that some of the "days" listed in the attached plan can be homework assignments. Plan on 1-2 weeks of online learning time to complete the project.

Coming up in our next Newsletter (April 15): ***How Does Nature Meet the Challenge of Design?***

Coming in early May: ***Combining What We Have Learned to Design More Sustainably***

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REDESIGN AN EVERYDAY OBJECT **Engineering Design Challenge**	
Supports empathy, creativity, collaboration and group decision-making; introduces Engineering Design Process.	
Day 1	Each student **surveys** family members to find out what the one thing that really bothers them might be. **Video Resource:** This is also a good time to have middle/high school students view the video Introduction to the Entrepreneurial Mindset (3 minutes) from Engineering Unleashed. **High School Background Reading (optional) –** *The Design of Everyday Things* (book) by Don Norman
Day 2	After surveying, they choose one challenge to focus on and conduct an **interview** with that person about the problem, product, or process. The Name Your Pain worksheet might be helpful for that. Some things to include in the interview include: ➢ Background (such as age, experience, lifestyle, etc.) ➢ The use of the product or process; how often, when, why ➢ The user's main objectives and motivations when using it ➢ The user's pain points regarding the object or process
Day 3	**Background research** on redesigning, re-purposing, and hacking objects. Some interesting ideas can be found here and may be helpful in sparking student thinking. • 20 Redesigned Everyday Products • Everyday Objects You Can Hack • A somewhat opposite "spin" is shown here in this Design Squad video where objects are re-purposed (hacked).
Day 4	**Form Groups - 4 students, 3 if needed** Assign students to groups of 3 or 4 and have them "meet" to discuss the objects/problems they have each focused on. They will need to agree on one or two that they want to create better solutions for. - Each student presents an idea of an object to be re-designed - Each group must reach consensus on 1 (or 2) object to re-design
Day 5	Once groups have determined their chosen re-design, they might find it helpful to complete the What We Need to Know form. Design Summary form is started, noting object/problem, constraints (limitations), criteria (goals).

Day 6	**Brainstorming Ideas:** Students brainstorm ideas as a group, recording ideas on an online document. There are some great apps that serve as creative whiteboards that we like to use. The free access versions are fine for this project. Our favorites include: ➢ The PostIt app ➢ LucidChart ➢ Miro Students might struggle with brainstorming if they don't have much experience with it. SCAMPER is a technique that many creative teams use in a range of industries. The SCAMPER activity worksheet in the project folder might be a useful guide to help them get started. Groups should record key ideas on Brainstorming form.
Day 7 - 8	Groups should choose one solution. No formal decision process is needed but the group needs to reach agreement. Complete Design Summary. Create marketing pitch (video, PowToons, or digital poster).
Day 9	Groups present (share online with class). Product should have a name and groups should have a company name and logo. The presentation or pitch and the completed Design Summary and Brainstorming form should be used as performance assessments.

RESOURCES

The Designed World – general resources

https://www.complex.com/style/2013/02/the-50-most-iconic-designs-of-everyday-objects/

https://pbskids.org/designsquad/pdf/parentseducators/DS_Invent_Guide_Full.pdf

Uses for Everyday Items

https://www.brain-sharper.com/social/everyday-items-using-wrong-tw/?utm_campaign=Everyday%20Items%20Lior%20v2%20En%20-%20Desktop%20USA%20TW&utm_source=Twitter&utm_medium=WC&psl=i_5486fa

The Design of Everyday Things **(book) by Don Norman**

https://www.amazon.com/Design-Everyday-Things-Revised-Expanded/dp/0465050654

Timeline Creation Apps

https://spark.adobe.com/make/timeline-maker/

https://www.visme.co/timeline-maker/

https://www.techlearning.com/tl-advisor-blog/7071

PowToons

https://www.powtoon.com/index/

Ergonomics

https://www.ewiworks.com/wp-content/uploads/2017/12/ChairStandards_Report.pdf

http://mwwg.net/uploads/3/4/5/2/34520510/furniture_design.pdf

https://www.archdaily.com/903027/the-importance-of-understanding-the-human-body-designing-for-people-of-all-shapes-and-sizes

https://www.ergonomics4schools.com/lzone/anthropometry.htm

https://www.ruthtrumpold.id.au/destech/?page_id=870 (From an International Baccalaureate (IB) project)

Resources for researching everyday items

Paper Clips

https://www.officemuseum.com/paper_clips.htm

http://theinventors.org/library/inventors/blpaperclip.htm

https://www.scientificamerican.com/article/the-paper-clip/

Stapler

https://bostitchoffice.com/articles/education/history-of-staplers/

https://www.inventionandtech.com/content/stapler-0

https://www.officemuseum.com/staplers.htm

Toothbrush

https://www.colgate.com/en-us/oral-health/basics/brushing-and-flossing/history-of-toothbrushes-and-toothpastes

https://www.huffpost.com/entry/mouth-health-how-long-hav_b_683535

https://museumofeverydaylife.org/exhibitions-collections/previous-exhibitions/toothbrush-from-twig-to-bristle-in-all-its-expedient-beauty/a-visual-history-of-the-toothbrush

Legos

https://www.history.com/news/the-disastrous-backstory-behind-the-invention-of-lego-bricks

https://www.thoughtco.com/lego-toy-bricks-first-introduced-1779349

https://www.infoplease.com/entertainment/legor-timeline

BandAids

https://www.jnj.com/our-heritage/18-facts-about-the-history-of-band-aid-brand-adhesive-bandages

https://www.smithsonianmag.com/smart-news/get-stuck-band-aid-history-180965157/

https://www.youtube.com/watch?v=98sFkESm0xg (TedEd video)

Umbrella

https://www.thoughtco.com/who-invented-the-umbrella-1992592

http://www.umbrellahistory.net/

https://www.heddels.com/2018/09/taking-cover-the-long-history-of-the-umbrella/

Ballpoint Pen

https://www.pens.com/blog/the-inventor-behind-the-modern-ballpoint-pen/

https://unsharpen.com/who-invented-the-ballpoint-pen-origins-of-a-modern-writing-instrument/

https://time.com/4083274/ballpoint-pen/

Thermos

https://www.thermos.com/history

https://www.kitchenkapers.com/pages/history-of-the-thermos-company

https://www.dailykos.com/stories/2016/2/22/1488807/-History-101-The-Thermos

Safety Pin

https://www.nine.com.au/entertainment/viral/the-history-of-the-safety-pin/d76ab9a2-ba66-4a90-a888-00af6e73b00b

https://www.theatlantic.com/technology/archive/2016/11/three-millennia-of-safety-pins/507629/

https://www.thoughtco.com/walter-hunt-profile-1991916

Researching Accidental Inventions

General Educator Resource – developed for British Science Week

https://www.britishscienceweek.org/app/uploads/2015/10/NSEW-Accidental-Discoveries-Primary-PackFULLOPT.pdf

Post-Its

https://www.post-it.com/3M/en_US/post-it/contact-us/about-us/

https://medium.com/the-history-of-office-supplies-and-equipment/post-it-notes-invented-by-accident-1f3427da7d59

http://www.todayifoundout.com/index.php/2011/11/post-it-notes-were-invented-by-accident/

https://www.cnn.com/2013/04/04/tech/post-it-note-history/index.html

https://www.thoughtco.com/history-of-post-it-note-1992326

PlayDoh

https://www.smithsonianmag.com/innovation/accidental-invention-play-doh-180973527/

https://www.wonderopolis.org/wonder/who-invented-play-dough

https://www.museumofplay.org/blog/play-stuff/2016/11/the-history-of-play-doh-good-clean-fun

http://www.todayifoundout.com/index.php/2011/11/play-doh-was-originally-wallpaper-cleaner/

Slinky

https://www.smithsonianmag.com/innovation/accidental-invention-slinky-180973016/

https://www.toyhalloffame.org/toys/slinky

https://www.popularmechanics.com/technology/a27657/slinky-toy-history/

Silly Putty

https://www.kidsdiscover.com/quick-reads/weird-science-the-accidental-invention-of-silly-putty/

https://www.thoughtco.com/the-history-of-silly-putty-1779330

https://www.toyhalloffame.org/toys/silly-putty

https://www.todayifoundout.com/index.php/2011/11/silly-putty-was-invented-by-accident/

Microwave Oven

https://spectrum.ieee.org/tech-history/space-age/a-brief-history-of-the-microwave-oven

https://www.popularmechanics.com/technology/gadgets/a19567/how-the-microwave-was-invented-by-accident/

https://www.livescience.com/57405-who-invented-microwave-oven.html

Design Requirements

The design requirements for your project will be unique to your specific problem and the product that you are designing. Therefore, you will develop your own constraints and criteria for this project. Your constraints and criteria should be specific and directly related to meeting the needs of your product's end user.

Example:
If you are designing a baseball bat that meets high school regulations, your design requirements might include the following.

Constraints:

- The bat can not be more than 2⅝ inches in diameter
- Its "drop" (inches of length minus ounces of weight) must be no more than 3.
  For example, a 34 inch bat must weigh at least 31 ounces.
- Made out of a material approved by the league

Criteria:

- Able to hit a baseball without breaking
- Comfortable grip
- Visually appealing

Constraints vs. Criteria

Constraints	*Criteria*
Constraints are **limits** that may hinder your creativity or design freedom. Constraints are restrictions that keep something from being the best that it can be. Constraints are often based on resources available (time, tools, materials, etc.), rules or regulations, and environmental conditions.	Criteria are the **requirements** or specific outcomes that must be met to be successful. Criteria are desirable characteristics that would be preferable in your final design solution. Criteria are often based on the goals for your design solution.
Questions to Consider: What might **interfere** with your creativity? What **rules** do you need to adhere to? What might make the problem **difficult to solve**?	*Questions to Consider:* What do you want your product to do? What are you **trying to accomplish**? How will you determine if your product is **successfu**l?
Examples: budget safety regulations environmental conditions	*Examples:* visual appeal ease of use comfort

Things to Remember:

- There is no perfect design.
- Different solutions may satisfactorily solve a problem, there is not one correct design solution.
- **The best designs optimize the desired criteria within the given constraints.**

CRITERIA

_____

_____

_____

CONSTRAINTS

_____

_____

_____

Object

CONSTRAINTS

_____

_____

_____

CRITERIA

_____

_____

_____

Reverse Engineering the Design Space

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Figure 2.8: Identifying Constraints and Their Impact

Constraint	Design Feature It Led To	If There Were No Constraint

HOW DO WE USE OBJECTS TO CHANGE THE WORLD?

Name

Date

IN THE LATE 1800S, the popularity of the bicycle helped lead to a variety of social changes, including new ways of dressing and greater independence for women and young people. What other objects have helped to change the world? What objects do you use to change the world today? Select an object from the past or present.

Draw, paste, or upload a picture of your object here:

THINK ABOUT the impact of the object you selected on the following:

- *The way people interact, communicate or work.*
- *Customs or values in a society.*
- *The economy or political life.*

Explain how this object helped to make four changes in the way we live, work, or play:

Smithsonian
National Museum of American History
Kenneth E. Behring Center

Patrick F. Taylor Foundation
OBJECT PROJECT

Name:

Name of Object:

These questions are meant to guide your research into the history and design of the object you have chosen.

1. What problem does/did it solve?

2. When was it first invented?

3. Who is credited with be the inventor/original maker?

4. List three major changes/innovations in its design.

5. What materials are typically used to manufacture this item?

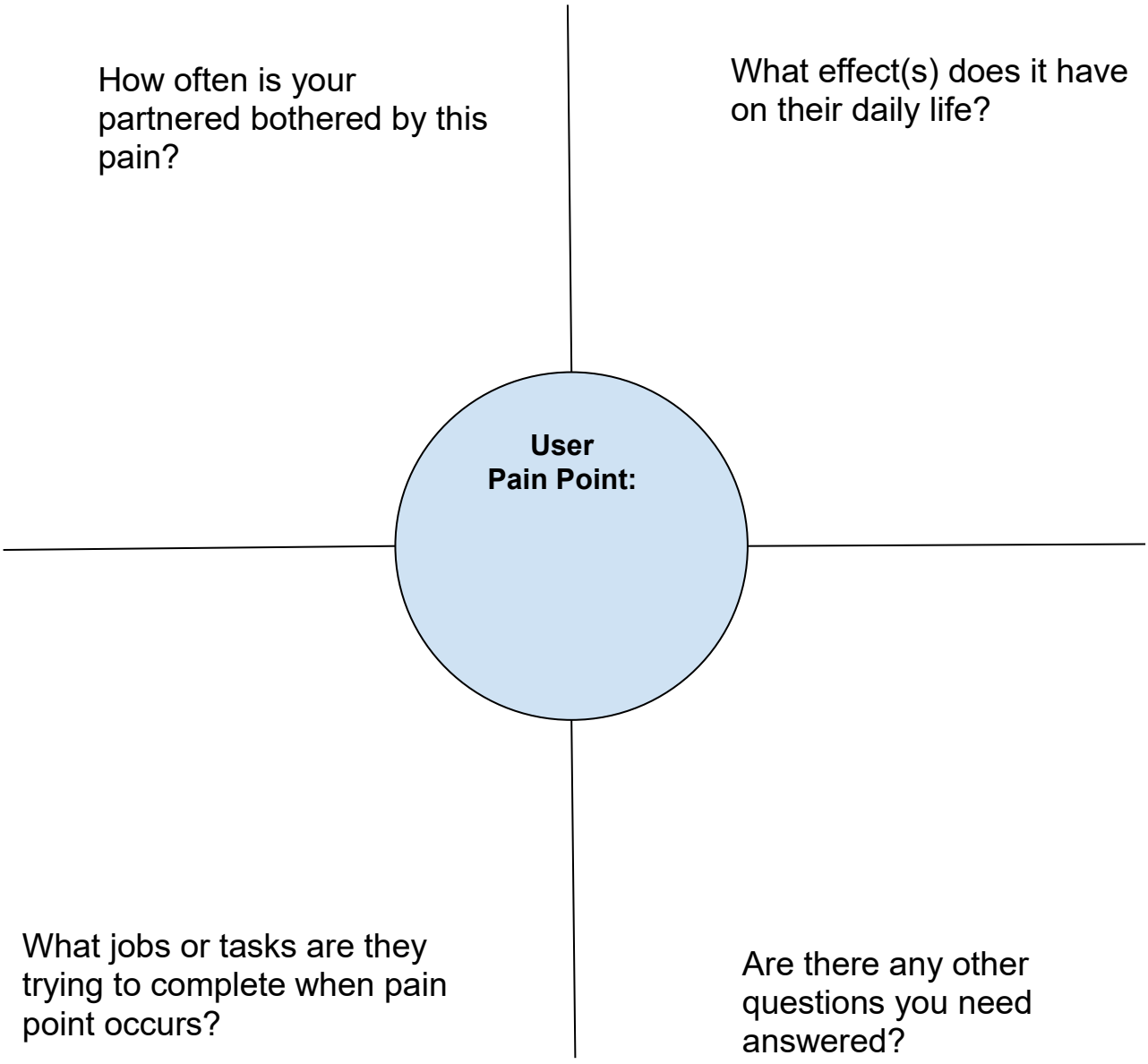
6. Are there any innovative or unexpected uses (hacks) of this object?

7. Has this object inspired other designs?

8. Fun facts about this object.

Name Your Pain Activity

Part 1: Interview your "client" by identifying their pain-point and asking them the questions below. Record responses in the corresponding boxes.



Part 2: Working by yourself, complete Section A. Once you are done, ask your interviewee for input or a possible ranking of what matters most.

Section A. *Identifying Key Needs*

Based on Interview Responses: (In no particular order.)	**Sketch or Notes**

End-user needs often become the criteria (goals) for a good design solution. Choose 2 from the above list and try to create a solution that meets the needs you have chosen. Working by yourself, draw a sketch or write a description below. Share with your "client" when you are done.

Section B. *Possible Design Idea(s) (sketch or description):*

Middle and High School Students Decide What They Need to Know

Name:	Project:
Directions: Please write down any ideas that you have about the following.	
What topics have we talked about?	
Who is the end user?	
How will the end user use the solution?	
Where will the end user use the solution?	
Why will the end user use the solution?	
What has someone tried before?	
What else do you think you need to know about?	
What else might you need to know more about? + Science concepts + Available resources + Things that might make implementation difficult (for example, language, resources, or culture)	

Design Summary

Team Members	
Criteria: List the *top 5 things* that your team must keep in mind to develop a good solution. List them in order from most important to least based on the information from the interview.	
Most Important Feature of the Solution: 1.	
2.	
3.	
4.	
Least Important Feature of the Solution: 5.	
Constraints: What are the *limitations and requirements* that the *solution must meet?* No more than 6.) Use the ***Identifying Design Constraints*** form to complete this.	

Design Statement: *What* will your team do to *develop a solution* for the problem? You may use a sketch, bullet points, or paragraphs to create a clear picture of your plan.

Sketch of planned solution

Meeting Criteria: How will your proposed solution (above) meet the identified criteria? Name the criteria **specifically** and the ways that they are being addressed. Use the list from the first page of this form.

Key Features: List the 1 or 2 things that are really an important part of your solution. Explain why they are key features.

1.

2.

Additional Background Information: Identify any data, statistics, cultural, or historical information that you may need to research.

Anticipated Issues/Problems: What *issues or roadblocks* will your team have to overcome in order to succeed?

(Example: How/Where will the materials be obtained? How may a scaled model not accurately represent the actual "product/solution"? How do you plan on getting the information or product to the end users? How might you actually test it?)

Brainstorming Summary

Some teachers like to use a form like this for groups to summarize key ideas from their brainstorming session.

Team members
What is the problem you are considering? Answer in one sentence.
What are your notes from the brainstorming? Only one team member records the notes.
After brainstorming, take a picture of the workspace or save your sticky notes. Then answer the following questions. What were three specific issues or aspects of the problem? What were the four to six design ideas that appeared most often during the brainstorming session? What are at least four key features of your design? Describe them in words or sketch them.

S **Substitute** one thing for another

C **Combine** with other functions, materials or things

A **Adapt** the design so it can be used for some other purpose

M **Modify**, Magnify, Minimise elements of its design

P **Put** the design to other uses

E **Eliminate**, Elaborate, Enhance some part of the design

R **Rearrange,** reverse sections or move parts around

Design Brief

In 10 minutes, list a range of possible design improvements and their benefits for your product. Produce an annotated sketch of one or two of these ideas to present to the group.

PRODUCT: _____

Substitute one thing for another

Questions: What kind of alternate material can I use? What part of the design could be substituted for something else?

Your improvement:	Benefit:

Combine with other functions, materials or things

Questions: What could be added to the design the design to make it different?

Your improvement:	Benefit:

Adapt the design so it can be used for some other purpose

Questions: What aspects of the design can be adjusted so it fits another purpose?

Your improvement:	Benefit:

Modify, Magnify, Minimise elements of its design

Questions: What if I exaggerate or modify a component? How can I make it larger or stronger? How can it be made smaller or shorter?

Your improvement:	Benefit:

Put the design to other uses

Questions: Who else might be able to use this design? What else could it be used for other than its original purpose?

Your improvement:	Benefit:

Eliminate, Elaborate, Enhance some part of the design

Questions: What can be removed? What can be expanded or developed upon further?

Your improvement:	Benefit:

Rearrange, Reverse sections or move parts around

Questions: How can the layout or pattern be changed? Can I interchange any components? What can be turned around?

Your improvement:	Benefit:

SCAMPER

Substitute one thing for another

Combine with other functions, materials or things

Adapt the design so it can be used for some other purpose

Modify, Magnify, Minimise elements of its design

Put the design to other uses

Eliminate, Elaborate, Enhance some part of the design

Rearrange, reverse sections or move parts around

Choose one or two of your design improvements. Produce an annotated sketch of the product and render it to show design elements such as material, texture and scale. Make the sketch large enough to be seen clearly when presenting your ideas.