

Phase I – Research and Planning – Due Date: Midterm (Denzil Mackrory)

1. Identify the “Big” concept to be covered by the engineering design challenge.

Concept - Movement of energy in systems.

I have decided to incorporate a design challenge in my Energy unit. This unit is taught under the concept of systems thinking. The chosen activity will serve to address the following:

1. Allow students to apply knowledge to solve a problem using engineering design thinking
 2. Introduce the use an engineering design journal
-

2. Research appropriate learning standards associated with the topic.

NGSS

- Physical Science
 - Conservation of Energy
 - Interactions of energy and matter
- Engineering
 - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

NTMS

- Problem Solving
 - Build new mathematical knowledge through problem solving
 - Solve problems that arrive in mathematics and in other contexts
 - Apply and adapt a variety of appropriate strategies to solve problems
 - Measurement
 - Understand measurable attributes of objects and units, systems and processes of measurement
 - Apply appropriate techniques, tools and formulas to determine measurements
-

3. Identify and discuss the different types of problem solving and declarative/procedure knowledge needed.

According Kirkley (2003) there are three types of problems:

1. Well structured problems
2. Moderately structured problems
3. Ill structured problems

Due to the aforementioned reasons in point 1, I would like the type of problem I pose to the students to be a moderately structured question for the following reasons.

- I would like the problem to be clear and convergent so that students are all working towards a common goal
- In the pursuit of creative thinking I would like students to appreciate that design thinking can result in more than one acceptable solution.
- I want students to reason abstractly, apply mental modelling and practice problem representation.

Well structured problems would limit creative thinking and all students would end up ‘doing’ the same thing. Using an Ill structured problem may present further challenges to students and take away from the reasons I mentioned above that I want to achieve with this task. Most students do not have enough declarative knowledge at this point of the year to tackle such a problem.

Table to show declarative and procedural knowledge needed.

Declarative Knowledge	Procedural Knowledge
Types of energy Energy transfers Conduction convection and radiation Modelling energy transfer with particle diagrams Calculating energy gained or lost in the system Building procedures	Systems thinking Engineering design thinking Possibly the scientific method

4. Explore objectives and ancillary concepts/content covered by the project.

Identify the types of energy in the system

Model and describe the energy transfers in the system

Calculate energy lost or gained by a system using $Q=mc\Delta T$

Use a design Journal to record evidence of the engineering design process.

5. Identify possible activities.

Table to show possible activities:

Possible activity	Description of activity	Suitability of the activity
Hot rocks activity	Students are presented with a pile of rocks. They are different in size and colour. Students construct a research question involving energy transfer. Students design and carry out an experiment to answer their research question.	<ul style="list-style-type: none"> • Ill Structured • Suitable as a scientific investigation, less suited to engineering design • Time - 2-3 hours • Requires more declarative knowledge
Energy in food	Students are presented with a range of foods (nuts, crisps, crackers). They must find the energy stored in the food with the equipment given (thermometer, tongs, burner, water, test tubes)	<ul style="list-style-type: none"> • Well structured • Suitable as a scientific investigation, less suited to engineering design • Time - 1 hour • Students have suitable declarative knowledge
NASA - Feel the Heat. Building a solar heater	Students must design and build a solar water heater. The objective is to see who can raise the temperature the most. Then calculate the energy needed to raise the water by the observed temperature.	<ul style="list-style-type: none"> • Moderate structure • Suitable as an engineering design task • Time - 2 hours • Students have suitable declarative knowledge
Rube Goldberg machine	Students design and build a Rube Goldberg machine to perform a simple task. Students conduct an energy analysis by collecting quantitative data.	<ul style="list-style-type: none"> • Ill structured • Suitable for scientific investigation and engineering design task • Time - 6 hours

	Students then use the data to make modifications to improve efficiency in the system.	<ul style="list-style-type: none">• Requires more declarative knowledge
--	---	---

6. Select the best activity for your classroom.

NASA - [Feel the Heat](#) → Building a solar heater

The rationale for choosing this activity

- It is a Moderate structure problem. I need an activity that promotes creativity and brainstorming that could lead to multiple design solutions. The tasks offers flexibility so that different groups will develop different design solutions but is structured enough to guide all students towards a common goal.
- It clearly focuses on engineering design thinking
- The task can be completed in the time constraints of the over all units.
- Most students should the declarative knowledge to complete the task.
- Suitable activity for introducing students to the design journal.

Bibliography

Kirkley, J. (2003). Principles for teaching problem solving. *Plato Learning*, 1-13.

Feel the heat [Fact sheet]. (n.d.). Retrieved September 18, 2018, from <https://pbskids.org/designsquad>