AC 2011-2460: STUDYING THE IMPACT ON MECHANICAL ENGINEERING STUDENTS WHO PARTICIPATE IN DISTINCTIVE PROJECTS IN THERMODYNAMICS

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Studying the Impact on Mechanical Engineering Students who participate in Distinctive Projects in Thermodynamics

Abstract

This paper summarizes two projects which were created in 2001 and incorporated within a Thermodynamics and Advanced Thermodynamics course. Intended learning outcomes of the projects include strengthening Thermodynamics related knowledge; improving communication abilities, and strengthening intellectual curiosity in areas related to thermodynamics and mechanical engineering, in general. The focus of this paper is on the framework development to measure certain effects that project participation may have had on student participants. In 2001, the projects were introduced and over the past nine years, each project has been refined through assessment in order to improve student learning while achieving intended learning outcomes. The two projects which were designed to prolong and strengthen students' interest in areas related to thermodynamics. The first project is an individual project within Thermodynamics which requires students to critically read a technical book related to Thermodynamics, technically review the book in written form, and orally present results to the class in an informal setting. The second is a team-based project within Advanced Thermodynamics which requires student teams to create and present a class-long presentation for a non-technical audience. The content of the presentation must strongly relate to Thermodynamics and have direct relevance to the audience. Past student teams have presented to a variety of audiences ranging from college level liberal arts classes to middle and high school science, math, and technology classes.

This paper includes a brief background of both projects with project rationale, past assessment results, and discussions on project refinement. A key element of the paper is the development of an enhanced assessment strategy to measure impact associated with participation on the team-based presentation project. An indirect measure involving focus groups is also introduced and administered on a pilot basis with sample results presented.

Background

Rochester Institute of Technology (RIT) has one of the oldest cooperative education programs in the country and therefore RIT firmly believes in learning through doing. The RIT Mechanical Engineering Department offers an Accreditation Board for Engineering and Technology (ABET) accredited degree in mechanical engineering (ME). Each fall, approximately 150 entering first year students select ME as a major. All ME majors enroll in Thermodynamics (ME 413) during their second or third years while a subset enrolls in Advanced Thermodynamics (ME 680) during their fourth or fifth years. ME 413 and 680 form a progression in course work into the study of Thermodynamics and, therefore, the courses are carefully integrated. For a detailed description of ME 413 and ME 680 refer to Bailey et al., 2004 [1]. After successfully completing Advanced Thermodynamics, students can choose to continue the study of classical thermodynamics by selecting a capstone design experience which incorporates advanced thermodynamics principles as discussed in George et al, 2006 [2]. A select group of students also conduct thermodynamic related research in their pursuit of a Masters of Science degree and related publications [3,4,5].

The team based presentation project evolved within advanced thermodynamic courses as a way to introduce upper-level engineering students to an engineering outreach opportunity while also strengthening communication skills and deepening engineering knowledge. The need for more workers with an engineering background in the coming years is clear [6] and it is often necessary for students to track into appropriate math and science classes as early as middle school if they are to be ready for a college engineering curriculum. RIT already has an active women in engineering (WE@RIT) outreach program [7] with a successful infrastructure in place, so it is a natural extension of work already being done within the college to start a program to recruit both young women and men into the engineering disciplines.

Based on feedback from participants in women-in-engineering outreach events at RIT, interaction with college students was always near the top of the list of program features the participants enjoyed [7]. At the same time, RIT students working as lab instructors on-campus or participating in teaching activities off-campus report that they viewed teaching experience as a valuable part of their college careers [8]. Data showing students' personal views on how they benefit by working as teachers of engineering is supported by other similar programs, such as STOMP at Tufts University [9,10]. The literature consistently reports that learning through teaching is highly effective in enhancing student learning [11-14].

This paper focuses on the development of a revised assessment strategy which will aim to measure lasting impact associated with project participation. The projects of interest are assigned within ME413 and ME680 and have been described in detail in a past publication by Bailey, 2008 [15]. A paper presented at the ASEE 2002 National Conference includes information regarding both projects in their earliest forms [16]. To provide sufficient context for the discussion of developing a revised assessment strategy, the *Course Project Overview* section of this paper offers a brief overview of the technical book review and team-based presentation projects assigned during Thermodynamics (ME 413) and Advanced Thermodynamics (ME 680), respectively. Included in this section are learning outcomes, deliverables and evaluation rubrics used for direct measures. The *Project Assessment Results: Technical Book Review* section presents results of project assessment based on indirect measures assembled from student feedback for each project. The final section, *Project Assessment Results: Team-Based Presentation*, describes a revised assessment strategy which includes efforts to measure impact associated with project participation through additional indirect survey instrument and focus group administration.

Project Overviews

The technical book review project, assigned in Thermodynamics, is an individual assignment that involves critically reading a technical publication, reviewing the publication, and presenting the results to the class in an informal setting. The technical publications selected by the students include books from a wide variety of topics, ranging from artificial intelligence to hybrid vehicle design and infrastructure issues. Students must relate topics explored within the book with topics learned in Thermodynamics. Thus, in writing a review, the student combines the skills of describing what is on the page, analyzing how the book tried to achieve its purpose as well as how it relates to Thermodynamics, and expressing personal reactions. A page-long list of suggested books is provided to the students at the time of project assignment. Detailed

information on the project's purpose, learning outcomes, scope, and milestone schedule is included as Figure 1. Performance criteria used to assess and evaluate the student's performance on the technical book review are included as Figure 2. The project's performance criteria (Figure 2) clearly show these expectations in order to aid students in the creation of the written document and expedite evaluation of written work.

Figure 1. Purpose, Learning Objectives, and Deliverables Associated with Technical Book Review Project Assigned in Thermodynamics (ME 413)

Purpose: This quarter in ME 413, students will complete a project worth 100 Points (10% of the overall course grade). The project is an **individual assignment** that involves critically reading a technical book, reviewing the book, and presenting your results to the class in an informal setting. *(Refer to Enclosure 1 for book selection ideas.)*

Learning Outcomes:

- Promote scholarly curiosity and research.
- Practice careful analytical reading.
- Develop lifelong learning abilities which are critical for engineers due to the acceleration of technical progress in application areas associated with thermodynamics.
- Enhance creativity through the creation of a relevant and appropriate review.
- Relate the study of thermodynamics to application(s) and/or topic(s) explored within approved technical book.

Scope and Details: *(Refer to Enclosure 2 for more information.)*

- Critically read a technical publication (approved by course instructor).
- Prepare a book review (1200 words MAX).
- Present your findings in an informal setting to your classmates.

Grade Plan and Project Milestone: Deliverables are graded events that are required no later than the dates specified. Submit to *mycourses dropbox* by noon on the date due.

PART II	**Due Date**	**POINTS**
Book Selection MEMO	Friday, week 2	5
Submission 1: Heading, Introduction, and Background	Friday, week 4	25
Submission 2: Summary + Incorporate Revised Past Submission(s)	Friday, week 6	25
Submission 3: Evaluation + Incorporate Revised Past Submission(s)	Friday, week 7	20
Submission 4: Conclusion- Final Project Submission, Incorporate All Past Revised Submission(s)	Friday, week 9	25
TOTAL		**100**

Figure 2. Performance Criteria for Technical Book Review Project Assigned in Thermodynamics (ME 413)

Book Selection Memo **Score: /5**

Performance Criteria	Score	Strengths	Areas for Improvement	Insights
Appropriate Memo Format (2)				
Book Selection (1)				
Reason Stated for Book Selection (2)				
TOTAL (5 Points)				

Submission 1: Heading, Introduction, and Background **Score: /25**

Performance Criteria	Score	Strengths	Areas for Improvement	Insights
Spelling/grammatical errors ((1) each)				
Heading (5)				
Introduction (10) book type; summary of technical book review; book overview and purpose; intended audience; personal reaction (hold space)				
Background Info. (10) book's context; criteria for evaluation				
Reference all Sources				
TOTAL (25 Points)				

Submission 2: Summary + Revised Submission 1 **Score: /25**

Performance Criteria	Score	Strengths	Areas for Improvement	Insights
Spelling/grammatical errors ((1) each)				
Include Revised Past Submission(s) Incorporated within New Submission (5)				
Summary (20) book thesis; main points; include primary supporting points and thermo. related discussion				
Reference all Sources				
TOTAL (25 Points)				

Submission 3: Evaluation + Revised Submissions 1, 2 **Score: /20**

Performance Criteria	Score	Strengths	Areas for Improvement	Insights
Spelling/grammatical errors ((1) each)				
Include Revised Past Submission(s) Incorporated within New Submission (5)				
Intro (5) brief personal reaction within this section if not done so already				
Evaluation (10) reaction to book with explanation; personal effect				
Reference all Sources				
TOTAL (20 Points)				

Submission 4: Conclusion- Final Project Submission **Score: /25**

Performance Criteria	Score	Strengths	Areas for Improvement	Insights
Spelling/grammatical errors ((1) each)				
Appropriate Length –1200 word max (5)				
General Structure and Organization (5) include sub-headings if necessary				
Include Revised Past Submission(s) Incorporated within New Submission (5)				
Conclusion (10) summarize ideas; advice for potential readers				
Reference all Sources				
TOTAL (25 Points)				

The team-based presentation project, assigned in Advanced Thermodynamics, is a team (2 or 3 person) assignment that involves creating and giving a forty minute long presentation for a specified audience. The content of the presentation must strongly relate to Thermodynamics and relevance must be established with the audience. Typical target audiences are non-technical; past examples include middle and high school math, science, technology classes or liberal arts classes. Detailed information on the project's purpose, outcomes, scope, and milestone schedule is included as Figure 3. Performance criteria used to assess and evaluate the student's performance on deliverables associated with the project are included as Figure 4. Student teams are required to submit a preliminary work plan which includes topic to be taught and specific target audience information. Half-way through the quarter, team-based In-Progress Reviews are scheduled in order for the team to walk-through the presentation with the professor. Prior to the final presentation, each team does a mock presentation to the class where peers provide assessment. Because many of the students in ME 680 are concurrently enrolled in the Multidisciplinary Senior Design course [17,18], elements related to the design process are listed on the milestone schedule (Figure 3) and within the performance criteria (Figure 4) to tie curriculum and reinforce the usefulness of a detailed design methodology.

Team presentations during the fall of 2010 included the following:

- "Basics of a Refrigeration Cycle" class was presented by two ME students (one male and one female) to a 7th grade enriched science class. Presentation included props which were passed around and questions designed to engage the 7th grade students. Teacher invited ME students to visit the classroom again for a follow-up session.
- Two ME students (two males) visited a Biology high school class and presented on "Marine Propulsion and Green Applications." Presentation included discussions/video clips on two-stroke diesel engines and emerging products which augment these engines through the use of solar cells and wind power.
- A first for ME 680 was the creation of a presentation that supported an existing Boy Scout merit badge. Three ME students (one female and two males) created a two-hour workshop titled "Sustainable Energy: Dawn of a Cleaner Future" for a local Boy Scout troop in support of their Energy merit badge. The presentation included video clips and animations as well as several hands-on activities involving fuel cell car kits and solar cells. The hands-on activities were borrowed from the Traveling Engineering Activity Kit (TEAK) Program [19]. The TEAK program was started over six years ago within the engineering college at RIT and it involves engineering students creating educational kits and curriculum to teach pre-engineering content to middle school students. Engineering students create the kits and then use them to teach middle school students. The ME 680 students were able to easily learn how to use the kits for instruction due to the documentation developed as part of the TEAK program.

Figure 3. Purpose, Learning Outcomes, and Deliverables Associated with Team-Based Presentation Project Assigned in Advanced Thermodynamics (ME 680)

Purpose: This quarter in ME680, students will complete a team (2 to 3 person) project with a total point value of 250 Points, roughly 25% of the overall course grade. The project assignment involves creating and giving a 40-45 minute long presentation/demonstration for a specified audience. The content of the presentation must strongly relate to Thermodynamics and have direct relevance to the audience.

Learning Outcomes:

- Enhance creativity through the creation of a relevant and appropriate presentation.
- Practice a systematic design process.
- Design presentation with your audience in mind.
- Create activities to stimulate audience interest and involvement.
- Assess presentation (following classroom interaction) while focusing on strengths, areas of improvements, and insights gained.
- Apply and strengthen Thermodynamic knowledge through teaching others.
- Improve communication abilities through written, verbal, and graphical means.
- Strengthen teamwork abilities.

Scope and Details:

- Design a presentation/demonstration for an identified target audience.
- Create a relevant, interesting talk.
- Include computer simulations, adequate graphics, and/or hands-on activities.
- Establish relevance with audience.
- Create activities that engage your audience. (If a student falls asleep during your presentation it is an automatic point deduction!)
- Assess presentation, focusing on strengths, areas of improvements, and insights gained.

Grade Plan:

GRADED EVENT	POINTS
Proposal Memorandum (Team)	20
In-Progress Review (Team)	40
Peer Review (Team)	80
Presentation (Team)	60
Assessment (Individual)	50
TOTAL	**250**

Project Milestone: Deliverables are graded events that are required no later than the dates specified.

Date	Deliverable (Point Value)
Thursday, week 3	**Team Deliverable: Proposal Memorandum (20 Points)** Memo must demonstrate completion of the following: Recognize and Quantify the Need, Develop Preliminary Work Plan, Establishing Design Objectives and Criteria; Concept Development (50% Complete)
Tuesday through Thursday, week 4	**Team Deliverable: In Progress Review (40 Points)** Concept Development (100% Complete); Detailed Design (DD) (50% complete)
Thursday, week 6	**Team Deliverable: Peer Review (80 Points)** Detailed Design (95% complete)
weeks 7 – 9	**Team Deliverable: Thermodynamics Presentation (60 Points)**
Within two business days of presentation	**Individual Deliverable: Assessment (50 Points)** Memo must include all relevant materials and self as well as team assessment.

Figure 4. Performance Criteria for Team-Based Presentation Project Assigned in Advanced Thermodynamics (ME 680)

Team Proposal Memo **Score: /20**

Performance Criteria	Score	Strengths/Insights	Areas for Improvement
Memo Format (2)			
Grammar, sentence/overall structure, etc. (-2 per typo)			
Recognize and Quantify the Need (2)			
Develop Preliminary Work Plan for project (2)			
Establish Design Objectives and Specs (4)			
Concept Development (5)			
Signatures from All Members (2)			
Work Plan presentation time/audience details (5)			
Total (20)			

Team In-Progress Review **Score: /40**

Performance Criteria	Score	Strengths/Insights	Areas for Improvement
IPR Format (4)			
Total Team Involvement (4)			
Final Work Plan - presentation admin. details (4)			
Comply w/ established Design Obj. & Criteria (5)			
Concept Development (10)			
Develop Presentation, demos, handouts (8)			
Address Comments from Memo Feedback (5)			
Total (40)			

Peer Review Performance Criteria **Score: /80**

Performance Criteria	Score	Strengths/Insights	Areas for Improvement
Total Team Involvement (10)			
Establish relevance with audience(10)			
Quality of Oral Presentation (10)			
Adequate, Clear Graphics (10)			
Create Experience that Engages Audience (30)			
Appropriate Length (10)			
Total (80)			

Team Presentation **Score: /60**

Performance Criteria	Score	Strengths/Insights	Areas for Improvement
Total Team Involvement	REQ		
Introduction (10)			
Establish relevance w/ audience (10)			
Quality of Oral Presentation (10)			
Adequate, Clear Graphics (10)			
Create Experience that Engages Audience (10)			
Appropriate Length (10)			
Total (60)			

Individual After Action Report Memo **Score: /50**

Performance Criteria	Score	Strengths/Insights	Areas for Improvement
Memo format (3)			
Include Attachments (5)			
Grammar, Spelling, Readability (10)			
Discuss 3 (min)- strengths, improvement, insights (32)			
Total (50)			

Table 1 includes a summary of the technical book review and the team presentation project participation history, from initial pilot at the United States Military Academy at West Point to the present.

Table 1. Participation History of Project Assignments

Semester or Quarter Info.	Number of Students	Course (Institution, year level)	Project Type
Fall 2001	8	ME 472 (USMA, 4th)	Book Review
Fall 2002	18	ME 472 (USMA, 4th)	Book Review
Fall 2003	18	ME 413 (RIT, 3rd)	Book Review
Spring 2004	19	ME 660 (RIT, 3rd)	Book Review
Fall 2004	50	ME 413 (RIT, 3rd)	Book Review
Fall 2005	38	ME 413 (RIT, 3rd)	Book Review
Winter 2005/06	170	ME 413 (RIT, 2nd)	Book Review
Fall 2007	33	ME 413 (RIT, 2nd)	Book Review
Winter 2007/08	31	ME 413 (RIT, 2nd)	Book Review
Sub-total	**385**		**Book Review**
Fall 2001	8	ME 472 (USMA, 4th)	Team Presentation
Fall 2002	18	ME 472 (USMA, 4th)	Team Presentation
Spring 2005	3	ME680 (RIT, 4th - 5th)	Team Presentation
Spring 2006	18	ME680 (RIT, 3rd - 5th)	Team Presentation
Spring 2007	18	ME680 (RIT, 3rd - 5th)	Team Presentation
Spring 2008	18	ME680 (RIT, 3rd - 5th)	Team Presentation
Fall 2010	7	ME680 (RIT, 3rd - 5th)	Team Presentation
Sub-total	**90**		**Team Presentation**

As indicated in Table 1, the technical book review project has been assigned to varying audience sizes and year groups. Students who have completed this project range in year level from second through fifth year standing. The author has found that notable successes on both projects are demonstrated by students of all year levels. There have been many examples of the book review project sparking an interest in a second or third year student which has lead that individual towards a certain co-op position, capstone design project, or research. The team presentation project has sparked an interest for students in the area of engineering education and students have gone on to participate as teaching assistants or as teachers in pre-engineering outreach initiatives like those sponsored through the WE@RIT program [7].

Over the past five years, steady improvements in student performance on both projects have occurred due to changes in feedback and grading structures as well as student expectations. For the technical book review, for example, the submission has been broken down into smaller assignments spread over the quarter. This change eliminated the prevalent practice of students waiting until the weekend before the review was due to start reading the book and writing the draft. Because students have nearly two months to read the book and write the rough draft, its graded weight has been increased significantly to encourage students to produce a near-final product which has been carefully edited. In order to assist students in this task, a thorough set of expectations are provided in the project's performance criteria (Figure 2). Typically the student's product is nearly complete in the rough draft form and only minor edits are necessary for the final submission.

The team-based presentation assignment has been refined as well over the years to improve the overall learning experience. Team sizes have been reduced from 3-4 person teams to 2-3 member teams. This allows for more participation from all team members. Presentation lengths have been increased from 20-30 minutes to 40 minutes (approximately) to allow students the time necessary to include hands-on activities and/or demonstrations within their classroom visit. Emphasis has been placed on the in-class peer-review in order to encourage teams to refine their presentations and activities for this graded event rather than in the days before their actual classroom visit. Graded events leading up to the peer review allow students to gain feedback on their presentation design and these have also been emphasized more in terms of point value. In addition, the role of leader on the team presentation project is more defined and has become more important over the years, adding a positive dimension to most of the team's experiences. It has certainly helped with the administration of this project due to the responsibilities that the leader assumes in team planning and scheduling.

Project Assessment Results: Technical Book Review

Formative assessment results based on student opinion data after completing the individual technical book review project assigned in Thermodynamics during the fall quarter of 2005 and winter of 2008 are included in Tables 2 and 3 with a student respondent sample size of 24 and 28, respectively. Student opinion data has been collected during all offerings of this project, however because the associated learning objectives have evolved over time, consistent data for comparison purposes is unavailable. Based on opinion data results collected in 2005 and 2008 for questions associated with a subset of project learning outcomes (Figure 1, Tables 2 and 3) student reported opinions declined in every area. Due to a curriculum change within ME between the 2005 and 2008 offering of this course, the year level of the student enrolled in Thermodynamics dropped from 3rd year to 2nd year (Table 1). This is a potential factor in explaining the general decline in student opinion regarding the course project and its value.

Table 2. 2005 Student Opinions Regarding Technical Book Review Project (n=24)

Question **Scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree*	**Average Rating**
Through completion of the ME 413 project I….	
promoted scholarly curiosity and research.	**4.1**
practiced careful analytical reading.	**4.2**
enhanced lifelong learning abilities.	**3.7**
enhanced creativity through the creation of a relevant and appropriate review and discussion.	**3.8**
strengthened assessment and evaluation abilities through preparation of book review.	**4.1**

The students' tendency to make a connection between the project and its promotion of intellectual curiosity declined from 4.1 to 3.5, careful analytical reading declined from 4.2 to 3.4, and so on, where a rating of five reflects a strong agreement and one represents a strong disagreement with the provided statement. To improve clarity of the survey question, the 2005 question related to "lifelong learning abilities" was rewritten to refer to "independent learning abilities" and the opinion data declined most significantly on this question from 3.7 in 2005 to 2.9 in 2008.

Table 3. 2008 Student Opinions Regarding Technical Book Review Project (n=28)

Question **Scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree*	Average Rating
Through completion of the ME 413 project, I….	
promoted scholarly curiosity and research.	**3.5**
practiced careful analytical reading.	**3.4**
enhanced independent learning abilities.	**2.9**
enhanced creativity through the creation of a relevant and appropriate review.	**3.1**
related the study of Thermodynamics to some aspect related to or discussed within my book.	**3.5**

Comments written on feedback forms in 2005 and before also provide insight into the student's opinion of this project. Representative examples are included below:

- *"The project is a great idea…might want to offer a wider selection of texts to read…overall a fun project"*
- *"I wasn't expecting to be doing a book review in Thermo, but it turned out to be a very rewarding experience. It gives students the opportunity to broaden their horizons..."*
- *"This book review was good in that it was designed to open our horizons to other fields of engineering. The only problem is that it was a lot of work along with all of the work we already had to do for the course."*
- *"Good to do something other than normal engineering problem solving."*

Comments written on feedback forms in 2008 were limited in number (7/28 provided written feedback). Representative examples are included below:

- *"The project is short and to the point."*
- *"I did not find the project useful at all. Just another hassle to deal with."*
- *"I feel that the technical book review was unnecessary."*

Shifting the year level of students who take Thermodynamics from 3rd to 2nd year coincided with a drop in general course performance as witnessed by declining exam averages. Based on several factors considered during the assessment of the book review project, the author decided to remove the project from the current offering of Thermodynamics. Plans for incorporating the project into another 3rd year ME course or into the semester lone version of Thermodynamics (transition from quarters to semesters will take place in 2013) are under consideration.

Project Assessment Results: Team-Based Presentation

Formative assessment results based on student opinion data after completing the team-based presentation project assigned in Advanced Thermodynamics during the spring quarter of 2006 and fall of 2010 are included in Tables 4 and 5 with a student respondent sample size of 13 and 6, respectively. Some questions were reworded over this time period (questions 2 and 3 from 2006 survey) to improve readability. Based on the results of opinion data analyzed in 2006 and 2010 for questions associated with a subset of project learning outcomes (Figure 3), students made a strong connection between the project and promoting their creativity, communication abilities, teamwork skills, and self-assessment abilities while strengthening their knowledge of Thermodynamics.

Table 4. 2006 Student Opinions Regarding Team-Based Presentation Project (n=13)

Question **Scale: 1 = unsatisfactory; 2 = marginal; 3 = satisfactory; 4 = above average; 5 = excellent*	Average Rating
Through my involvement with the ME680 Team Presentation….	
1. I enhanced my creativity through the creation of a relevant and appropriate presentation.	**3.9**
2. I used a design process to create a presentation with my audience in mind.	**3.9**
3. I enhanced my creativity by creating an activity to stimulate audience interest and involvement.	**3.8**
4. I improved my self-assessment skills by completing a self-assessment based on my presentation.	**3.7**
5. I applied and strengthened my Thermodynamic knowledge through teaching others.	**4.2**
6. I have improved my communication effectiveness by written, verbal, and/or graphical means.	**4.5**
7. I have improved my teamwork abilities.	**4.3**
8. I have improved my understanding of contemporary issues associated with the field of mechanical engineers.	**4.5**

Table 5. 2010 Student Opinions Regarding Team-Based Presentation Project (n=6)

Question **Scale: 1 = unsatisfactory; 2 = marginal; 3 = satisfactory; 4 = above average; 5 = excellent*	Average Rating
Through my involvement with the ME680 Team Presentation….	
1. I enhanced my creativity through the creation of a relevant and appropriate presentation.	**4.3**
2a. I improved my design skills by using a systematic design process in creating the presentation.	**3.6**
2b. I designed the presentation with my audience in mind.	**4.5**
3. I created activities to stimulate audience interest and involvement.	**4.5**
4. I improved my self-assessment skills by completing a self-assessment based on my presentation.	**4.3**
5. I applied and strengthened my Thermodynamic knowledge through teaching others.	**4.5**
6. I improved my communication effectiveness by written, verbal, and/or graphical means.	**5.0**
7. I improved my teamwork abilities.	**4.5**

The After Action Memo required on this project after the team's final presentation is an excellent means to assess student learning and impact. In 2010 a focus group was also added as an indirect assessment measure. Representative quotes from memos and the focus group include:

- *"I get so used to dealing with engineers that talking to a non-technical audience about thermo was a great experience."*
- *"I really needed to know the topics that we taught."*
- *"Project definitely improved team work abilities"*
- *"Would like to do more of these types of projects in other engineering classes"*
- *"I was so nervous about giving this presentation that I had trouble sleeping the night before but all of the practice in class helped and I was able to do a good job."*
- *" I used to be confident in my communication effectiveness - this project showed me my flaws and need to tailor presentation based on audience"*
- *"Peaked my interest in this area"*

- *"I think our group worked really well together dividing the tasks logically and keeping each other informed of developments. Honestly one of the best group projects with each person completing individual tasks and collaborating on the content for the presentation."*
- *"I really thank you professor to give me a chance to present something to high school class. The biggest outcome for me in this presentation was that i had a experience now to give presentation in front of non-technical audience."*
- *"Sharing knowledge with future engineers makes me feel good inside. The feeling that you get for helping someone out is priceless. Also, I gained a wealth of knowledge myself in researching this topic. It reinforced what I previously learned in my engineering classes and taught me other uses of gas turbine engines that I can relate to."*
- *"It is vital for an engineer to learn how to bridge this gap" (between technical and non-technical audiences when discussing engineering related issues)*
- *"The most important thing that I learned from this project was the importance of having a team leader. I have never really done a group project with an identified team leader and it does help to have one person that is in charge of keeping the project on track."* (from a team member)

During the focus group, 5 out of the 6 students thought that they would be more likely in the future to participate in engineering outreach because of their participation on this project. When asked if they would remember the project and its impact on them in five years, 5 out of 6 students thought that they would remember the project and be able to describe what they had accomplished.

In addition a new indirect measure was tested to better understand the impact that the team-based presentation project had on the student's educational experience. This tool was adapted from the existing RIT Cooperative Evaluation Form which is completed by each engineering student at the end of their co-op experiences. All engineering students at RIT are required to complete 50-weeks of cooperative education during their undergraduate program of study. Therefore, students are experienced with completing the survey questions as posed in Figure 5. Figure 5 also includes the average results obtained after the completion of the 2010 project in ME 680 (n=7). Results strongly correlate with those reported in Table 5.

Conclusions

This paper summarizes two projects which are incorporated within a Thermodynamics and Advanced Thermodynamics course. The first project is an individual project within Thermodynamics which requires students to critically read a technical book related to Thermodynamics, technically review the book in written form, and orally present results to the class in an informal setting. The second is a team-based project within Advanced Thermodynamics which requires student teams to create and present a class-long presentation for a non-technical audience. The content of the presentation must strongly relate to Thermodynamics and have direct relevance to the audience. Intended learning outcomes for both projects include strengthening Thermodynamics related knowledge; improving communication abilities, and strengthening intellectual curiosity in areas related to thermodynamics and mechanical engineering, in general. Based on assessment results of the technical book review project, a significant change is adopted to realign this project with a more conducive course. In regards to the team-based presentation project, assessment results reveal that all outcomes are being achieved using indirect measures involving two different survey instruments and a focus group format.

Figure 5. Survey to Measure Impact on Educational Experience as a Result of Participation in Team-Based Presentation Project (2010, n=7)

Please assess the extent to which your project experience provided you with the opportunity to accomplish the items below. Also, please assess the extent to which your academic program prepared you for the items below, and check the box if you feel your abilities were enhanced as a result of this project:	5=Extensive, 3=Moderate, 1=Minimal, 0 = None **Level of Opportunity**	5=Excellent, 3=Average, 1=Poor, 0=None **Academic Preparation**	Yes/No **Enhanced by Project?**
Apply your knowledge of mathematics, science, and engineering.	3.7	4.5	**6 – yes 1 - no**
Communicate effectively through writing.	4.3	4.3	**7-yes**
Communicate effectively through oral presentations.	5.0	4.6	**6 – yes 1 – no answer**
Learn new information and skills and develop new abilities.	4.1	4.6	**6 – yes 1 - no**
Gain awareness of the global and societal impact of your work.	4.3	3.9	**6 – yes 1 – no answer**
Understand the need for continuous learning of engineering, scientific, mathematical, technical, and managerial concepts and solutions throughout your career.	4.7	4.7	**6 – yes 1 - no**
Become more aware of contemporary issues pertaining to engineering, science, mathematics, and management.	4.1	3.9	**4 – yes 2 – no 1 – no answer**
Applied innovative solution to transform a creative idea to a new product, processes, or services	3.7	4.3	**4 – yes 3 - no**

	5=Strongly Agree, 3=Neutral, 1=Strongly Disagree **Level of Agreement**
Provided an experience that was educationally meaningful and challenged my abilities.	4.7

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