AC 2012-4062: ENGAGED IN THERMODYNAMICS - BUILDING INDUSTRY COLLABORATIONS FOR EDUCATION

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Engaged in Thermodynamics – Building Industry Collaborations for Education

I. BACKGROUND

This paper will discuss an on-going NSF-CCLI grant that addresses improvements in student pedagogy and educational materials for the engineering thermodynamics curriculum. This will be accomplished by completing development of the concept of an "Engineering Scenario". Engineering Scenarios are textbook supplements based on actual engineering facilities and equipment. They expand on the case study concept by including skills-based problems that can be used in place of traditional homework problems but written in the context of the real-world environment, as well as additional design problems based on design methods and actual solutions at real facilities. Accompanying supplementary and background information promotes increased inquiry-based or student-centered learning, better addresses students' real world expectations, and leads to an increase in overall student engagement. A Phase 1 grant allowed for the development and repeated formative assessment of a single scenario, leading to the current Phase 2 grant.

To test the Scenario concept, material was originally generated around the engineering facilities of Minnesota State University Mankato (MSU), located in southern Minnesota. This supplemental material was designed for dissemination in an electronic format and for use with standard thermodynamic textbooks on the market. The product was titled "Engaged in Thermodynamics" and was evaluated over two years in courses at MSU. Following extensive formative assessment several student guided modifications were made to the original format. Additional links and cross-links were placed throughout the narrative allowing students to move more seamlessly between related topics. Walk through videos of the plant were added to allow the students to get a better perspective of the size and location of all of the equipment. Audio commentary was provided on these videos by undergraduate research assistants working on the project. For all skill-based homework problems a "Reality Check" link was provided in the problem statement. This link takes the student directly to the location in the Background information that described the related real-world aspects of the problem. This made the material easier to use and navigate and promoted more student investigation into the problem background.

For full development of the material several additional facility types were selected that would span the field of thermodynamics. These facilities were selected based on several criteria: 1) they had to be recognizable and interesting to the students, 2) they should allow various skill and knowledge aspects of the thermodynamics curriculum to be addressed, and 3) existing contacts were in place that would facilitate access and advice. This resulted in the original list of facility types shown in Table 1. The types were divided into full scenarios, which would have extensive site information, and mini scenarios, which would be smaller more generic applications.

Based on feedback from faculty during a proof-of-concept workshop it was suggested that students might be more interested in local site descriptions, rather than descriptions from other geographic locations. Therefore, the full development plan was to identify two to three sites for

Table 1: Initial Facility Types Selected for Initial Scenario Development

Full Scenarios (5 facility types)
Combined Heating and Cooling, including Co-generation aspects
Brayton-Rankine combined cycle power plant
Nuclear power plant
Ethanol processing plant
HVAC facility

Mini Scenarios (4-6 application types)
Diesel generators
Refrigeration/Chiller units
Solar thermal heating
Fuel cells

each facility type. While this amplified the work involved, it was believed that the span of locations would offer more options for faculty and students to be engaged.

The development of the Engaged in Thermodynamics material relies on access to real world stories, data, and system information. This requires a close working relationship with operations and facilities staff as well as equipment manufacturers. This paper will discuss the careful balance of not demanding too much of the industry contact while obtaining quality and useful information. Challenges that have been faced by the grant team as well as the relationships that have evolved will now be detailed. Note, in most cases the names of specific companies and sites have intentionally been omitted in this paper.

II. INITIAL INDUSTRY INTERACTIONS

Initially it was decided to focus on a couple scenarios and complete them before working on the others. Since the combined heating and cooling scenario was already done for the MSU campus it was selected for completion. The combined cycle power plant was selected as the next one to work on. This would allow the inclusion of the Brayton cycle and air property information that goes along with the gas turbine application.

For the combined heating and cooling scenario, several possible central facilities plants were identified and researched around the country. Using the criteria previously discussed, students and faculty identified the ones they thought would help round out the material the best. For the second site, a college campus on the east coast was selected. This facilities plant offered topics of heating, cooling, and cogeneration using a gas turbine. In addition, there was an existing relationship with the staff. The difference in geographic region was also attractive. For the third site, the Center for Disease Control and Prevention (CDC) campus was selected. There was existing information discussing the many engineering design issues with the recent updating of their central facilities. The name recognition of the CDC was also seen as a benefit toward student engagement.

The staff at the college facilities plant was contacted first. They expressed interest and agreed to help. Permission was given to make use of any information and photos already on their plant website. However, they expressed concern that they would not have the time to help given reductions in plant personnel. The key to the Scenario concept is that it allows skill-based and design problems to be based around real world facilities, using real world values. This implies that a large amount of information must be gathered on system components, operating conditions, and design issues. This is not information that is typically provided in site descriptions online. A list of questions was prepared and submitted to the plant personnel to fill in these blanks. Despite repeated attempts to make contact by phone and email these questions remain unanswered. Knowing a little bit about the system the students then tried to research operating parameters for the specific components, such as the gas turbine. While this added some information it has not provided the parameter information for the overall system that is needed to put things into perspective for the students.

The Building and Facilities office for the CDC was also contacted. They were also positive and friendly. In this case a different situation arose. To help engage students the Engaged in Thermodynamics material makes maximum use of photos and videos of the real site. In the case of the CDC, security restrictions do not allow photos to be taken in many of the facilities. This places a severe restriction on what can be used and/or shown of the actual equipment.

Lastly, in the case of the combined cycle power plant, a local plant had recently been constructed and was identified as a "low effort" target site. The plant was designed and constructed by a design firm but is operated by a local utility. Several avenues were explored to find an initial contact for this site, including the company website, contacting the local Chamber of Commerce and utilizing the University's alumni and industry outreach services. To-date an appropriate contact has still not been identified.

III. SUBSEQUENT AVENUES OF COLLABORATION

Given the lack of success with the initial interactions, development goals were relaxed. Rather than focusing on certain facilities types, an approach of "take whatever presents itself" was adopted.

As mentioned, while information on the additional college facilities plant could not be obtained the make and model of their gas turbine was known. Students therefore set out to determine as much as they could about this one component. In the scenario material it would be necessary to have this data to construct skill-based problems dealing with the Brayton cycle and its processes. Information from the manufacturers that was available on the web was initially gathered and reviewed. While technically in-depth, the material left several values out and did not fully explain the reasons for or functioning of certain components. Therefore, efforts were made to contact the manufacturer. The international headquarters for the company instructed the students to contact the local branch offices around the country. These were then called and in each case the initial phone call was unsuccessful in making contact with an information source. For each phone call one of the first questions was also "Are you a college student?". An email for a sales engineer was finally received from one location. After a two week wait, the student was contacted by the engineer. This led to a detailed 45 minute phone call answering all of his questions with an exchange of email addresses.

A combined cycle power plant was also located in the region, but at a greater distance than the first. In contrast to the first plant, this site promoted community and educational interaction with the facility. The fact that they are part of a community cooperative power organization probably contributes to this. A site visit was quickly arranged. It was immediately clear that the type and level of questions they were used to getting were much more general. While they were initially hesitant to provide access to some information or to attempt some explanations, this quickly changed once they began to interact with the students. The fact that the students had already researched the equipment, knew the terminology, and understood the technical answers made a great impact. This site has not only provided useful information for the Engaged in Thermodynamics material, but has expressed an interest in future class visits, student internships, and possible senior projects.

A third avenue that has opened up is for the fuel cell scenario. Feedback from students during the original proof-of-concept indicated that they were looking for more detailed and in-depth information in how the engineering equipment actually worked and was put together, rather than just theoretical equations. Additional efforts were therefore placed on creating or obtaining additional schematics, cross-sections, and animations of systems. During a professional development tour with a fuel cell manufacturer, the project was discussed with a corporate relations specialist. Permission was given to make images, explanations, and animations on the corporate web site. This will provide a rich source of information as we start to work on the fuel cell scenario.

IV. DISCUSSION AND FUTURE PLANS

As evident, there have been successes and failures with the industry collaborations on this project. The first thing that has resulted from this is a restructuring of the development plan. It no longer appears feasible to have such detailed information for every facility site. The current goal is to have complete parameters and properties for at least one site of each facility type. This will allow sufficient skill based problems to be generated. Other sites will still be researched and included, however, they will be used to compare and contrast the different designs and implementations. This will hopefully generate a more comprehensive education to the field and promote interest.

With regard to collaborations several lessons can be taken away. The difficulties experienced are not unexpected. Collaborations can be difficult. A typical collaboration between an engineering program and a company will involve a joint project (e.g. a senior project option). In these cases there is a possible benefit to the company. When gathering information for educational material when no such concrete benefit exists, an existing relationship or appealing to altruistic motivations are the only avenues.

For a project like this there are several types of support that can be negotiated with industry collaborators. Listed from easiest to hardest they are:

- Make use of existing materials and resources; such as web resources, photos, reports, and magazine/journal articles.
- Visit the facility and take photos and/or get snap shots of things like control panels.
- Hold question and answer sessions where specific information can be filled in.
- Get full access to design reports and interviews with personnel about projects and decisions at the facility.

Three lessons for dealing with potential collaborators can also be taken away:

- Do not waste their time – Do your homework and be prepared with short directed queries.
- Be patient and persistent – Their time is short and may come in spurts.
- Be flexible and embrace opportunities.

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