Introducing Engineering into the Dominican Republic Classroom: Teacher Workshops

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Abstract

First-year students beginning engineering at Ohio Northern University are engaged in a year-long Introduction to Engineering course sequence. The second semester of this sequence is a first-year cornerstone course in which all engineering students propose and design a device to alleviate some effect of poverty in an assigned population. Ohio Northern University is also in their second year of an innovative, new and unique Bachelor of Science degree in Engineering Education. Tying these opportunities together resulted in the development of workshops to introduce engineering, math and science into classrooms in the Dominican Republic.

A team from ONU visited a series of three schools affiliated with Solid Rock International in the Dominican to introduce hands-on math concepts to teachers from classrooms with 3 year olds through high school. Over 100 teachers who teach over 2,200 students attended the program and were introduced to the engineering design process and activities available on the IEEE tryengineering.org web site. These activities are typically part of the IEEE Teacher In Service Program (TISP), which is designed to train engineers to hold in-service workshops for teachers who then take hands-on engineering projects into their classroom. Teachers are provided with lesson plans (available in English and Spanish), tied to educational standards in the United States. Each activity is designed to be inexpensive (often less than U.S. $10 for a classroom). This program has been successfully implemented throughout the United States for over ten years and has seen very limited international expansion to countries with a strong IEEE presence.

This paper will discuss the very successful workshops, including assessment collected at the conclusion of each workshop. The structure of the workshops and the involvement opportunities for the undergraduate students who participated will also be described.

This paper will be of interest to programs with available international service opportunities for undergraduate students or programs interested in innovative activities to introduce engineering into K-12.

Introduction

IEEE Teacher In Service Program (TISP)

The IEEE Teacher In Service Program (TISP) is designed to train engineers to hold in-service workshops for teachers who then take hands-on engineering projects into their classroom. Through the IEEE sponsored website, tryengineering.org, teachers are provided with lesson plans tied to United States national educational standards where applicable. Each activity is designed to be inexpensive (often less than $10 for a classroom)[1]. This program has been successfully implemented throughout each IEEE region in the United States for over ten years and has expanded internationally. For example, efforts using IEEE professionals in the classroom in Hong Kong successfully allowed the introduction of engineering principles into rural schools[2].

Lesson plans are available for download and most are translated into Spanish and seven other languages. Surveys assessing participants' satisfaction after these workshops indicate that participants are highly satisfied with the experience. For example, surveys of a large implementation of TISP activities for a school district in central Indiana showed teachers agreed or strongly agreed that the activities added to their knowledge base, and nearly 90% claimed that they would implement the activities in their classrooms[3].

Solid Rock International in the Dominican Republic

Solid Rock International[4] is a 501c3, not-for-profit organization with a mission to holistically serve the poor in the Dominican Republic by focusing on all aspects of health. Solid Rock operates six schools in the Dominican Republic. Given the state of public education in the Dominican, a private school education is highly sought after but can be expensive for families. Most of these schools are located in the western half of the country. They include:

- Two schools in San Juan de la Maguana: CCED and Lucille Rupp Schools
- Elias Piña
- El Cercado
- Rosario
- Santo Domingo (travel time is about 4 hours)

The largest school, CCED in San Juan, is a complete K-12 facility with approximately 90 teachers and 2,000 students.

Implementation of Teacher Workshops

Faculty from engineering and education accompanied a team of eight engineering students, including two majoring in Engineering Education[5] to conduct a series of three workshops in the Dominican Republic in May 2012. The team selected three lesson plans available from tryengineering.org to implement, largely driven by considering the availability of materials in the Dominican. Selected lessons included:

- Assembly Line: Students build a "colored brick" individually, then design a manufacturing line to build a 'brick' efficiently.
- Robot Arm: a material list of common office supplies and scrap and design process that results in a robot arm that can transport a water bottle.

Figure 1: Teachers working individually on 'colored bricks'

- Rotational equilibrium: students calculate the balancing point of a stick with a series of distributed weights. Supplies were delivered for this session, but it was not incorporated.

The team discussed the required materials with Solid Rock staff in San Juan de la Maguana to ensure the workshop information would be sustainable and all materials could be acquired in the future. For the initial workshops, sufficient materials were purchased in the U.S. and brought to the Dominican Republic. In addition to offering each of the hands-on activities, an additional set of 5 lesson plans were printed in Spanish and distributed each teacher.

Schools were not in session during the workshops due to the Presidential election, allowing an atmosphere similar to an "in-service day" often found in the U.S. Teachers were given lunch and a small stipend (500 RD pesos) for their participation, modeled after similar workshops held in the U.S. The first workshop (CCED and Lucille Rupp Schools in San Juan) involved 85 teachers, seven translators and the entire team of students. The following two workshops (Elias Piña and El Cercado) involved 15 teachers with a smaller cohort of translators and students. Students who did not participate in the teacher workshops assisted in other activities in the larger mission team, including remote medical clinics or construction projects. Although three activities were planned, the need to translate, the enthusiastic participation from the teachers and the intermittent availability of power limited us to two activities.

Engineering Design Process

The workshop began with introductions, background and presenting a translated version of the engineering design process. The instruction through the day continually referred back to the design process. When similar workshops are held in the U.S., the tie to educational standards is heavily emphasized; however, this was not applicable for the Dominican workshops. The relationship to educational standards is available in the lesson plan handouts. The lectures and explanations were geared toward emphasizing the importance of math, science and engineering in an interdisciplinary context.

Figure 2: Teachers working in an assembly line

Assembly line

The first activity was *The Assembly Line*. In this task, the teachers are presented a scenario in which 3 million blocks must be assembled and delivered; individuals are then given detailed set of instructions on how to build a child's block out of two paper lunch bags, crumpled scrap paper

and markers. The Color Bricks, or in this case, Ladrillos de Color, were manufactured and stacked. Results varied in each workshop, but typically individuals in the group produced one block in about 12 minutes.

Following individually building bricks, the concept of an assembly line was presented. Teams were formed, and more blocks were developed more efficiently. Each assembly line could produce approximately 8-10 blocks in the same amount of time, depending on the efficiency of the team.

Robot Arm

The *Build a Robot Arm* lesson emphasizes the importance of the engineering design process. Teams are given a set of materials including 22" cardboard strips, paper clips, 3' of tape, etc., and tasked to build an arm that can lift a water bottle, move it, and place it back on the table.

Teams worked diligently and the demonstrations were, to say the least, enthusiastic. Teams cheered as each robot arm worked, although there were some teams that stretched the rules a bit.

We had an opportunity to allow one of the first-year students in engineering education to lead this section of the workshop on the third day of workshops.

Figure 3: Robot arm testing

At the conclusion of each day, each school principal thanked the team and enthusiastically invited us back for follow-up workshops.

Assessment: Dominican teacher perspective

Teachers were asked for feedback through post-session discussion and a post-workshop survey. The feedback and comment session was met with fantastic response; teachers were very willing to share their gratitude and their ideas for implementing the activities in their classrooms.

A total of 94 surveys were completed, 69 on the first day from the combined workshop of three schools, plus 13 from the second and 12 from the third day. Surveys were comprised of six open-ended questions in Spanish. Responses were then translated and evaluated. Overall, the response across all schools and all instructors was highly positive. While the norms of social desirability and the positive wording of the question might incline respondents to answer affirmatively, the explanations of these affirmative answers is more revealing of the perceived value of the workshops.

The first question asked: "Did you find this workshop beneficial? Please explain." All 95 respondents answered this question, and all responses were positive. One of the key reasons given was the fact that the activities were a new and creative way to help the teachers make learning fun for students. For example, one instructor wrote, "Yes, because you have given us new strategies for teaching and making dynamic and enjoyable the work and doing teams on the

part of the students." Another writes, "Yes, because I learned new techniques to make the classes more fun." In addition to making learning more enjoyable, the teachers also felt that the activities would help their students discover and enhance their creative abilities. Representative responses include:

- Yes, because it encourages the use of creativity and imagination. It also teaches how to work in a group.
- Yes. First, I learned to teach with motivation. Later my students learn to be creative and these activities to solve with greater ease problems in the area of math and other areas.
- Yes, it shows me a different focus of how to motivate teamwork and to help my students discover their strengths and weaknesses.

A common theme found in teacher responses is the emphasis on teamwork and the positive experiences that can have for students.

The second and third questions asked: "Which activities from this workshop will you use in your future classes?" and "Is there any reason you would not use these activities in your classes in the future?" While all teachers received a packet with five different activities in Spanish, only two activities were actually carried out in the workshop due to time limitations. Most participants either named the activities by name ("the colored bricks" or "the robot arm") or referenced that they would use "both," clearly indicating only the two activities actually done during the workshop, and not any of the others that were included in the packet. Only one individual answered that there was an activity that he or she would not use. This individual commented, "The robot because it uses too much time."

The intent of the activities is to introduce engineering concepts into the K-12 curriculum, a goal commonly heard in the U.S. Rather than focus on 'engineering', question 4 focused on math. "Do you think these activities would increase students' performance in mathematics? How?" Most responses to this question were positive and revolved around students having to perform various measurements or calculations, certainly necessary within engineering. Comments include:

- They are going to develop logical mathematic thought because they are going to measure, calculate which figures to draw.
- They will learn to solve problems using things from their surroundings and working in groups, formulating hypotheses, and planning methodologies to solve the problems. [Note that this seems to reference the engineering design process.]

Another common response to this question had to do with the fact that the activities were motivating for students on a number of levels, inciting creativity, enjoyment, and critical thinking, as can be seen in these comments:

- I believe they will be of great help in that the boys and girls will love learning doing these things.
- These activities are going to help to think first, and later to coordinate and develop different forms to solve the problem.

These responses demonstrate that the teachers see many different types of benefits that can result from these activities—those directly related to course content of math and science, and those related to less concrete skills like creativity, critical thinking, and problem solving.

Question 5 asks: "Do you think these activities would encourage more students to go into the fields of engineering, math, or science? Why?" The most common responses tended to focus around two main themes: student self-efficacy in the skills necessary to work in these fields and student discovery of the creativity associated with these fields. Some of the representative comments include:

- Yes, because of the opportunity to be creative and to create self-confidence.
- Yes, because you can awaken in them curiosity and interest in constructing and manufacturing new things.
- It awakens their interest for the creation of new things and satisfaction of achieving them; it is gratifying.
- I believe that yes, already out children many times do not believe that they are able to be these things; however, with these games, they can see their creations and believe it is simpler than they thought.

The final question asked: "Would you recommend this workshop to others?" We really did not expect any negative responses, and we indeed received a 100% positive response rate saying that each teacher clearly would recommend the workshop to others.

In the "Comments" section of the survey, one response that appeared numerous times was that the workshops weren't long enough. Since the teachers were in the workshop from 9:00 a.m. until 2:00 p.m. on a non-work day, comments indicating they would like to have spent more time in the workshop provide insight to the degree of engagement and interest of these teachers. One teacher wrote, "I hope you continue to do similar workshops and that last longer about more things." Another said, "The time ought to be longer, in order to be able to analyze, construct, and reconstruct."

Consistently throughout the "Comments" section, the teachers asked for additional workshops in the future: "This workshop was excellent to me. I hope you will return to share with others about this, and congratulations and thanks. God bless you.**"**

Assessment: Student perspective

Eight Ohio Northern University students were originally intending to participate in the teacher workshops. Other students were traveling mainly to participate in other, medically-related events. As the teacher workshop planning unfolded in the Dominican, we encouraged any student to participate in as many experiences as possible. This meant that we had a fairly large team of students at each site to assist with small groups during the activities. Two of the students were directly involved in presenting material during the third day of workshops.

The faculty leading the workshops observed that, as could be expected, participating in the workshops may be a life-changing event for many students. Two were selected to lead portions

of the workshops based on conversation after the first and second days of workshops. One student majoring in Engineering Education and therefore, a pre-service teacher, expressed an interest in becoming more involved. He led the section on the design of the robot arm.

On an open-ended assessment, Tyler said, "One of the difficulties in doing these workshops overseas is the language barrier. We had anywhere from 2 to 6 translators during these workshops, and they were definitely our most valuable asset. Speaking through a translator is a difficult thing to get used to, but the teachers seemed to really grasp the activities that we presented them with." Tyler generally appears very comfortable in front of a crowd; in this case, he was comfortable enough that he presented the material as he would in the United States. After about a minute, he realized that the translator was waiting for a break to translate. This didn't seem to have an effect on the delivery of the content; indeed, the teachers were well aware that our group did not speak Spanish. Our translators were obviously extremely valuable and we could not have been successful without them.

Further, Tyler observed "One thing that I am not sure on is whether or not the participants took away the fact that this is for engineering, not just fun activities. Although they seemed fun and they worked on critical thinking and design, their purpose may have been slightly muddled. I fear its main goal may have been lost in translation or not explained at all. I hope that they can explain to their students that there is a purpose to these things, and that it is the field of engineering, not just fun." This comment was very interesting and speaks somewhat to the difference in culture. The Dominican teacher participants were fully engaged: when the activity could be fun, the activity was exceptionally fun. When there could be a competitive atmosphere, the atmosphere was extremely competitive in a very friendly way. The enthusiasm didn't begin to be comparable to the professional atmosphere found in similar workshops held in the United States. Further assessment to judge the effectiveness of the activities in the classroom is planned.

Stacy, majoring in Civil Engineering and a student leader in international service opportunities at Ohio Northern University, observed that the concept of an assembly line didn't seem to be understood clearly, and that it was possible that the Dominican teachers weren't as familiar with the term as students in the U.S. may be. We asked her to present the concept at the third workshop and results were vastly improved. Stacy worked seamlessly with the interpreter and offered a more thorough, more basic explanation of the concept of the assembly line.

Morgan, also a Civil Engineering major, mentioned that she found this opportunity to be truly life-changing. She describes the experience of helping in the workshop: "I thoroughly enjoyed each of the teacher workshops. The first one was the most exciting because there were so many teachers that came to the workshop. It was very heartwarming to see all of the teachers actively getting involved in the two lessons plans that were taught and given to the teachers. Our challenge of not speaking Spanish did not hinder us teaching the teachers at all. We had translators and used actions to help get the lesson and point across. Watching and interacting with the teachers was my favorite part because I got to see how they approached each step of the lesson and how they interpreted the activity." Her comments during a reflection period held on the last evening in the Dominican demonstrated that she appreciated a crucial concept in international aid: we must NOT approach these activities as "Americans coming to the rescue."

"One suggestion is next time instead of us doing all the teaching I think the teachers at the workshop should have a lesson plan that we as a group can take back and use in the classroom." This statement showed an understanding that effective international aid means working with the people in the Dominican, not just engaging in a "drop and run" mentality.

Future research

Post-workshop feedback was enthusiastically positive, but the true assessment questions remain:

- Will the teachers implement these (or related) activities in the classroom, and
- Will they have an effect on the students?

To assess these questions, a future visit is planned to interview the school administrators to see if they are aware of teacher implementation, to interview the teachers to see if they have implemented the activities and what effects they have seen, and to interview students to assess their perception of engineering, the engineering design process and concepts such as problem solving.

We intend to present these and/or additional activities to public schools that have not been visited. More than one student observed that, to avoid a perception that "the Americans are here

Figure 4: Teachers from San Juan de la Maguana with Ohio Northern University faculty and students

to tell you what you are doing wrong and what you need to do right," we should ask the Dominican teachers to present some innovative practices to the contingent from the U.S.

Acknowledgement

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