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Engaged in Thermodynamics - Student Engagement in the Classroom

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Abstract

This paper will discuss an on-going NSF-CCLI grant that addresses improvements in student pedagogy and educational materials for the engineering thermodynamics curriculum 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 student 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. At this stage of the grant, assessment is being conducted in thermodynamics classes at several institutions. Surveys related to student engagement are being given to track student reactions to the thermodynamic material across the semester.

I. Background

The "Engaged in Thermodynamics" material is intended to address several pedagogical difficulties in thermodynamics, and related, courses. With a focus on real world content and design information the material is intended to promote student interest and engagement. Expanding on a case study format, additional background information is added to allow the student to form a connection to the real-world environment. The term Engineering Scenarios has been coined for the resulting material.

In the original concept, each Engineering Scenario would be based on a specific real-world engineering facility in a form similar to, but expanded from, a case study[1]. The scenario would include extensive background information on the facility, including images and schematics of key components, narratives on facility history and purpose, and information on the engineering personnel responsible for the facility. A complete scenario is generated from a combination of narratives, skill-based problems, and design problems. Skill-based problems differ from existing textbook problems in that they are written in the context of the existing facility instead of being written in generic terms. By basing these problems on a specific and well-researched facility the instructor's knowledge is fortified and the student's interest can be exploited to encourage greater engagement.

Previous research, conducted as part of a NSF CCLI Phase 1 project, determined that students typically come into a thermodynamics course with a high expectation of being exposed to real world content. With a traditional textbook and course format these expectations were not met. However, using early versions of the Engaged in Thermodynamics material the student expectations were better met. Initial research also indicated that there was a significant relation between final grade and the level of student engagement. The focus of the current work is to 1) expand the material content, 2) promote use of the material at other institutions, and 3) assess the student impact of the material.

II. Overview of Engaged in Thermodynamics

The Engaged in Thermodynamics material has been constructed in a web based format. This allows easy dissemination and flexibility in classroom use. The material consists of background information for thermodynamics related facilities, engineering information for the systems and components found in the facilities, homework style problems based on the facilities, and design problems taken from the facilities. Currently descriptions for three locations, six basic systems, and seven basic components are included and used for problems (Table 2).

Examples of the material pages are shown in Figure 1 and Figure 2. The current version of the material (Version 3b) can be found at http://cset.mnsu.edu/engagethermo.

Table 2: Topics currently covered in the Engaged in Thermodynamics material.

Locations	Minnesota State University, Mankato Facilities Plant
	The College of New Jersey Cogeneration Plant
	Faribault Energy Park
Systems	Gas Turbine Plant
	Combined Cycle Plant
	Cogeneration
	Generator Sets
	Centralized Heating and Cooling Plant
	Military Tanks (Drivetrains)
Components	Boiler
	Chiller
	Cooling Tower
	Steam Turbine
	Gas Turbine
	Diesel Engine
	Fuel Cell

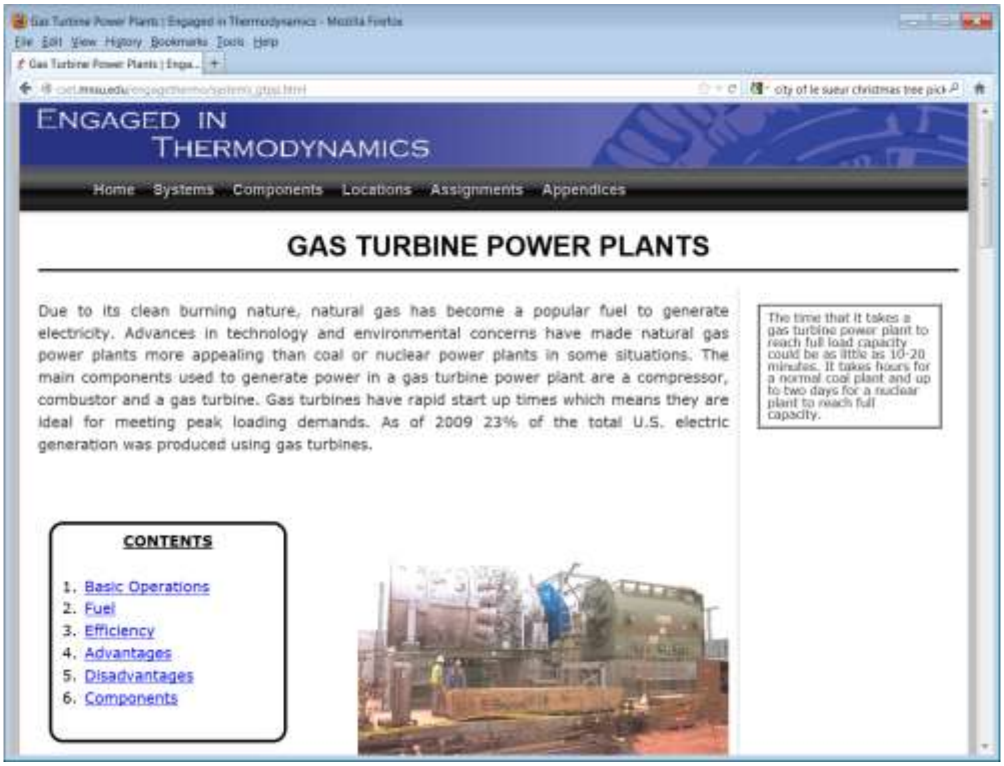

Figure 1: Example of a System homepage.

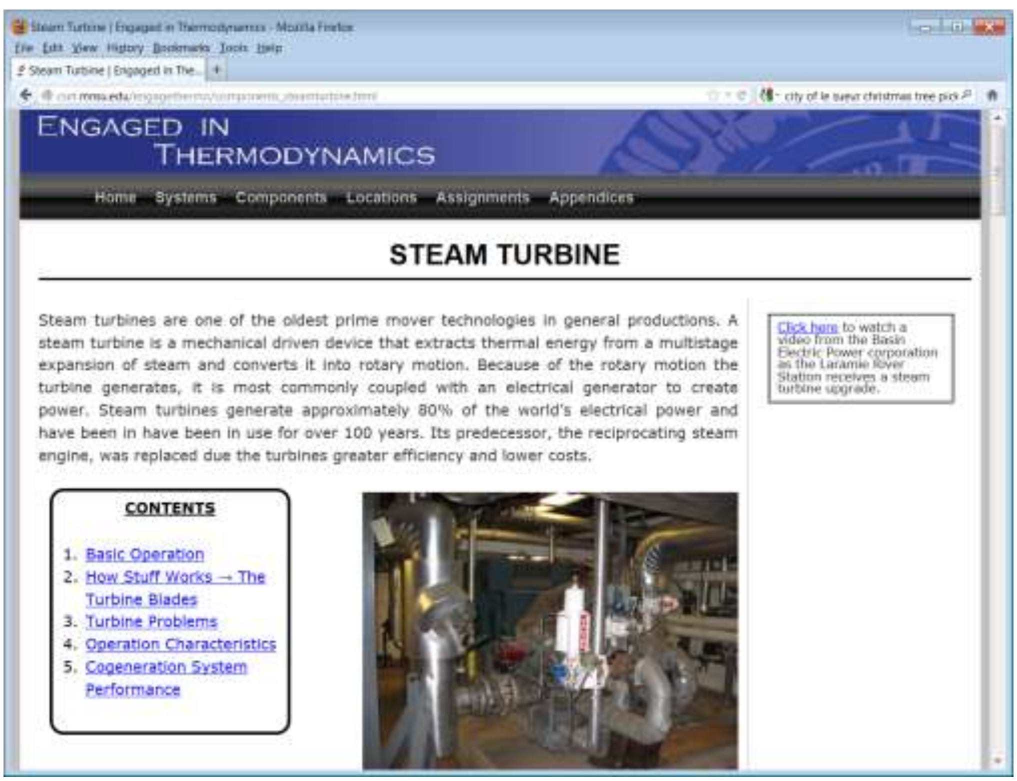

Figure 2: Example of a Component homepage.

III. Overview of Student Engagement

Considerable educational research in recent years has been devoted to the topic of student engagement. However, the definition of engagement continues to be elusive. Other terms that have been used for engagement include “quality of effort” and “involvement”.[2] Student and faculty opinions of what constitutes engagement have also been shown to differ.[3] Research has shown a clear link between environment, curriculum, and student engagement.[4,5] Smith et al. have provided an overview of several classroom practices aimed at promoting engagement.[5]

One of the most popular methods of measuring student engagement is the National Survey of Student Engagement (NSEE). The NSEE survey focuses on aspects of student participation in activities as an indication of engagement and pedagogical quality[6]. For the purposes of this grant research it was desired to have a quick in-class method of measuring engagement. While the NSEE and the CASEE surveys are well documented instruments it was decided they were too time intensive to provide the quick snapshot this project was seeking. Using these surveys as a guide and with substantial feedback from undergraduate students a shortened survey was created. It consists of five questions measured on a 5-point Likert scale (Table 2). In their current form these questions have been referred to as an “Opinionairre”.

Table 2: Questions from the “Engaged in Thermodynamics Student Opinionnaire”

1. Compared to other courses in engineering, do you find yourself wanting to learn more in this course?
2. Compared to other courses in engineering, are you asking more questions about the material? (in and outside of class)
3. Compared to other courses in engineering, do you talk/think more about the material in this course?
4. Compared to other courses in engineering, do you find you are preparing better for this class?
5. How well do you think you are doing in this course so far?

IV. Assessment Data

During Fall 2012 the engagement Opinionairre was administered in two separate, and distinct, thermodynamics courses (each at a different institution). The survey was given near the end of the semester. Basic statistics on the results are shown in Table 3. The primary difference between the two courses was size (N = 51 versus N = 5). In addition, Course A made use of the Engaged in Thermodynamics material while Course B did not. The average response to student interest was higher for Course A, which made use of the Engaged material, but the small sample size precludes a definite correlation. Looking at correlations between the five opinionairre questions provides interesting insights. For both courses, the correlation coefficient between question #1 and #2 was essentially zero. This would seem to indicate that there is no correlation between students desire to learn and the amount of questions they ask. The correlations between question #3 and #4 for the two courses were 0.46 and 0.78, respectively. This indicates a moderate to high correlation between students talking about the material and preparing for class. Similarly the correlation between questions #4 and #5 indicated a moderate to high correlation, with values of 0.49 and 0.78 respectively. As would be hoped this indicates, at least a student perception, that preparing better for a course correlates to performance in the course. Taking these two correlations together one might conclude there would also be a positive correlation between questions #2 or #3 and #5. In other words, that an increase in asking more questions in class or thinking about the material more would result in an increase in performance. However, while positive correlations were found these were weaker and ranged from 0.19 to 0.36.

Students were also asked to provide input on what aspects were the most and least engaging in the course. Of the 56 total respondents, 15 included an answer related to real world application or examples as a positive aspect. Responses concerning negative answers were not as specific. However, the difficult nature of the material and 2nd Law aspects (entropy and exergy) were cited often.

Table 3: Opinionairre results for Fall 2012.

Course A	Question #1	Question #2	Question #3	Question #4	Question #5
N = 51					
Average	3.8	3.3	3.7	2.9	3.0
Std Dev	1.2	1.2	1.1	1.2	0.9
Course B					
N = 5					
Average	3.2	3.3	3.7	2.8	3.4
Std Dev	1.5	1.6	1.2	1.0	1.3

Table 4: Correlation of Opinionairre questions for Fall 2012.

	Question #1	Question #2	Question #3	Question #4	Question #5
Course A					
Question #1		0.08	0.28	0.37	0.26
Question #2	0.08		0.48	0.29	0.19
Question #3	0.28	0.48		0.46	0.27
Question #4	0.37	0.29	0.46		0.49
Question #5	0.26	0.19	0.27	0.49	
Course B					
Question #1		-0.03	0.04	0.44	0.54
Question #2	-0.03		0.37	0.54	0.30
Question #3	0.04	0.37		0.78	0.37
Question #4	0.44	0.54	0.78		0.78
Question #5	0.54	0.30	0.37	0.78	

V. Conclusions and Future Work

The assessment phase of this research is still in its initial stages. While the data hints at interesting aspects, additional data will be needed to make more significant conclusions. Data collection will continue through the Spring 2013 semester. In addition, faculty and student focus groups will be conducted in conjunction with the numerical surveys. The additional qualitative data should provide added insight into the student perceptions of the courses and the Engaged in Thermodynamics material. With more information on the exact format of the courses and the manner in which the Engaged material was used a better correlation between student engagement and the material can be made.

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