Engineering Notebooks for Formative Assessment (Resource Exchange)

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Target Grade Level: 4-8

Engineering to Transform the Education of Analysis, Measurement, & Science

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Project Description

The EngrTEAMS project has been developing a suite of 13 integrated STEM curricula for grades 4 – 8. The curricula are hands-on engineering design challenges that integrate mathematics and science grade-appropriate content, mapping to Next Generation Science Standards for engineering and discipline-specific standards. Each unit was inspired by a teacher and developed in conjunction with members of the EngTEAMS. The design projects in each unit vary in context and in terms of the mathematics and science concepts needed to create an adequate solution. Yet, within all the variation, each unit is an authentic engineering design challenge. The common design elements that cut across curriculum were specified in three overarching design competencies (Douglas, Moore, & Adams, 2016), each with specific objectives concerning the knowledge and practices that comprise the competency.

Design Competencies

Competencies	Objective	Students…
1: Students define the problem from the perspective of stakeholders. Students generate and then refine description of problem based on new information. Students engage in problem scoping (i.e., define the problem and needs, and then identify the knowledge, criteria, and constraints required for a desirable solution).	A	Gather information to examine the problem (ask questions to client)
	B	Explain the problem based on a synthesis of information.
	C	Explain why the problem is important to solve based on evidence.
	D	Identify the relevant end user.
	E	Explain the background knowledge needed to develop a solution.
	F	Explain criteria based on synthesis of given and found information.
	G	Explain constraints based on synthesis of given and found information.
	H	Revise the problem based on evidence found while developing effective solution.
	I	Communicate how their understanding of the problem deepened through the design process.
2: Students use evidence to develop an optimal solution. Specifically: develop possible solutions, evaluate solutions, implement, test, and optimize the solution.	A	Use evidence from problem scoping to generate multiple initial ideas for the design solution.
	B	Select potential solution through systematic evaluation of various solutions based on the problem.
	C	Implement potential solution.
	D	Test potential solution.
	E	Analyze test results.
	F	Apply evidence gathered through test analysis to improve the performance of chosen solution.
	G	Gather additional information (*i.e.,* regarding applied science/mathematics concepts) to improve solution performance.
	H	Evaluate the alignment between their proposed solution and the problem.
	I	Test improved solution.
	J	Explain what they have learned through testing and evaluation process.
3: Students communicate their design solution through use of evidence-based reasoning.	A	Justify why their design solution is appropriate based on application of core science/mathematics concepts.
	B	Justify why their design solution is appropriate based on information obtained in problem scoping.

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Notebooks in the Curricula

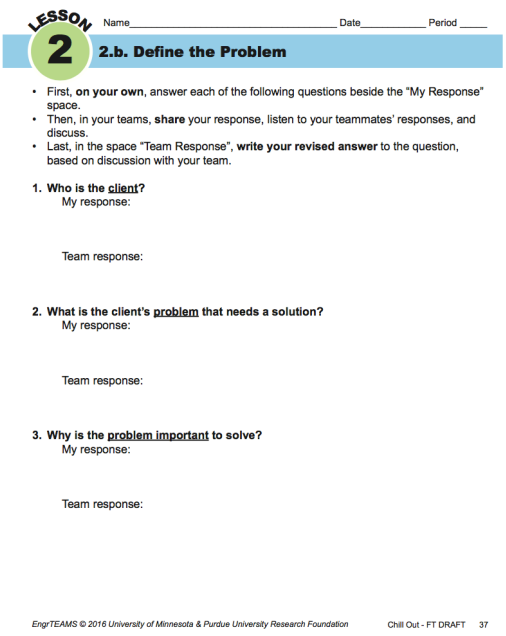
Throughout the design project, each student maintains an engineering notebook in order to take notes, develop ideas, record testing and observations, document decisions, and plan next steps. Each of the 13 units has both common elements of the notebook and elements that are specific to that unit. The common elements of the notebooks are based on three overarching design competencies (Douglas et al., 2016) and then prompts are mapped to specific learning objectives and identified at which point in the design process students were developing those skills. In all these notebook assessment activities, students are provided with scaffolding for their design practices and how to provide evidence of their design process. Additionally, as students progress through their design projects, they are prompted to reflect and reconsider their understanding prior to collecting evidence.

Teachers can use the notebooks as an embedded assessment tool to provide timely feedback to students regarding design practices. The notebook prompts are written to capture evidence of student design skills, as specified in the design competencies. Students use the notebooks in a variety of ways to capture evidence of their design practices, such as brainstorming, sketching ideas, and recording their test results, as well as responding to questions concerning their design decision-making.

Examples from Engineering Notebooks

The following are examples of the common notebook pages in the EngrTEAMS curricula.

Define the Problem



LESSON 2 — Name_____ Date_____ Period ____

2.b. Define the Problem

- First, **on your own**, answer each of the following questions beside the "My Response" space.
- Then, in your teams, **share** your response, listen to your teammates' responses, and discuss.
- Last, in the space "Team Response", **write your revised answer** to the question, based on discussion with your team.

1. **Who is the client?**
   My response:

   Team response:

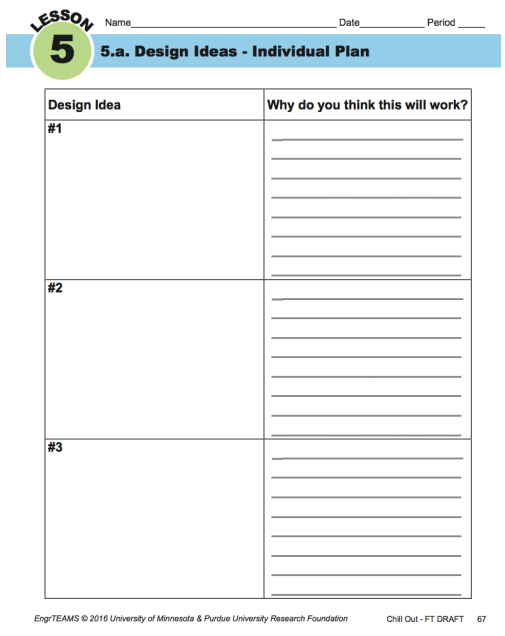
2. **What is the client's problem that needs a solution?**
   My response:

   Team response:

3. **Why is the problem important to solve?**
   My response:

   Team response:

Generate Ideas

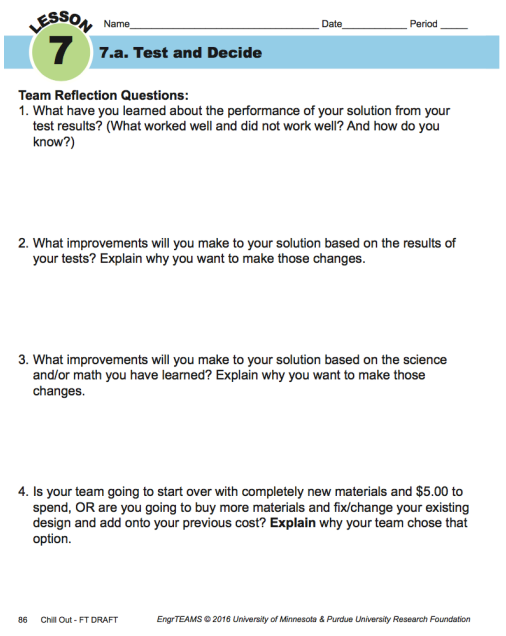


LESSON 5 — Name_____ Date_____ Period ____

5.a. Design Ideas - Individual Plan

Design Idea	Why do you think this will work?
#1	
#2	
#3	

Test Ideas



LESSON 7 — Name_____ Date_____ Period ____

7.a. Test and Decide

Team Reflection Questions:

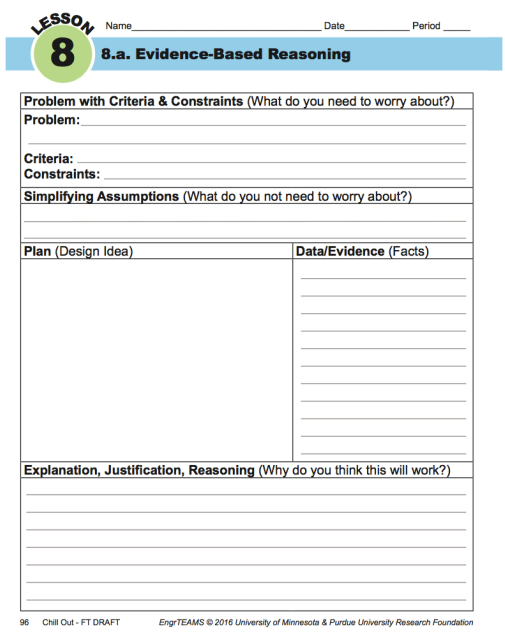
1. What have you learned about the performance of your solution from your test results? (What worked well and did not work well? And how do you know?)

2. What improvements will you make to your solution based on the results of your tests? Explain why you want to make those changes.

3. What improvements will you make to your solution based on the science and/or math you have learned? Explain why you want to make those changes.

4. Is your team going to start over with completely new materials and $5.00 to spend, OR are you going to buy more materials and fix/change your existing design and add onto your previous cost? **Explain** why your team chose that option.

Justify Solution



LESSON 8 — Name_____ Date_____ Period ____

8.a. Evidence-Based Reasoning

Problem with Criteria & Constraints (What do you need to worry about?)
Problem:
Criteria:
Constraints:

Simplifying Assumptions (What do you not need to worry about?)

Plan (Design Idea)	**Data/Evidence** (Facts)

Explanation, Justification, Reasoning (Why do you think this will work?)

