

Hands-On STEM Lesson Plans Developed through Engineering Faculty and STEM Teacher Collaboration (Evaluation)

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Abstract

With a shortage of engineering content currently found in many STEM classrooms, the Manhattan College Engineering STAR (Scholars Training and Retention) Center explored the concept of collaboration between engineering faculty and science, technology, engineering and math (STEM) educators at the middle and high school level to create lesson plans with an emphasis on engineering for integration into their classrooms. With the increased demand for STEM education available to all students, the professional development shared with educators topics related to engineering that could be incorporated into science, technology, and math curriculum. Throughout each session, teachers worked toward their professional development through the National Science Foundation (NSF). Twenty STEM teachers and twelve engineering faculty members were divided into groups and worked collaboratively over the course of one year to develop lesson plans incorporating a hands on activity for the particular topic suggested by the engineering faculty member. During the initial session, educators and engineers came together to begin their mutual learning. Faculty members used a variety of materials to demonstrate their particular engineering concept and allowed the educators to internalize the concepts to build and mold them into lessons that were applicable to elementary, middle and high school level students. With the mentorship of the lead engineering faculty member, teachers were encouraged to draft their lesson and look for guidance when necessary to ensure effective learning. The support from both the faculty and educator allowed for each member to understand what each professional brings to their particular field. Upon completion of the lesson plan, educators shared the finalized copies with the other groups and the educators implemented their newly developed lesson plan into their curriculum. Finally, the STAR members met to discuss and share the experiences, challenges, and accomplishments of their lessons and work to create, in the next session, a lesson plan with an entirely new engineering subject.

Introduction

The constant change and growth occurring in science and math standards, although challenging at times, can be beneficial in motivating teachers to create not only interesting and thought provoking lesson plans, but illustrate concepts that students today should be exposed to when thinking about their futures. When dissecting the *Next Generation Science Standards* (NGSS)¹ as well as the *Common Core State Standards for Mathematics* (CCSS)², it is clear to see the greater demand and drive for bringing engineering into classroom practices. The challenge then lies in the hands of the teachers in the middle and high school classrooms that must present concepts that are somewhat unfamiliar and unique to their initial certifications.

For many teachers, the idea of lifelong learning and professional development are necessary aspects to being a highly effective educator, but the programs chosen need to be inspiring and engaging. One of the issues with many professional development programs is the lack of inclusion of the entire group and a greater focus on individual achievements. This results in little accomplished for the teachers, and even less for their students³.

Inclusion of the entire group in professional development can result in greater partnerships that are bi-directional. In the case of this program, the professional development intended to benefit both P-12 teachers and the higher education professors.

Prior literature on collaborations between university professors and P-12 teachers support the need for bi-directional partnership.⁴ While these partnerships are often common, they generally provide greater support of the P-12 teachers. Studies have shown that simply introducing STEM higher education faculty into P-12 settings does not necessarily produce positive results. The professional development needs to be properly planned and executed, care needs to be taken in selecting participating faculty, and the university needs to support the partnership especially in considering how this partnership is considered in promotion and tenure decisions.⁵ While higher education faculty can contribute additional content knowledge, P-12 teachers complement pedagogy.

Professional development improves the creativity in the classroom through long-term trials and observations of the wide variety of instructional techniques that can be applied to improve student learning⁶. As part of a National Science Foundation grant, the Engineering Scholars Training and Retention (STAR) Center offered a professional development opportunity that brought together teachers and college engineering faculty to form a partnership to create dynamic lesson plans that promote inquiry in the classroom. The stigma very often placed on the math and science classroom is that the content is difficult and uninteresting. By providing multiple professional development sessions, constant communication with the engineering professors, and peer review with other teachers within the program, teachers developed lesson plans that helped not just one, but all teachers interested in bringing engineering to life in their classrooms.

When presenting math or science content at the middle and high school level, these initial experiences could potentially be the catalyst to drive students toward a career in these essential fields. The goal of persuading student career paths toward STEM fields lies in the ability to increase a more technical engineering education through the development of hands-on activities in school and at home⁷.

However, too often the courses currently being offered minimally, if at all, explore the concepts of engineering. Through the Engineering Scholars Training and Retention (STAR) Center the objective of the program was to use a series of professional development days to encourage current math and science teachers to integrate engineering into their courses. Through collaboration with elementary, middle and high school teachers and engineering professors, with concentrations in mechanical, chemical, environmental, civil and electrical engineering, the sessions exposed both parties to what is occurring outside of their respective fields and ways that each can benefit from the other. The final product of a lesson plan may not be directly applicable to the engineering faculty; however, the professors are positively impacted in their own professional development by being able to creatively think and influence students before they reach college. They experience the effort required to make the material applicable and interesting and watch it come to life in their team members' classrooms, while allowing them to evaluate their own teaching styles through the eyes of the teachers to reflect upon.

Procedure & Methods

Thirty-four public and private schools in close proximity to Manhattan College received invitations to participate in the program. The Engineering STAR Center offered STEM teachers working with students in grades 6-12 the opportunity to participate in a series of three professional development days over the course of one year to learn engineering principles they could include in their math and science curriculum. In agreeing to participate in this professional development, teachers would need to develop and teach lesson plans in their content area, while

incorporating an engineering focus. Upon completion of each session, evaluations were completed to make changes to better accommodate both teachers and engineering faculty. Manhattan College Engineering faculty members were invited to participate by developing their own lessons with engineering principles that would be applicable in their field to a middle or high school classroom setting. By creating these lessons, the professors were asked to focus on a principle of engineering that was valuable and contained an idea that could be applicable to real world concepts. The professors selected a topic, developed a materials list, and included resources and supplemental material so that each teacher could effectively prepare for the professional development session. Topics included measuring the pressure experienced by a scuba diver, determining the optimal packing for coins and candy, environmental pollutions, specifically cleaning an oil spill, examining forces on bridges, building a balloon rocket to demonstrate how thrust is generated, harnessing wind energy, and understanding how a GPS works. In the list of topics, the engineering faculty member explained the concept, the hands-on activity participants would do, materials needed, and provided resources for the teacher to review prior to the session, as well as a suggested connection for math or science. Teacher participants received a list of the offered topics and selected a topic they could integrate into their curriculum.

Nineteen teachers and twelve engineering professors participated in the first STAR Center Professional Development. They worked to evoke a change in the future of engineering education. Both the teachers and professors were able to meet before breaking into groups to listen to speakers on their contrasting professions. The assistant dean of the School of Engineering gave a keynote address to the teachers on the topic “What is Engineering?” including crucial points ranging from stereotypical engineering for bridges and buildings to things taken for granted like the clothing that is worn every day. A local STEM school principal and teacher addressed the engineering faculty on the topic “Building a STEM School from the Ground Up” making these professors aware of the challenges often faced in schools trying to drive a higher demand on STEM education. The presenters for both groups emphasized that although STEM fields are often a priority in education, the engineering aspect often is overlooked. This type of professional development could make positive changes in many schools.

Following the keynote presentations, the engineering professors met with their assigned teachers to begin the development of the chosen engineering topics. Each team was a 2:1 ratio of teacher to professor, which allowed for a higher level of comprehension and comfort. Each team was allotted one hour and thirty minutes to go over the content and the important concepts behind their specific sect of engineering. Each professor was able to show their material and ideas through any medium often-using worksheets, PowerPoint presentations and videos, where applicable. Some sessions were able to begin their hands on activities right away, while other professors allowed for the teachers to ask questions and to make sense of the concepts while explaining some of the information. The materials were explained and the rationale for using them in their demonstrations. By providing each team with the specific template to be followed when completing the plan over the next few weeks, the STAR Center could ensure that each teacher was submitting a plan that would include all criteria required. **The template included basic sections for the grade level audience, the lesson title and a brief overview but eventually required more specific sections to correlate the assessments and outcomes, discussion of the instructional strategies and sequencing, and the rationale and casual explanation of the engineering that was used in the classroom. Overall the template was used as an outline to maintain a similar structure to allow each plan to be used in any**

professional development participant's classroom. Having this specific template presented the engineering concepts throughout the plan but specifically described the engineering content in the casual explanation and rationale to give the teachers a brief explanation of the details. The use of this outline tied the engineering content to education practices to create the highest amount of internalization for students in a format that was easy to access and understand.

The poster session followed the initial portion of the workshop to expose teachers to some of the undergraduate and graduate level research that was currently being done at Manhattan College. These students were invited to come and present to the professionals and discuss some of their ideas about engineering being brought into the middle and high school classrooms. The teachers and professors were involved and were able to sit and discuss with others during lunch about what they had seen and heard, as well as what they were excited to accomplish in the following sessions.

In the second section of the workshop teachers were able to experiment and test many of the concepts presented and evaluate how exactly to bring these concepts to life in their own classrooms. The second section of the workshop was again one hour and thirty minutes giving the teachers and professors enough time to perform the hands on activity and to discuss ways to create the lesson plan. At this point the teachers were given the opportunity to explain the ways to set up a lesson using the model provided and explain to the professors the way that the lesson would need to be taught and with what amount of time in each period. Both professionals were able to brainstorm and offer new ideas and creative concepts to present this material to students based on the particular level and content taught by the teachers in the schools.

In order to initially evaluate the effectiveness of the first professional development day, surveys were distributed to teachers and faculty at the opening of the session, to examine the initial opinion regarding the other's approach to teaching. At the close of each workshop, teachers were asked to complete an evaluation on the individual engineering topic attended and the effectiveness of their lead engineering advisor. The initial surveys included 20 parallel statements with responses of strongly agree, agree, undecided, disagree, and strongly disagree. The evaluations asked the teachers to anonymously rate the workshops by providing the session and professors name and followed the same format with 12 survey questions and 3 short answer responses, for example "What aspect(s) of the workshop did you most appreciate or enjoy?" and "What do you need more of to be able to do the work discussed in today's workshop?"

Based on the work done, teachers were then asked to draft their individual lesson plans and continue to work with their specific engineering professor towards a final draft. Upon submission to the Engineering STAR Center, lesson plans would be reviewed with comments and feedback using the rubric created for evaluation and approved for presentation in each respective classroom.

Survey and Evaluation Findings

When evaluating the Engineering STAR program, the use of the surveys and evaluations gave immediate insight into each professional's comprehension of the other's field, the effectiveness of these workshops and the internalization of what was presented. For the teacher's survey, statements such as "I feel enthusiastic about integrating engineering concepts in my classrooms instruction" showed that 68% strongly agreed, while the other 32% agreed. The same question asked to engineering professors phrased "I feel enthusiastic about teaching engineering

in science/mathematics classrooms.” yielded results of 45% strongly agreed while 55% agreed. This one statement can lead to the conclusion that science and math teachers, as well as, the engineering professors are aware of the importance of the expansion to engineering practices and are ready to embrace the changes with a positive outlook. By having the recognition of all parties, the lack of engineering currently exposed to elementary through high school students will narrow as both the professor and teachers are committed to making the changes required to bridge the gap.

When educators were asked to identify with “I could read any literature on engineering and then explain it to another person.” the results expressed that only 9% of the teachers strongly agreed and 21% agreed they could complete the task leading to the conclusion, that many are still unfamiliar with the language used and will need additional support in this area. Similarly, when engineering faculty was asked their feelings on the statement “I could read any literature on teaching and learning and then explain it to another person” only 9% strongly agreed, and 37% agreed. One area for this potential increase could be that the engineering professors are educators in undergraduate and graduate level classes and have experience with teaching.

Table 1. Sample of initial survey statements

Teacher Survey Statements	Professor Survey Statements
1. I feel enthusiastic about integrating engineering concepts in my classrooms instruction.	1. I feel enthusiastic about teaching engineering in science/mathematics classrooms.
2. I could read any literature on engineering and then explain it to another person.	2. I could read any literature on teaching and learning and then explain it to another person.
3. It is not necessary for me to receive training in aspects of engineering to effectively integrate engineering concepts in my science/math lessons.	3. It is not necessary for me to understand pedagogical strategies to effectively integrate concepts in engineering and natural science.
4. I prefer to teach inquiry-based lessons as opposed to lecture courses.	4. I prefer to teach inquiry-based lessons as opposed to lecture courses.

The teachers and engineering faculty had similar opinions on many of the questions (see chart 1 and 2). However, upon a complex examination of the surveys, differences were noted in their preferences for teaching approaches (see chart 3 & 4). These results indicated a need to bridge the gap between teachers’ and engineers’ philosophical approach on how to teach.

As seen in Chart 1, (teachers’ survey) the statement “It is not necessary for me to receive training in aspects of engineering to effectively integrate engineering concepts in my science/math lessons,” shows there was strong belief that receiving information would be necessary to bring the engineering into the classroom according to the educators. When providing this development to the teachers, the teachers would recognize the vast amount of engineering already introduced in science and math as well as the importance of bringing even more recognition to their students and exploring more options with a greater understanding.

Chart 2 presents the engineering faculty’s opinion of the statement “It is not necessary for me to understand pedagogical strategies to effectively integrate concepts in engineering and natural science”. The vast majority disagreed and strongly disagreed, proving they also recognized the importance of understanding the various aspects of a classroom and the ways to

teach and have students learn. Students with interests in STEM fields tend to have a higher preference for classroom learning than non-STEM students, which makes it incredibly important that these engineering professors are aware of the environments they provide ⁸.

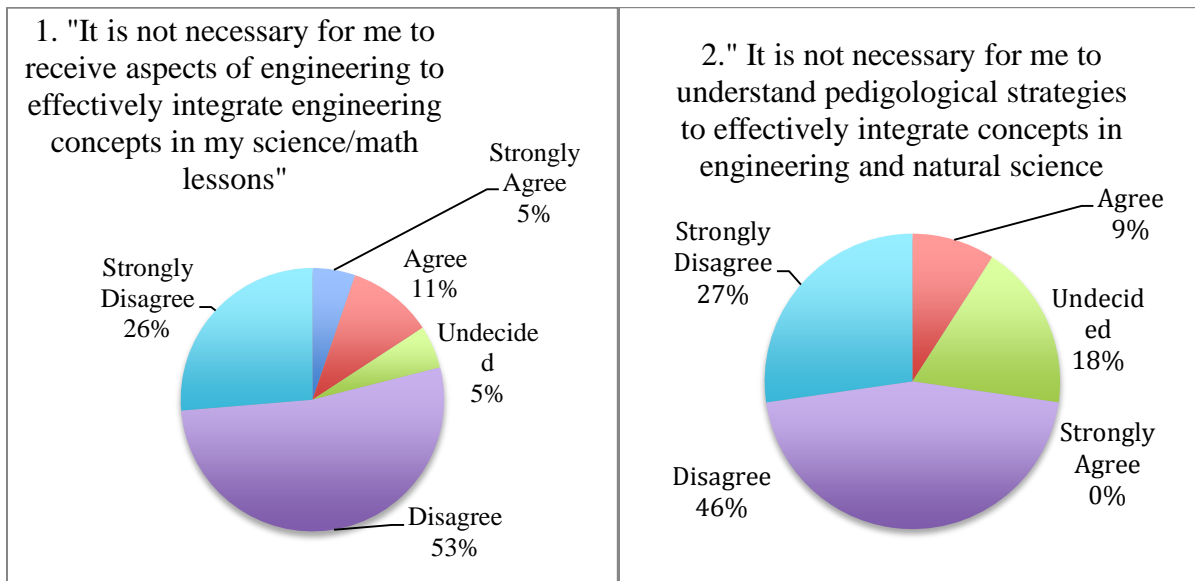


Chart. 1 & 2. Results of survey question asked to teachers and engineering professors, respectively.

After looking at the results for the statement, "I prefer to teach inquiry-based lessons as opposed to lecture courses." (Chart 3 & 4), the greatest level of discrepancy was noted between engineers and educators. Most engineering professors were undecided when answering, while most teachers agreed that they preferred to use inquiry-based education as opposed to lecture. At the college level lecture style classrooms are very often used, which could be the potential reason why so many professors were undecided. Most educators would agree that in middle and high school classrooms, lecture style is usually unproductive and rarely gets the students to internalize the material at hand. In discovering this inconsistency, the focus is now to narrow the gap and provide professors with the awareness that many teachers must have in the STEM classrooms. By asking teachers, who favor the use of inquiry in the classroom, to develop a lesson plan focused on the engineering topic, the engineering professors were exposed to a new way to teach the material in a format that would offer less lecture and meet the needs of the college level students with different learning styles. By reviewing the inquiry-based lessons, the engineering professors were able to see how students can explore and experiment with different methods and ideas to internalize a topic. By using exploration in their classrooms as a means for learning, students are then able to create a personal learning style that will be most beneficial for them. With this newly gained learning style, students begin to scaffold new ideas with prior knowledge in order to gain new knowledge.

While a lecture style may be positive in some instances, to keep students engaged and focused toward a goal, it is important for the engineering professors, in order to bridge the gap between middle and high school level learning with college level learning, to see how exploration and experimentation can be used not just in a lab setting. By having the engineering professor work with the teacher in reviewing a lesson plan there was a dual purpose. One was that the teacher would be able to adapt and incorporate the engineering topic into their middle or

high school level classroom. The second was for the engineering professor to be open to different styles of teaching, mainly inquiry-based learning where students explore and experiment with the topic. In doing so, the engineering professor would gain a better understanding of how students learn at a non-college level. In reflecting on these two different styles of teaching, is it expected that a college professor will automatically change their style of teaching? No. However, this is part of the challenge in bridging the gap between middle and high school level learning and college level learning.

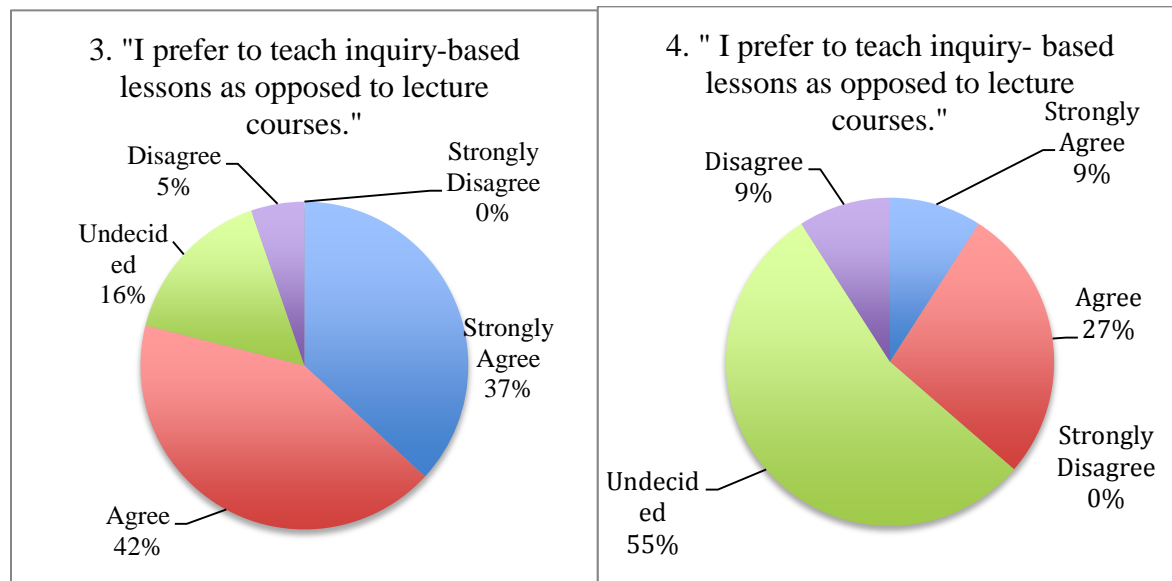


Chart. 3 & 4. Results of survey question asked to teachers and engineering professors, respectively.

Upon completion of the workshops, teachers were given the opportunity to assess their session and the teaching styles of their engineering professor that were effective. The evaluations revealed an overall positive response to the day as indicated in Table 2.

Table 2. Evaluation form for Professional Day

Statements	Percent of Strongly Agree & Agree
The goals of the workshop were clearly outlined.	79%
The content was similar to the description outlined in the promotional materials	83%
The workshop was applicable to my job.	92%
I will recommend this workshop to other colleagues in my program	79%
The program was well paced within the allotted time	100%
The instructor was a good communicator	91%
The material was presented in an organized manner	87%
The instructor was knowledgeable on the topic	96%
I am eager to attend the follow up workshop	88%
The goals of the workshop were met	88%

One other source of evidence that was helpful in determining the effectiveness of the program was the open-ended questions included in the evaluation forms completed at the end of each professional development day. Teachers were asked to respond to three questions: (1) What aspect(s) of the workshop did you most appreciate or enjoy? (2) What aspect(s) of the workshop did you least appreciate or enjoy? (3) What do you need more of to be able to do the work discussed in today's workshop? Teachers responded they most liked the hands-on activity, the professors, and the practical application they could make for their own students. Fewer teachers indicated aspects they did not like. Two thought the day was too long, one thought there was not enough time to work with the professors, one felt the content was too difficult, one felt the topic was not applicable, and six indicated that the tour of the labs during the second professional day was not helpful. Time and supplies were the most frequent responses from teachers as to what they needed to do the work discussed in the workshops. One other teacher also noted she needed a greater understanding of the engineering topic while one other indicated he needed a more practical application of the topic for his class.

The professors' comments to these open-ended questions mentioned they most enjoyed finding a way to collaborate with local schools and teachers, learning what is taught in middle and high school classes, and working with teachers in different disciplines. The professors also commented on how they benefited from learning the challenges these teachers face on a daily basis, and realizing the impact of the vast differences in demographics of the students these teachers teach and how those demographics influence learning. By reviewing the professors' evaluations, it seems they would like more time to engage in this type of collaboration. These comments indicate the participating teachers and professors have found the sessions very useful in helping them develop their own understanding of what teachers and engineering professors do and how they can help each other in promoting engineering education.

By providing the Engineering STAR Center with this feedback, professors were able to get a complete understanding of how strong their individual teaching style, organization, and presentation skills are, while also providing input to the areas that could use improvement. By receiving this from teachers, who are specifically trained in how to explain in a supportive manner, the engineering faculty can improve in their own classrooms and develop the structure to accommodate more students. Overall, the educators provided positive and constructive feedback to ensure that their needs were met, and to help the engineering professors develop stronger teaching styles in their college courses. The teachers provided and expressed the enjoyment of the "hands-on activities" and the interest in "learning the new material and experimenting."

Lesson Plan Evaluation Findings

While the survey and evaluation form gave insights into the teachers' and engineering faculty's perceptions and learning from the sessions, examining the quality of the lesson plans provided a more direct measure of the success and needed changes of the program. The STAR staff reviewed each lesson plan using a rubric (Table 3). The rubric included three components for evaluating the quality of the plan: completeness, clarity, and incorporation of engineering principles, and used a rating scale of highly effective, effective, developing, and ineffective. STAR reviewers determined that in order for the plan to be approved, the lesson had to receive ratings of highly effective or effective in at least two of the three components. After the first submission of plans, 50% of the plans met approval requirements while the other 50% were given additional suggestions for developing the plan. Even with the approval to teach,

feedback was added to each plan with suggestions for improvement, praises for innovative ideas, or questions for minor clarification.

Table 3. Lesson Plan rubric attached to each plan

	Highly Effective	Effective	Developing	Ineffective	Review Comments
Complete <i>The lesson plan template is followed and the written plan is complete with all components needed to teach the lesson. All the sheets the students filled out, lab reports, or rubrics for the projects are included.</i>	All components are included and highly organized and options for developing the lesson are provided	All components of the written plan are included	Most components of the plan are included; still need to include worksheets or other instructional materials	Some components are listed but many components still need to be developed or included	** Comments provided specifically for each plan**
Clarity <i>Lessons fit together coherently targeting a set of performance expectations; the plan is well-structured and easy to replicate.</i>	Extensive directives in the plan give teachers step-by-step format to follow and provides built in flexibility for students to design and carry out investigations	The plan as written is easy to follow and deliver to engage and support student learning.	The overall plan can be followed but sections of the plan are not clear for next steps in delivery.	The plan lists activities but does not provide enough explanation for teaching the concept and engaging students in the process.	
Incorporates Engineering Practices <i>Engages students in authentic and meaningful scenarios that reflect the practice of math/science and engineering as experienced in the real world and that provide students with a purpose (e.g., making sense of phenomena and/or designing solutions to problems).</i>	Incorporation of engineering practices are evident and include opportunities for students to: <ol style="list-style-type: none"> 1. Ask questions (for science) and defining problems (for engineering) 2. Develop and use models 3. Plan and carry out investigations 4. Analyze and interpret data 5. Use mathematics and computational thinking 6. Construct explanations (for science) and design solutions (for engineering) 7. Engage in argument from evidence 8. Obtain, evaluate, and communicate information 	Incorporation of engineering practices are evident and include opportunities for students to: <ol style="list-style-type: none"> 1. Ask questions (for science) and defining problems (for engineering) 2. Develop and use models 3. Plan and carry out investigations 4. Analyze and interpret data 6. Construct explanations (for science) and design solutions (for engineering) 	Incorporation of some engineering practices are evident and include opportunities for students to: <ol style="list-style-type: none"> 1. Ask questions (for science) and defining problems (for engineering) 2. Develop and use models 3. Plan and carry out investigations 	Incorporates some opportunity for students to carry out an investigation	

When reviewing the lesson plans, the requirements were that each teacher must provide a lesson following the same format. Each teacher was provided with a sample lesson plan and blank outline to reference as needed through the process. When the first round of lesson plans were submitted, the initial review found that 60% of the plans followed the template requested. By having the same format, teachers are familiar with the requirements and can implement

another plan created in the program in their own STEM classroom. There was constant communication through email between the engineering professor and the team of teachers regarding revising and editing until the first draft was complete. The submissions were then reviewed by Engineering STAR Center with the rubric. Upon review of each lesson plan, comments were provided to each teacher who submitted their plan. By having the engineering faculty work closely with the teachers through the entire process and through each stage of lesson planning, it exposed the professors to the daily requirements of preparation in a middle and high school classroom, as well as the limitations faced. It also allowed for the middle and high school teachers to experience a higher level engineering topic that could be manipulated into a middle and high school curriculum through creativity.

The review data indicated that 80% of lesson plans were complete with rating as effective or higher. However, only 40% of the plans met the criteria for clarity and 50% met the criteria for incorporating engineering principles. These results suggested teachers and engineering faculty needed more direction for developing effective plans.

To provide more support and identify the confusion faced in creating the first plan, at the second session of the professional development, teachers and engineering faculty reviewed anonymous plans created and previously submitted by teachers from the first professional development session. This allowed both groups a greater opportunity to determine if a plan was meeting the expectations and as to whether or not another teacher, who had not created the plan, could use it effectively. Allowing others to dissect examples gave a better understanding of the work that is required, and also generated self evaluation of their own plans when asked to reassess the first submission. Acting as reviewers, teachers and engineering faculty used the rubric and included feedback to the plan developer. The STAR reviewers provided additional feedback to each teacher who submitted a lesson plan and gave suggestions for ways to improve the plan. Teachers are in the process of submitting revisions to their first submitted plan based on the scored rubric and feedback. The teachers are also submitting the second lesson plan to the respective engineering faculty member for initial approval of the plan. With both teachers and engineering faculty using the rubric, a greater effectiveness in lesson plans is anticipated.

Engineering professors and the teachers had to adapt the lessons based on their contexts, their own understanding of the topic, and their approach to teaching. In preparation for the workshop sessions, each engineering professor planned a possible topic investigation. When each professor created their topic presentation, they were asked to provide an idea that they believed would be important to bring into the classroom before entering an undergraduate engineering program. They were given the freedom to present to the teachers through any platform and provide any information and demonstrations they believed would be beneficial. The teacher participants received 10-12 possible topics for investigation. Teachers selected three preferred topics and the STAR team assigned teachers to one of their preferred topics. Prior to the professional development day, the teachers reviewed the investigation proposed by the professor with their own study of the references included in the investigation. Two plans submitted by engineering professors are displayed in Table 4.

Table 4. Engineering professors' submitted plans

Proposed Engineering Topics for Investigation	
Environmental Pollution	Thrust
a. Dr. Wilson – Environmental Engineering	a. Dr. Leylegian – Mechanical Engineering
b. Lecture: Environmental pollution and oil spills	b. Lecture: How does an airplane or rocket move through the air? Thrust is generated by the
c. Hands-on activity: Create and clean an oil spill	

using different methods. Students can see the effects of an oil spill on land and water and test engineering approaches to treating oil spills (skimming oil off water, adding a dispersant (detergent), etc.). Students can also be introduced to density.

d. Materials

- Aluminum pan
- Large stone (to represent “land”)
- Water
- Oil (dark vegetable oil or vegetable oil with food coloring added in)
- Feather
- Spoon
- Detergent that works well on oil/grease
- Oil-absorbing cloth/pads
- Plastic cups

e. References

- A history of major oil spills:
http://www.nytimes.com/interactive/2010/05/10/us/20100510_OIL_TIMELINE.html?_r=0
- Oil spill pollution:
<http://www.environmentalpollutioncenters.org/oil-spill/>
- How to clean oil spills:
<http://www.ceoe.udel.edu/oilspill/cleanup.html>
- Environmental Engineering and oil spills:
https://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_enveng/cub_enveng_less_on01.xml

f. Optimal for chemistry or biology teachers.

expansion of gas through a nozzle.

c. Hands-on Activity: Build a balloon rocket to demonstrate how thrust is generated by expanding gas.

d. Material: String, straw, balloon, scotch tape.

e. References:

- What is Thrust? – NASA:

<https://www.grc.nasa.gov/www/K-12/airplane/thrust1.html>

- The Four Forces – Smithsonian National Air and Space Museum:

<https://howthingsfly.si.edu/forces-flight/four-forces>

- Engines – Smithsonian National Air and Space Museum:

<https://howthingsfly.si.edu/propulsion/engines>

- Jet Engine Thrust – How Stuff Works:

<http://science.howstuffworks.com/transport/flight/modern/turbine8.htm>

e. Optimal for physics teachers

When the professors and teachers met for the lesson plan development, the professors gave background information on the topic and had the teachers investigate through the hands-on activity. Together they determined how the concept could be explored in a middle or high school setting. In speaking with the professors and teachers, this required several iterations of the actual plan. One teacher in the evaluation explained: “Professor L. and I worked well to flesh out our goals and work through classroom scenarios and dueled on the things I already do in class.” One of the professors shared, “We did a couple of iterations of revision, and I think we're all satisfied with it [lesson plan].”

In reviewing the final lesson plans, STAR reviewers noted that teachers adapted their plans to their own schools and classes. Two teachers from different schools but who worked with the same engineering professor created lesson plans that met the needs of their students. Nadine taught middle school science and Tara taught high school chemistry. The topic they investigated with Dr. Wilson – Environmental Pollution – (Table 4) – included creating and cleaning a simulated oil spill. The teachers also investigated the concept of density. Nadine’s lesson plan focused on students understanding the issues that surround environmental clean-up, while Tara had a greater emphasis on density. Both teachers included the simulated oil spill and clean up as a part of the lesson, however, Tara’s lesson was heavily focused on demonstrating the differences in density of various liquids and determining best clean-up methods in terms of cost

and human/environmental impact. The transition of these concepts translated from professor to teacher to classroom was shown in various strategies for the different grade level requirements. In the middle school lesson plan, the initial focus was on “What does an engineer do” to first discuss the different fields of engineering and discover how often throughout the day we see engineering applied. This discussion allowed students to complete a “foldable” chart with different types of engineering. Next, students were asked to focus on the environmental engineering section by viewing a short video, taking notes of the impact the oil had on the land, water, air and, aquatic life. Students reviewed with PowerPoint notes containing pictures and finally created their own oil spill to determine the best way to clean up the oil through a series of methods. The sponge activity incorporated in the high school chemistry lesson also looked to elicit prior knowledge, but in the form of a brief density experiment involving the various liquids. Although both activities asked students to make use information they may already know to draw conclusions, the high school activity focused on the science content already understood and the middle school lesson looked to briefly introduce engineering. Moving forward, the high school lesson asked students to draw connections to why density would play a major role should they need to clean an oil spill. Based on their conclusions students researched major oil spills across the country and in their area. Students would then complete the lab or the simulated oil spill but taking it a step further to determine the cost effectiveness of each and the technologies used. Finally, the high school students were asked to present their findings to the class and support their findings or suggest another strategy.

Kelly worked with Dr. Leylegian as a group of two. Because there was no other teacher in the group, she and Dr. Leylegian. were able to investigate his planned topic and then move more immediately into adapting the topic for her 11-12th grade physics students. While this lesson more readily translated engineering to the high school physics class, Kelly still made her own adaptations in her selection of resources that she provided to her students.

In most instances, the topic and the hands-on activity planned by the professor had some relation to what the teachers included in their curriculum. However, no plan presented by the engineering professors could be taken as given and transferred to a 6-12 grade class. When reviewing the plan, it was clear that Kelly provided the same idea of thrust through the use of the balloon rockets, but the idea of thrust was also expressed in the concept of a “pop” rocket and the development of fuel mix trials. The adaptation used in this classroom expressed the concepts that Dr. Leylegian was attempting to express but was taken one step further providing another hands on lab activity to build on the way thrust and Newton’s third law of motion can be applied, which are concepts required by New York State to be discussed in the physics curriculum. In working through this program, this particular lesson plan was able to apply the mechanical engineering concepts to the physics classroom and mold this topic to fit both requirements. In creating this inquiry based lesson, the students were asked to discuss questions like “ How do you make rockets fly?” and “What will make a balloon fly?” Students are constantly being asked to draw conclusions in this lesson before being told or given the information. For the engineering professors, being able to see the way the teachers do not provide the information directly, but instead ask students to make connections before testing their theories, provides these engineering professors the opportunity to bridge the gap between their undergraduate students, as these students were once in a middle and high school classroom.

As lesson plans were submitted, reviewers also took note of which plans were effective, highly effective, and developing and compared them with the reviews on each engineering professors evaluations of their presentations. Of the teachers who fell into the highly effective to

effective range, their professors evaluations strongly agreed that “the material was presented in an organized manner”, “the instructor was a good communicator” and “ the instructor was knowledgeable on the topic”. For the lesson plan that did not meet the criteria to be effectively taught in the classroom on the first draft, their review of the presentation for 2 of the 12 professors disagreed and strongly disagreed that the “material was presented in an organized manner” and “the instructor was a good communicator”. Through these evaluations and lesson plans, the professors are able to continue to work on the requirements when presenting their material to students, and the educators and the lesson plans can be improved through the communication that is encouraged between the teacher and professor.

Limitations and Next Steps

Despite complete cooperation from both the engineering professors and educators, some limitations did present themselves through the initial lesson plan development. With many individuals from different backgrounds, some teachers struggled with complete understanding of the specific lesson plan format. With multiple sessions in the future, the familiarity with not only their team but with the expectations of the way the lesson plans must be submitted will become more apparent and comfortable. By keeping the same format for all submissions, when the Professional Development Program is completed, each teacher will not only walk away with more knowledge of engineering, but also lessons plans that can be used and referenced from multiple topics in a format that is recognizable.

When preparing many of the lessons, some materials are potentially not in the budget and could hinder the ability of the teachers to present this new engineering topic. By creating these relationships with the engineering professors at Manhattan College, the teachers are given the opportunity to stay in touch and ask for opinions and ideas when faced with the challenge of finding affordable materials to use in their classrooms. Teachers were permitted to borrow materials from the engineering department when this was feasible and practical. In Dr. Wilson’s second topic workshop “water filtration” the lab did require filtration columns to understand the concepts of particles being stopped before moving through the water cycle. With these columns not readily available to the teachers, the middle school science teacher who worked with Dr. Wilson opted to attempt building her own filter out of plastic soda bottles. Although teachers did make their own materials list for their individual lessons, the materials are occasionally expensive and difficult to come across. By using less expensive resources, the teacher provided an idea that could be used in all classrooms with limited funding. The benefits were also demonstrated to the engineering professors, who often do not need to be innovative when teaching their material at the college level, as the budget is usually inclusive of most required resources.

With many of the lesson plans requiring materials often unattainable due to school budgets, a potential solution still being evaluated is the creation of a “lending library”. The lending library would be stored at Manhattan College to be accessed by the teachers in the professional development program when presenting the engineering topics to their classrooms. By having many of materials required for each lesson, the schools have the opportunity to bring engineering in without spending money outside their means and potentially bringing awareness to a concept that is crucial and interesting.

The goal moving forward with the Engineering STAR Center is that it can focus not only on the new engineering topics that the engineering faculty have prepared, but also provide teachers with even more feedback on the lesson expectations and a rubric when looking at their

own, as well as other lessons prepared from the initial professional development session. In the second session with a more comfortable relationship between the teacher and engineer teams, the engineering faculty were able to share more about personal research they do on the college level and gave teachers a more in depth look at the labs that these engineers work in on a daily basis. The collaboration exposes another hands-on approach that creates a more personal connection to the topics in engineering and the idea behind what an engineer does.

Conclusion

The Engineering STAR Center is a program in its early stages, but it is one that provides a new outlook on the way engineering can be introduced and well received not only by the inquisitive students in the classroom but by the teachers who now have the confidence to bring these profound ideas to light. The engineering faculty who are passionate about what they perform and understand on a daily basis, are made more aware of the challenges that are occurring in classrooms and are able to bring their own creativity to the topics, while also learning about the pedagogy so often overlooked. By bringing these two professions together, the changes that can be made over the year spent by teaching and learning together shows substantial growth in both fields. It provides a more certain future for the middle and high school students that will go on to become engineers, as well as the teachers who have been able to collaborate and share the knowledge they have received by completing this program.

“As concerns mount over the college preparation and ongoing professional development of teachers, a tremendous opportunity exists to systematically address national STEM education imperatives. K-12 and higher education partnerships could allow systematic study and application of the collaborative work... as STEM faculty gain teaching knowledge and apply it to higher education courses.”⁹ These partnerships could serve as the centerpiece of STEM education development.

Acknowledgment

The support provided by the National Science Foundation under grant number 1439738 is greatly appreciated. We also thank STEM teachers, engineering and education faculty members and Engineering Ambassadors who participated in this program.

Bibliography

1. NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.
2. National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics*. Washington, DC: Authors.
3. Meyers, Bob. "The Highly Engaged School: A Successful Model for Professional Development." *National Association of Independent Schools* 74.2 (2015): 105-09.
4. Pomeroy, D. "Synergistic Interactions of K-16 Partnership Work, Research, and Teaching in Higher Education Science Faculty Members". Paper presented at the National Association for Research in Science Teaching (NARST), Philadelphia, PA March 21-24, 2010.

5. Foster, K. M., et al., "Partnership for STEM Education." *Education Forum* 329.5994, (2010): 906-907.
6. Al-Balushi, Sulaiman M., and Nasser S. Al-Abdali. "Using a Moodle-Based Professional Development Program to Train Science Teachers to Teach for Creativity and Its Effectiveness on Their Teaching Practices." *Journal of Science Education and Technology* 24.4 (2014): 461-75.
7. Vitic, Mateja Ploj, and Andrej Sorgo. "Can We Expect to Recruit Future Engineers Among Students Who Have Never Repaired a Toy?" *EURASIA Journal of Mathematics, Science & Technology Education* 12.2 (2015): 249-266.
8. Mills, Leila A., and Putthachat Angnakoon. "How Do High School Students Prefer to Learn?" *International Association for Development of the Information Society, 12th International Conference on Cognition and Exploratory Learning to Digital Age* (2015): Paper presented at the International Association for Development of the Information Society (IADIS) International Conference on Cognition and Exploratory Learning in the Digital Age (CELDA) (12th, Maynooth, Greater Dublin, Ireland, Oct 24-26, 2015). 133-139.
9. Pomeroy, D. "Synergistic Interactions of K-16 Partnership Work, Research, and Teaching in Higher Education Science Faculty Members". Paper presented at the National Association for Research in Science Teaching (NARST), Philadelphia, PA March 21-24, 2010.

Appendix A: Survey for Current STEM Teachers and Students

Manhattan College Survey for Current STEM Teachers/Students

An investigation into the perspectives of educators on the collaborative approach to integrating engineering concepts in teaching of science and mathematics.

Introduction:

For each of the statements below tell us how much you agree or disagree. Please express your feelings openly and honestly because we are interested in what you think. Do not write your name on the survey at any time. This is a five point questionnaire with the following five-point rating scale: Strongly Agree (**SA**) = 5; Agree (**A**) = 4; Undecided (**U**) = 3; Disagree (**D**) = 2; Strongly Disagree (**SD**) = 1. Place an "X" in the circle which corresponds to your response for each statement, for example .

- | | | | | | |
|--|------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|
| 1. The literature on engineering is difficult to understand. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 2. I could read any literature on engineering and then explain it to another person. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 3. When I see any literature on engineering I tend to ignore it as language I do not understand. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 4. I am intimidated by the language and jargons used in engineering journals and news articles. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 5. I prefer to work with data that relates to education than data relating to engineering. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 6. I believe that teachers of science and mathematics are usually "A" students as undergraduates. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 7. Integrating engineering concepts in science and mathematic classrooms is necessary for students' success in the 21st century. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 8. Engineering concepts are difficult to teach in elementary grades. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 9. Students in secondary school are better able to understand engineering concepts than students in the middle school. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 10. If I had a choice, I would prefer a course taught by a teacher than by engineering instructors. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SA
<input type="radio"/> |

- | | | | | | |
|--|------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|
| 11. A knowledge of engineering disciplines should only be taught to students who plan to pursue careers in engineering. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SA
<input type="radio"/> |
| 12. It is not necessary for me to receive training in aspects of engineering to effectively integrate engineering concepts in my science/math lessons. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SA
<input type="radio"/> |
| 13. The most important aspect of teaching science is motivating students rather than the memorization of facts. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 14. All students can enjoy learning engineering concepts. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 15. Engineering concepts should be taught mostly through an interdisciplinary approach. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 16. It is difficult to integrate engineering concepts with other disciplines. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 17. I feel enthusiastic about integrating engineering concepts in my classrooms instruction. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 18. I prefer to teach inquiry-based lessons as opposed to lecture courses. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 19. I am confident in my ability to teach cooperative learning techniques. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 20. I prefer to plan my science lessons with engineering students outside of the classroom than to involve them in classroom instruction. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |

Demographic Information

Gender: _____

Age: ___20-30 ___30-40 ___50...

Subject Area Concentration/Licensure: _____

Grades you currently teach: _____

Grades you plan to teach: _____

Teaching Experience: ___less than one year ___1-2 years ___3-4 years ___More than four years

Appendix B: Survey for Current Engineering Faculty and Students

Manhattan College

Survey for Current Engineering Faculty and Students

An investigation into the perspective of engineering faculty on the collaborative approach to Integrating education concepts into the teaching of science and mathematics.

Introduction:

For each of the statement below tell us how much you agree or disagree. Please express your feelings openly and honestly because we are we are interested in what you think. Do not write your name on the survey at any time. This is a five point questionnaire with the following five-point rating scale:

Strongly Agree (**SA**) = 5; Agree (**A**) = 4; Undecided (**U**) = 3; Disagree (**D**) = 2; Strongly Disagree (**SD**) =

1. Place an "X" in the circle which corresponds to your response for each statement, for example X.

- | | | | | | |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1. The literature on teaching and learning is difficult to understand. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 2. I could read any literature on teaching and learning and then explain it to another person. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 3. When I see any literature on teaching and learning I tend to ignore it as language I do not understand. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 4. I am intimidated by the language and jargons used in education journals and news articles. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 5. I prefer to work with data that relates to engineering than data relating to teaching and learning. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 6. I believe that teachers of science and mathematics are usually "A" students as undergraduates. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 7. Integrating engineering concepts in science and mathematic classrooms is necessary for students' success in the 21st century. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 8. Engineering concepts are difficult to teach in elementary grades. | SA | A | U | D | SD |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 9. Students in secondary school are better able | SA | A | U | D | SD |

- | | | | | | |
|---|------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|
| to understand engineering concepts than students in middle school. . | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 10. If I had a choice, I would prefer a course taught by engineering instructors than by classroom teachers | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 11. A knowledge of engineering disciplines should be taught only to students who plan to pursue careers in engineering. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 12. It is not necessary for me to understand pedagogical strategies to effectively integrate concepts in engineering and natural science. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 13. The most important aspect in teaching engineering Is motivating students rather than memorization of facts. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 14. All students can enjoy learning engineering concepts. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 15. Engineering concepts should be taught mostly through an interdisciplinary approach. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 16. It is difficult to integrate engineering concepts with other subjects. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 17. I feel enthusiastic about teaching engineering in science/mathematics classrooms. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 18. I prefer to teach inquiry-based lessons as opposed to lecture courses. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 19. I am confident in my ability to teach cooperative | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |
| 20. I prefer to plan engineering lessons with teachers than to participate in the classroom instruction. | SA
<input type="radio"/> | A
<input type="radio"/> | U
<input type="radio"/> | D
<input type="radio"/> | SD
<input type="radio"/> |

Demographic Information

Gender: _____

Age: ___20-30 ___30-40 ___50...

Engineering Area: _____

Teaching Experience: ___less than one year ___1-2 years ___3-4 years ___More than four years