AC 2012-3062: TEACHERS MAKE LOUSY STUDENTS, AND WHAT YOU CAN DO ABOUT IT

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Teachers Make Lousy Students – And What You Can Do About It

Abstract
A pre-engineering program was included in the College's Research Experience for Teachers (RET) program to further equip participants with an understanding of engineering. The program described the fields of engineering and engineering technology allowing participants to explore engineering disciplines and design processes. The overall goal of the pre-engineering program was to help teachers better understand engineering and engineering technology so that they could appropriately address engineering and technology related topics in their classrooms. The program content was provided using a variety of means including instructor led presentations and projects. Significant effort was made to develop interactive discussions between participants and the instructor while making use of an item of current interest. This paper describes the evolution of this pre-engineering program based on participant evaluation of the program and instructor observations. Results of participant evaluations indicate that appropriate and significant improvements were made that resulted in better learning experiences for the participants. The lessons learned are directly applicable to other K-12 teacher professional development programs.

Background
In 2005 the College of Engineering & Appl8ied Science at the University of Cincinnati received funding from the NSF to pilot a Research Experience for Teachers program with 5 teachers. Subsequently, the College has received two RET Site grants, one for 2006-2008 and the second one 2009-2011[1-5]. Each year approximately 12 math and science teachers have participated. The goals of the RET program have been three fold:

1. To educate, cultivate, and facilitate middle and high school science and mathematics teachers by exploring the scientific method of inquiry and the critical research skills that engineers use to solve open-ended real-world problems.
2. To develop the participating teachers into role models for their schools who apply their research experiences in their classrooms and with colleagues.
3. To enable middle and high school students to directly link their education to events and issues occurring within their city and community and encourage them to become effective citizens in a technology-driven society.

The basic approach in the program has been discovery through actual construction and experimental testing, field data collection, observing and recording, computer simulations, synthesizing, and generalizations. Each year six research project topics were chosen to provide an overall view on research relevant to urban issues including: 1) availability of safe drinking water, 2) air pollution and waste disposal issues, 3) performance evaluation of civil infrastructure systems (buildings and bridges) under earthquakes, 4) mobility and congestion cost issues of transportation systems, 5) renewable energy systems using fuel and solar cell technologies, and 6) use of robotics for automation. Two teachers worked as a team on a project in one of these six research areas for six weeks during the summer under the mentorship of a faculty member and a dedicated engineering graduate student. In addition, teachers participated in a professional development program taught by education and engineering faculty members and practicing engineers. The professional development program included presentations and discussions on inquiry-based learning and assessment using engineering as a context for teaching as well as interaction with professional engineers (one from each research project area) to reinforce how math and science are used in real-world projects.

Beginning in 2008, the professional development program also included a fairly extensive pre-engineering program. This paper specifically addresses this pre-engineering program and how the RET organizers modified the program in order to be responsive to participant behavior and feedback.

Structure and Goals of Pre-Engineering Program

The pre-engineering program was introduced to describe the fields of engineering and engineering technology allowing participants to explore engineering disciplines and design processes. The overall goal of the program was to help teachers better understand engineering and engineering technology so that they could appropriately address engineering and technology related topics in their classrooms. A secondary goal was to help teachers understand the connections between science and math taught in schools and the use of these subjects to solve engineering problems. The content of the program included topics that enabled participants to distinguish between engineering disciplines and to be knowledgeable about topics common to all disciplines. While there is no consensus on what content knowledge or pedagogies are required for effective K-12 engineering education[6] our program sought to prepare teachers to integrate engineering into their classroom activities[7-9].

The pre-engineering program was led by a staff member in the college who has experience working with high school teachers on other pre-engineering programs including an introduction to engineering course for high school students[10-11]. The pre-engineering course made use of the same text used in the introduction to engineering program; Engineering Your Future – A Project Based Introduction to Engineering[12].

The RET Pre-engineering program content was provided using a variety of means. A project-based format was used in conjunction with traditional instructor-led presentations since this format engages the participants and models the type of activity the teachers could lead in their own classrooms[7,9,13,14]. All presentation materials were available to participants before, during and after the sessions via the University's Blackboard web site. As much as practical, interactive discussions between participants and the instructor were used to engage the participants. These were centered on the topic being presented while making use of an item of current interest. For example, the impact of technology on society was framed around a discussion of the oil spill in the Gulf of Mexico. Some topics were presented using web-based audio and video followed by discussions among the participants.

Project-based work was used to develop several topics presented and provided opportunities for active learning for the participants. In most cases, participants worked in teams on projects to model the approach that would be used in the schools. The projects typically provided an open-ended problem centered around a topic (e.g. the engineering design process) and required participants to work together to solve the problem[15, 16]. Participant teams were then asked to provide an informal presentation of the results of their project work.

Pre-Engineering Program Implementation and Refinement

The pre-engineering program was added to the RET in the summer of 2008. Sessions covering a wide range of topics were developed. The topics were intended to provide the participants sufficient background so that they would be knowledgeable about the variety of engineering disciplines and the significance of the design process, teamwork and the impact of engineering on society.

The content was presented by one individual and each teaching session included discussions about the topic as well as didactic material. In a few cases, the content was partially presented using web-based video modules that had been developed for the high school introduction to engineering course. Teaching sessions were 2-3 hours in duration. The 2008 session also included 3 short projects (completed during the teaching sessions).

Table 1 lists the topics that were presented in the pre-engineering program as well as information about the nature and duration of the program. The Table also provides commensurate information for the programs conducted in 2009, 2010 and 2011.

Table 1 Characteristics of Pre-Engineering Program

Topic	2008	2009	2010	2011
Pre-engineering Introduction	X	X	X	X
Working in Teams and Managing Time	X	X	X	
Engineering Design – The Design Process	X	X	X	X
Civil Engineering	X	X	X	X
Energy Use and Alternatives	X	X	X	
Technical Communication	X	X	X	
EE / Computer Engineering / CS	X	X	X	
Problem Solving Strategies	X	X	X	
Mechanical Engineering	X	X	X	
Aerospace Engineering				X
Materials Science & Engineering	X	X	X	X
Engineering Tools, Technology and Society	X	X	X	
Number of Distinct Sessions	9	9	8	4
Duration of Each Session	2-3 Hrs	2-3 Hrs	2 Hours	3 Hours
Total Instructional Time	30 Hours	28 Hours	16 Hours	12 Hours

2008 Program Evaluation

Participant satisfaction surveys were developed by the RET program evaluation team to understand the participating teachers' perceptions of the entire summer program experience. The surveys used a 5-point (ranging from very dissatisfied to very satisfied) Liker scale and open-ended questions. Twelve math and science teachers took part in the 2008 program. The results of the pre-engineering program survey are given in Table 2.

Table 2 Pre-Engineering Program Evaluation 2008

Items	Mean (SD)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The sessions (presentations and projects) in the pre-engineering program helped broaden my understanding of engineering and engineering technology.	4.33 (0.49)	33.3%	66.7%	0	0	0
2. The sessions (presentations and projects) in the pre-engineering program helped me understand the various career choices within engineering and technology.	4.00 (0.60)	16.7%	66.7%	16.7%	0	0
3. The sessions (presentations and projects) helped me understand the engineering design process.	4.00 (0.85)	33.3%	33.3%	33.3%	0	0
4. The sessions (presentations and projects) helped me to be able to apply the engineering design process in my teaching.	3.50 (0.91)	8.3%	50.0%	25.0%	16.7%	0
5. The sessions (presentations and projects) provided me with ideas and examples illustrating how engineering applications use math and science knowledge, which I can use in my classes.	3.83 (0.72)	16.7%	50.0%	33.3%	0	0
6. The sessions (presentations and projects) helped me to understand how math and science knowledge leads to different engineering career choices.	3.58 (0.90)	0	75.0%	16.7%	0	8.3%
7. The sessions (presentations and projects) helped me to understand how math and science knowledge is used by engineers to solve societal problems.	3.58 (0.90)	0	75.0%	16.7	0	8.3%
8. The presentations were an effective means to teach the concepts.	2.83 (0.94)	0	25.0%	41.7%	25.0%	8.3%
9. The projects were an effective means to learn the concepts.	4.08 (1.2)	41.7%	41.7%	8.3%	0	8.3%
10. The instructor presented the concepts effectively.	3.67 (0.65)	0	75.0%	16.7%	8.3%	0
11. The students in my school would benefit from having a pre-engineering course available.	3.92 (0.90)	25.0%	50.0%	16.7%	8.3%	0
12. There were too many presentations.	4.17 (0.84)	33.3%	58.3%	0	8.3%	0

13. There were too many projects.	2 (1.28)	8.3%	8.3%	0	41.7%	41.7%
14. The sessions allowed for questions, answers and discussions.	4.17 (0.72)	33.3%	50.0%	16.7%	0	0
15. I would recommend other science and math teachers participate in a pre-engineering program.	3.75 (0.87)	16.7%	50.0%	25.0%	8.3%	0

During the initial offering of the pre-engineering program several things became clear:

- Project-based activities in conjunction with traditional presentation of material were an effective way to present topics and engage the participants in the learning experience. With careful planning, instruction on topics could be more fully integrated into the project activities. Participants expressed both an interest in this approach and the utility of the approach. Program materials should be modified to accomplish this.
- Participants responded well and were highly engaged when connections could be drawn between what was taught in their schools and the principles and practices of engineering. It will be a benefit to include as many of these connections as possible.

2009 Program and Evaluation

Based on instructor observations and participant feedback, slight modifications were made to the program for 2009. The total time spent in the program was reduced slightly and more time was devoted to project work while maintaining the distinct topics covered. The same individual led all teaching sessions as in 2008. The 2009 program featured 2 short projects (completed during the teaching sessions) and 1 longer project that required dedicated sessions. Program characteristics are listed in Table 1.

Twelve math and science teachers took part in the RET and pre-engineering program in 2009. Participant evaluation of the pre-engineering program is given in Table 3.

Table 3 Pre-Engineering Program 2009 Evaluation

Items	Mean (SD)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The sessions (presentations and projects) in the pre-engineering program helped broaden my understanding of engineering and engineering technology.	4.17 (0.58)	25.0%	66.7%	8.3%	-	-
2. The sessions (presentations and projects) in the pre-engineering program helped me understand the various career choices within engineering and technology.	4.17 (0.83)	33.3%	58.3%	-	8.3%	-
3. The sessions (presentations and projects) helped me understand the engineering design process.	4.08 (0.67)	25.0%	58.3%	16.7%	-	-
4. The sessions (presentations and projects) helped me to be able to apply the engineering design process in my teaching.	3.50 (0.80)	8.3%	41.7%	41.7%	8.3%	-

5. The sessions (presentations and projects) provided me with ideas and examples illustrating how engineering applications use math and science knowledge, which I can use in my classes.	3.83 (1.03)	25.0%	50.0%	8.3%	16.7%	-
6. The sessions (presentations and projects) helped me to understand how math and science knowledge leads to different engineering career choices.	4.00 (0.74)	16.7%	75.0%	-	8.3%	-
7. The sessions (presentations and projects) helped me to understand how math and science knowledge is used by engineers to solve societal problems.	3.83 (0.72)	8.3%	75.0%	8.3%	8.3%	-
8. The presentations were an effective means to teach the concepts.	2.92 (1.31)	8.3%	33.3%	16.7%	25.0%	16.7%
9. The projects were an effective means to learn the concepts.	3.75 (1.42)	41.7%	16.7%	8.3%	16.7%	8.3%
10. The instructor presented the concepts effectively.	4.08 (0.67)	25.0%	58.3%	16.7%	-	-
11. The students in my school would benefit from having a pre-engineering course available.	3.92 (0.90)	33.3%	25.0%	41.7%	-	-
12. There were too many presentations.	4.25 (1.14)	58.3%	25.0%	-	8.3%	-
13. There were too many projects.	2.17 (0.72)	-	8.3%	8.3%	75.0%	8.3%
14. The sessions allowed for questions, answers and discussions.	4.25 (0.45)	25.0%	75.0%	-	-	-
15. I would recommend other science and math teachers participate in a pre-engineering program.	4.00 (1.21)	41.7%	33.3%	16.7%	-	8.3%

There were a number of lessons learned from the 2009 implementation:

- The participants were most engaged with the project-based activities. While some traditional presentations were effective and well received it would be beneficial to incorporate the teaching, as much as possible, within the context of a project.
- It was necessary to make explicit connections for participants on how the projects relate to particular engineering disciplines. They do not have enough background to make these connections for themselves.
- The web-based instructional modules were also an effective means of presenting material and concepts. The use of this type format was a good supplement for in-person presentation but would not be an effective substitute for in-person presentations for this type of program. The modules used were relatively short – 10 to 15 minutes. This was a good length to keep participants attention.

2010 Program and Evaluation

Based on the observations and participant feedback, slight modifications were made to the program for 2010. The total time spent in the program was reduced considerably and a greater percentage of the time was devoted to project work while maintaining the distinct topics covered.

The same individual led all teaching sessions as in 2009. The 2010 program featured 2 longer projects that required dedicated sessions, and 2 demonstrations conducted outside the classroom. Program characteristics are listed in Table 1.

Twelve math and science teachers took part in the RET and pre-engineering program in 2010. Participant evaluation of the pre-engineering program is given in Table 4.

Table 4 Pre-Engineering Program 2010 Evaluation

Items	Mean (SD)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The sessions (presentations and projects) in the pre-engineering program helped broaden my understanding of engineering and engineering technology.	4.08 (1.165)	41.7%	41.7%	8.3%	-	8.3%
2. The sessions (presentations and projects) in the pre-engineering program helped me understand the various career choices within engineering and technology.	4.17 (1.030)	50%	25%	16.7%	8.3%	-
3. The sessions (presentations and projects) helped me understand the engineering design process.	3.92 (.900)	25%	50%	16.7%	8.3%	-
4. The sessions (presentations and projects) helped me to be able to apply the engineering design process in my teaching.	3.83 (.937)	25%	41.7%	25%	8.3%	-
5. The sessions (presentations and projects) provided me with ideas and examples illustrating how engineering applications use math and science knowledge, which I can use in my classes.	4.42 (.669)	50%	41.7%	8.3%	-	-
6. The sessions (presentations and projects) helped me to understand how math and science knowledge leads to different engineering career choices.	3.92 (.793)	16.7%	66.7%	8.3%	8.3%	-
7. The sessions (presentations and projects) helped me to understand how math and science knowledge is used by engineers to solve societal problems.	4.17 (.718)	33.3%	50.0%	16.7%	-	-
8. The presentations were an effective means to teach the concepts.	3.67 (.778)	8.3%	58.3%	25.0%	8.3%	-
9. The projects were an effective means to learn the concepts.	3.92 (.515)	8.3%	75%	16.7%	-	-
10. The instructor presented the concepts effectively.	4.00 (.894)	25.0%	50.0%	8.3%	8.3%	-
11. The students in my school would benefit from having a pre-engineering course available.	4.00 (1.044)	41.7%	25.0%	25.0%	8.3%	-
12. There were too many presentations.	3.25 (.866)	-	50.0%	25.0%	25.0%	-

13. There were too many projects.	2.58 (.900)	-	16.7%	33.3%	41.7%	8.3%
14. The sessions allowed for questions, answers and discussions.	4.17 (.577)	25.0%	66.7%	33.3%	-	-
15. I would recommend other science and math teachers participate in a pre-engineering program.	4.25 (.866)	41.7%	50%	8.3%	-	-

Based on participant feedback and instructor observations the following lessons were identified:

- For projects and engineering calculations, the participants worked in groups. This was helpful in that group members do help each other and contribute particular areas of strength. This practice though can contribute to a misunderstanding of the importance and function of teams as compared to groups. Engineering projects often require a team of interdependent individuals contributing while a group can rely on one "strong" contributor to accomplish the tasks. The teaching material on teams needs to be reinforced after group work so participants are clear that there is a distinction.
- Participants were highly engaged when connections could be drawn between what was taught in their schools (math and science) and the principles and practices of engineering. These discussions led to greater exploration and sharing among participants on how best to help their students make these same connections. These discussions should be fostered and perhaps documented.
- The participants are given so many topics and activities through the RET that care should be taken not to overwhelm them with either information or activities.
- Structuring discussions around current topics enables the participants to better appreciate the relevance of engineering professions to society. These discussions have to be managed well to keep the group on-topic but these explorations should be encouraged.

2011 Program and Evaluation

The RET program team reviewed participant feedback prior to the 2011 session and concluded that several significant changes would be beneficial. The instructor for the program recommended that high school teachers who currently teach the introduction to engineering class be added as instructors. These "master teachers" (once science teacher and one technology teacher) were added to help the RET participants make connections between the courses they currently teach and the opportunities for using engineering as a framework for teaching math and science. The second major change was to reduce substantially the number of distinct topics and sessions to reduce the potential for overloading the participants. Table 1 provides details of the 2011 implementation.

Twelve math and science teachers took part in the RET and pre-engineering program in 2011. Participant evaluation of the pre-engineering program is given in Table 5.

Table 5 Pre-Engineering Program 2011 Evaluation

Items	Mean (SD)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The sessions (presentations and projects) in the pre-engineering program helped	4.67 (.492)	66.7%	33.3%	-	-	-

broaden my understanding of engineering and engineering technology.						
2. The sessions (presentations and projects) in the pre-engineering program helped me understand the various career choices within engineering and technology.	4.33 (.492)	33.3%	66.7%	-	-	-
3. The sessions (presentations and projects) helped me understand the engineering design process.	4.67 (.651)	75.0%	16.7%	8.3%	-	-
4. The sessions (presentations and projects) helped me to be able to apply the engineering design process in my teaching.	4.42 (.996)	66.7%	16.7%	8.3%	8.3%	-
5. The sessions (presentations and projects) provided me with ideas and examples illustrating how engineering applications use math and science knowledge, which I can use in my classes.	4.42 (.669)	50.0%	41.7%	8.3%	-	-
6. The sessions (presentations and projects) helped me to understand how math and science knowledge leads to different engineering career choices.	4.08 (.669)	25.0%	58.3%	16.7%	-	-
7. The sessions (presentations and projects) helped me to understand how math and science knowledge is used by engineers to solve societal problems.	4.25 (.662)	33.3%	58.3%	8.3%	-	-
8. The presentations were an effective means to teach the concepts.	4.25 (.754)	16.7%	41.7%	41.7%	8.3%	-
9. The projects were an effective means to learn the concepts.	4.25 (.866)	41.7%	50.0%	8.3%	-	-
10. The instructor presented the concepts effectively.	4.33 (.651)	41.7%	50.0%	8.3%	-	-
11. The students in my school would benefit from having a pre-engineering course available.	4.58 (.669)	66.7%	25.0%	8.3%	-	-
12. There were too many presentations.	2.67 (.778)	-	16.7%	33.3%	50.0%	-
13. There were too many projects.	2.42 (1.084)	8.3%	-	33.3%	41.7%	16.7%
14. The sessions allowed for questions, answers and discussions.	4.58 (.515)	58.3%	51.7%	-	-	-
15. I would recommend other science and math teachers participate in a pre-engineering program.	4.58 (.515)	58.3%	41.7%	-	-	-
16. Having instructors who are teaching engineering in high school was beneficial to the program.	4.50 (.905)	66.7%	25.0%	8.3%	-	-

Based on participant feedback and instructor observations the following lessons were identified:

- Use of peer instructors provided legitimacy to the concerns of participants and they served as role models for implementing project-based and engineering design –based instruction in K-12 settings.
- Providing fewer engineering topics but providing a greater depth of exploration was well received by participants.
- As indicated in prior years, structuring discussions around current topics enabled the participants to better appreciate the relevance of engineering professions to society. These discussions had to be managed well to keep the group on-topic but these explorations should be encouraged.
- As indicated from earlier sessions, it was very useful to make explicit connections for participants on the relation between projects and particular engineering disciplines. They did not have enough background to make these connections for themselves.

Results and Discussion

As described earlier, the goals of the pre-engineering program were to help teachers better understand engineering and engineering technology so that they could appropriately address engineering and technology related topics in their classrooms and to help teachers understand the connections between science and math taught in schools and the use of these subjects to solve engineering problems. Table 6 presents a summary of items over the 4 year investigation that addresses the attainment of these goals and the process of improving the program.

Table 6 Summary of Program Evaluations - Mean (Std Dev)

Items	2008	2009	2010	2011
1. The sessions (presentations and projects) in the pre-engineering program helped broaden my understanding of engineering and engineering technology.	4.33 (0.49)	4.17 (0.58)	4.08 (1.165)	4.67 (.492)
2. The sessions (presentations and projects) in the pre-engineering program helped me understand the various career choices within engineering and technology.	4.00 (0.60)	4.17 (0.83)	4.17 (1.030)	4.33 (.492)
3. The sessions (presentations and projects) helped me understand the engineering design process.	4.00 (0.85)	4.08 (0.67)	3.92 (.900)	4.67 (.651)
4. The sessions (presentations and projects) helped me to be able to apply the engineering design process in my teaching.	3.50 (0.91)	3.50 (0.80)	3.83 (.937)	4.42 (.996)
5. The sessions (presentations and projects) provided me with ideas and examples illustrating how engineering applications use math and science knowledge, which I can use in my classes.	3.83 (0.72)	3.83 (1.03)	4.42 (.669)	4.42 (.669)
6. The sessions (presentations and projects) helped me to understand how math and science knowledge leads to different engineering career choices.	3.58 (0.90)	4.00 (0.74)	3.92 (.793)	4.08 (.669)
7. The sessions (presentations and projects) helped me to understand how math and science knowledge is used by engineers to solve societal problems.	3.58 (0.90)	3.83 (0.72)	4.17 (.718)	4.25 (.662)
8. The presentations were an effective means to teach	2.83	2.92	3.67	4.25

the concepts.	(0.94)	(1.31)	(.778)	(.754)
9. The projects were an effective means to learn the concepts.	4.08 (1.2)	3.75 (1.42)	3.92 (.515)	4.25 (.866)
10. The instructor presented the concepts effectively.	3.67 (0.65)	4.08 (0.67)	4.00 (.894)	4.33 (.651)
11. The students in my school would benefit from having a pre-engineering course available.	3.92 (0.90)	3.92 (0.90)	4.00 (1.044)	4.58 (.669)
12. There were too many presentations.	4.17 (0.84)	4.25 (1.14)	3.25 (.866)	2.67 (.778)
13. There were too many projects.	2.00 (1.28)	2.17 (0.72)	2.58 (.900)	2.42 (1.084)
14. The sessions allowed for questions, answers and discussions.	4.17 (0.72)	4.25 (0.45)	4.17 (.577)	4.58 (.515)
15. I would recommend other science and math teachers participate in a pre-engineering program.	3.75 (0.87)	4.00 (1.21)	4.25 (.866)	4.58 (.515)
16. Having instructors who are teaching engineering in high school was beneficial to the program.	-	-	-	4.50 (.905)

A comparison of participant responses to items 1-7 in Tables 2-6 indicates that the program was successful at meeting these goals each of the years the program was offered. In each of the years there was general satisfaction that the program improved participant understanding of engineering and the ability to help students apply math and science principles. In general, there is also improvement in participant response each year that indicates that changes made to the program have been well received by participants.

Participant responses to items 8, 9, 12, and 13 indicate that the College made appropriate and beneficial changes to the content and presentation of the content each year. In particular item 8 regarding the effectiveness of the presentations clearly demonstrates that participants appreciate having fewer presentations.

The improvement of participant response to items 11 and 15 further indicates that the changes made to the program were appropriate for the audience and nature of the RET experience. The changes in these responses provide an important indication of how teacher professional development programs should be conducted.

A one-way analysis of variance (ANOVA) was conducted to quantitatively evaluate the significance changes in the program content and delivery had on participant's evaluation of the course from 2008 through 2011. ANOVA is an appropriate analysis of variance statistic to use in this situation because the independent variable was the program year and the dependent variable was the mean rating for multiple evaluation questions. These questions rate respondent's level of agreement with different statements on the same non-absolute value scale and the value specifically compared is the mean response for all participating teachers who answered during a particular year. The question response scale was five points with 1 being strongly disagree, 2 being disagree, 3 being neither disagree nor agree, 4 being agree and 5 being strongly agree. This coding indicates a magnitude of difference between the items.

Looking at rating means from 2008 compared to rating means from 2011, the ANOVA was significant at the 0.05 alpha level (95% level of confidence) for items 3, 4, 5, 7, 8, 10, 11, 12, and 15. Table 7 provides the evaluation results for those items that were found to be statistically significant.

When differences between 2010 and 2011 are compared, the most significant improvement was reported for item 3 (greater than 95% level of confidence). Changes in items 1, 8, 12, and 14 were also found to be significant but at lower confidence levels. These are presented in Table 7.

Table 7 Analysis of Variance – Significant Differences by Evaluation Question

Items	2008 results compared to 2011 results	2010 results compared to 2011 results
1. The sessions (presentations and projects) in the pre-engineering program helped broaden my understanding of engineering and engineering technology.		F(1,22)=2.612, p=.120
2. The sessions (presentations and projects) in the pre-engineering program helped me understand the various career choices within engineering and technology.		
3. The sessions (presentations and projects) helped me understand the engineering design process.	F(1,22)=4.699, p=.041	F(1,22)=5.417, p=.029
4. The sessions (presentations and projects) helped me to be able to apply the engineering design process in my teaching.	F(1,22)=5.580, p=.027	
5. The sessions (presentations and projects) provided me with ideas and examples illustrating how engineering applications use math and science knowledge, which I can use in my classes.	F(1,22)=4.324, p=.049	
6. The sessions (presentations and projects) helped me to understand how math and science knowledge leads to different engineering career choices.		
7. The sessions (presentations and projects) helped me to understand how math and science knowledge is used by engineers to solve societal problems.	F(1,22)=4.316, p=.050	
8. The presentations were an effective means to teach the concepts.	F(1,22)=16.663, p=.000	F(1,22) = 3.439, p=.077
9. The projects were an effective means to learn the concepts.		
10. The instructor presented the concepts effectively.	F(1,22)=6.177, p=.021	
11. The students in my school would benefit from having a pre-engineering course available.	F(1,22)=4.157, p=.054	
12. There were too many presentations.	F(1,22)=20.597, p=.000	F(1,22)=2.979, p=.098
13. There were too many projects.		
14. The sessions allowed for questions, answers and discussions.		F(1,22)=3.505, p=.075
15. I would recommend other science and math teachers	F(1,22)=8.088,	

participate in a pre-engineering program.	p=.009	
16. Having instructors who are teaching engineering in high school was beneficial to the program.		

Conclusions

The addition of the pre-engineering program achieved the goal of helping the RET participants better understand engineering and the engineering design process. The pre-engineering program also enabled participants to apply the engineering design process and equipped them to use engineering as a context to apply math and science principles. The Research Experience for Teachers program is conducted in a highly structured format to provide participants the research experiences and the ability to incorporate those experiences into lessons that can be used in the participants' classrooms. The inclusion of significant additional content through the pre-engineering program was appreciated but resulted in participants feeling somewhat overwhelmed with new content.

The results presented in Tables 6 and 7 indicate that participants appreciated fewer sessions and that the goals of the pre-engineering program could be met with fewer sessions. While this resulted in less content being presented these results support that the changes to the program content and delivery methods had a positive effect on participant's reactions to the pre-engineering program.

Based on item 16 from Table 5 it is also clear that participants value learning from peers. The inclusion of peer teachers provided for more discussions of implementation of concepts and approaches in the participants' own classrooms.

The following are recommended for K-12 teacher professional development programs based on the results of this project.

- Structure the program so that participants have sufficient experiences to meet program goals but are not overburdened with too much material or too many different experiences. It will take feedback and evaluation to determine the best program structure.

- Project-based activities should be used as much as appropriate, even for content that is routinely provided through presentations. Even when their primary method of teaching is presentation-based, teachers appear to be particularly disapproving of presentations.

- Provide explicit connections between the projects and the underlying principles so that participants clearly understand and can relate the principles to their own students[17].

- Provide explicit connections between the projects and the relevant fields (careers and degrees) that would engage in that type of application.

- Include peers as presenters / project leaders in the program. Teachers are receptive to peers and are more likely to understand how the topics they are learning can be implemented in their own classrooms when they learn from peers.

- Discussions that relate topics to current events and items of relevance are engaging and provide a framework for application of concepts. Teachers are quite willing to contribute to these conversations so it is very important to manage these discussions well.

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