CfAO EHR: Developing a New Learning Activity for Engineering Interns
Brainstorming Session: Feb. 23, 2004, 2:30-3:45 pm
Present: Oscar, Lisa, Ravi, Julianna, Anne, Malika, Hilary, Lynne, Fernando, Julia.

Handouts:

1. What is Engineering? (Brainstorming Worksheet)
2. (post-meeting) Hilary's meeting notes

Post-Meeting Synthesis:

The goal of Monday's session was to collect as many ideas as possible on what a new learning activity for engineering interns might look like. The discussion revolved around three main topics:

1) What is engineering? And what is it about engineering that we want students to learn about?
2) How does this fit with the inquiry process? How can the inquiry process be modified to mimic the engineering process?
3) What are some actual engineering problems that we could give students to work on? In particular, what are some relevant examples that could be used for the Mainland Short Course?

Since the session was attended by a mix of scientists, engineers, and educators, it's not surprising that the responses to these question were equally mixed. A summary of the responses are given below.

What is engineering? What is it all about?

- Engineering is often associated with technology: playing with cool toys, building things, making something new, applying science to solve a problem, designing a solution to meet certain needs, etc.
- Several people pointed out that science & engineering tend to overlap, and that (in some cases) it doesn't make sense to separate them out. Julia suggested the idea of a spectrum, with engineering on one end and pure science on the other, and that most research projects will involve a blend of science & engineering. Lynne agreed and pointed out that many astronomers don't consider themselves as just scientists or just engineers (i.e. instrumentation), but as both scientists AND engineers.
- Julianna suggested that instead of focussing on people [i.e. engineers vs. scientists] and what they do, focus more on the *process* of engineering, itself.

So, what is the engineering process all about?

- The steps listed on the worksheet were read aloud, along with some additional substeps:

    1. Identifying the problem. Figuring out the specs for the problem.

2. Understanding the fundamental principles involved.
3. Designing a solution (or set of solutions). This involves:
   - Brainstorming all possible ideas for a solution.
   - Refinining a few of the ideas into actual solutions [designs].
   - Prototyping and testing solutions. Evaluating which is the best solution for the particular circumstance.
   - [Other steps to consider: cost analysis, manufacturability (e.g. can those tolerances actually be achieved?), assembly procedures, test plans (how can you tell if it works?), trouble-shooting, etc.]
4. Implementing the best solution.
5. Testing & documentation of final solution.

- All agreed that this sounded like a good definition of the engineering process.

How does this fit with the inquiry process?

- Next, Julianna directed the group's attention to Table 2-7 from "Inquiry in the National Science Education Standards" (reprinted and filled out, below).
- In particular, since "inquiry, as it relates to science education, should mirror as closely as possible the enterprise of doing real science", then why not: inquiry, as it relates to *engineering* education, should mirror as closely as possible the enterprise of doing real *engineering*.
- [One suggestion for the "engineering" column of Table 2-7 is given below.]

Table 2-7. Common Components Shared by Instructional Models (modified)
(from Inquiry in the National Science Education Standards, NRC, 2000, p. 35)

Science		Engineering
Students engage with a scientific question, event, or phenomenon. This connects with what they already know, creates dissonance with their own ideas, and/or motivates them to learn more.	1	– *Students engage with an engineering problem.* – *This involves identifying the problem, understanding the fundamental principles involved, and developing the specifications needed to correct the problem.*
Students explore ideas through hands-on experiences, formulate and test hypotheses, solve problems, and create explanations for what they observe.	2	– *Students explore possible solutions to the problem by brainstorming ideas and refining their ideas into actual designs.* – *Students evaluate different designs by doing a cost analysis & considering other factors, to determine the best design (or set of designs) for the given conditions or constraints.*

Students analyze and interpret data, synthesize their ideas, build models, and clarify concepts and explanations with teachers and other sources of scientific knowledge.	3	– *Students build prototypes to test their designs and to further their understanding of the solution space for the problem.* – *Additional design iterations are executed, as needed.* – *The final prototype (design solution) is implemented, tested, and documented.*
Students extend their new understanding and abilities and apply what they have learned to new situations.	4	– *Students extend their new understanding of the problem and their new abilities to design and implement solutions, by applying what they have learned to new engineering problems.*
Students, with their teachers, review and assess what they have learned and how they have learned it.	5	– *Students, with their teachers, review and assess what they have learned from their design process and how they have learned it.*

How can "Barry-style" inquiry be altered to incorporate engineering?

- Several people thought that elements of engineering could be easily incorporated into the "Light, Color, and Spectra" inquiry, from the Mainland Short Course. Julia mentioned that last year's inquiry generated a lot of engineering [and technology] oriented questions. Lynne suggested that engineering questions could be encouraged and the extra materials needed to explore these questions could be kept on hand. (However the scope of the engineering questions would still be limited by the materials available.)
- [Problem: someone will need to identify what extra materials are needed. Also, technology questions (e.g. how does a CRT work?) can not be explored in a hands-on environment – this can only be answered (safely) by looking it up.]
- Lisa reminded us that inquiry could include a "research component", just like Scott's activity at COSMOS.
- Another suggestion was to include the "cost analysis" step into the inquiry synthesis. For example, after students present their solutions, a facilitator could ask, "which solution is best for condition X? for condition Y?" [e.g. Building a house in Santa Cruz, CA, is very different from building a house in Rochester, NY!]
- Also: Different groups of students could be given different materials to work with, to a) reduce competition, and b) to force different design solutions.
- Anne suggested that an appropriate "teaser" for an engineering-type problem might be to show students something that is clumsy and that doesn't quite work right, and then ask students to: a) figure out what's wrong with it; and b) figure out how to make it work better.

What are some sample engineering problems?

- Going back to the PD Workshop, Ravi pointed out that the "challenge" portion of the foam activity at the PD Workshop is a good example of an engineering-oriented activity.
- Following up on Anne's idea, Lynne suggested showing students a large, clumsy, highly aberrated heliostat, and then asking students to improve on it. Some suggestions for improvements: make it smaller, make it work better (e.g. produce clearer images), and clean the (planted) thumbprints off the optics!
- Julia and Julianna discussed the idea of building a macro-scale Shack-Hartmann wavefront sensor, following a description they had seen from Carthage College. Lisa (who has seen this model before) cautioned that the difficulty with this model is in making it sufficiently interactive for use in inquiry; further work would be needed to address this issue.
- Ravi suggested creating a "toy" problem related to computer engineering, since computers are relatively easy to get [and easy to program].
- Finally, Fernando pointed out that since inquiry activities can be developed around almost any topic, then (within the context of the Mainland Short Course) it may be better to focus first on identifying what content areas we actually want to teach, and then visiting local labs to see what equipment we actually have available. Ultimately, this will affect what engineering problems we can actually develop for the students.
- Three content areas that worked well for the Maui Short course are: 1) optical engineering; 2) electronics; 3) software.

Where do we go from here? (Summary)

A lot of good ideas were generated at the meeting, and the basic groundwork for an "engineering-oriented" inquiry activity was developed.

However, more discussion time is still needed to generate more concrete ideas for engineering problems that students can actually explore, particularly within the context of CfAO Short Courses, such as the Mainland, Maui, and Observatory short courses.

And hopefully, this will form the agenda for a future meeting, for those of you who are still interested in pursuing this theme. ☺

Thank you for your participation so far!

Submitted by: Julianna Lin (e-mail: jlin@cvs.rochester.edu)