Work In Progress: Model Eliciting Activity for an Undergraduate Thermal Measurements Laboratory

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At Cal Poly, San Luis Obispo our undergraduate engineering education is designed to prepare students for industry. The rise of technology in modern engineering demands a shift in the way undergraduates are prepared for the modern workplace. Engineering problems should focus on the development of analytical models that describe a system. These models, once made, can be used to solve future problems of a similar type. By recreating and inventing some simple engineering problems that can be solved using models, instructors can introduce students to this process to prepare for professional practice.

Model Eliciting Activities (MEAs) are a way to make students think critically about open-ended problems. To ensure that new MEAs are held to a high standard they are subject to six basic principles: model construction, reality, generalizability, self-assessment, model documentation, and effective prototype.

1.) Model Construction: Requires the development of a model or decision algorithm.

2.) Reality: It must be set to a relevant engineering application.

3.) Generalizability: The resulting model should apply to other similar applications.

4.) Self-Assessment: The students must be able to verify the quality of their own work.

5.) Model Documentation: Requires a response or memo describing the model.

6.) Effective Prototype: Involves key engineering concepts that are usable in future work.

With these guidelines MEAs are being introduced into some of the courses in the Mechanical Engineering Department at Cal Poly. Several MEAs have been tried and tested in dynamics, thermodynamics, and mechanical engineering design courses. The next goal is to create an MEA for engineering statistics that includes a hands-on laboratory. The current project focuses on the statistical uncertainty in measuring devices during the process of making steel.

Current MEA Project Description

Steely Dan Steel Manufacturing (fictitious client) has asked Cal Poly to help them choose data acquisition (DAQ) systems to better ensure the consistency of their steel. Steely Dan needs to decide which temperature-measuring DAQ system they should use for each of the steps needed to create steel. Each process has an optimal temperature range with varying allowance for error. The temperature needs to be monitored and averaged continually to ensure consistent results. More expensive DAQ systems are able to take more temperature measurements per second. The student teams will generate a model that takes the desired temperature range and uses it to decide which DAQ system is most appropriate. After checking the model with a DAQ system in the lab, an appropriate DAQ system needs to be found for Steely Dan's blast furnace. Afterwards, Steely Dan needs a memo that describes how they can use the model to choose the necessary DAQ system for each of their other steel processes.

Before the Cal Poly student teams can start they need to be briefed on infrared temperature sensors and how they are used in steel processes. Before the lab, a short quiz assesses their statistics background and includes some open-ended questions about uncertainty.

This MEA will be implemented in a three hour thermal measurements lab in the winter quarter of 2010. The lab has 16 students in their 2nd or 3rd year of college and focuses on hands-on engineering statistics. The main concepts that are being taught in the MEA are the uncertainty associated with finite samples and the inherent uncertainty in temperature measuring devices. Table 1 presents a list of the MEA principles and how the current project satisfies each one.

Table 1: Below is a list of the principles and how the MEA satisfies each one.

Principal of MEA Construction	**Satisfied by:**
Model	The students are creating a system to determine an appropriate DAQ for steel processes.
Reality	High quality steel needs to be made at very specific temperatures for consistency. High-grade infrared temperature sensors are used to monitor these processes.
Generalizability	The model is applied to the blast furnace only but can be used for any of the other steps in the creation of steel.
Self Assessment	The students are forced to check their model against data they collect in the laboratory.
Model Documentation	The student teams will write a memo explaining their model.
Effective Prototype	The concept of statistical uncertainty for finite samples is something that can be seen in many engineering industries.

The goal of MEAs is to promote real-world thinking that students can use as engineering practitioners. Experiences like creating a system model and thinking critically on open-ended problems are essential for success in the workplace. Guiding undergraduates into this type of thinking will better prepare them for the constantly changing field of engineering.

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