Introducing Engineering into the Dominican Republic Classroom: Teacher Workshops

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Abstract – **Ohio Northern University (ONU) started a Bachelor of Science in Engineering Education degree in 2011. Students in the program are engaged early in their collegiate career in innovative programs to introduce engineering concepts into K-12. Part of their first year of study involves a course requiring the design of a device to alleviate some effect of poverty. 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 activities available on the IEEE tryengineering.org web site. These workshops will be followed by assessment during the next academic year.

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.

Post-workshop qualitative assessment showed very promising results: the teachers were excited and indicated they plan to integrate the concepts.

Index Terms – Engineering Education, International, Poverty Alleviation, Teacher Workshops

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. Teachers are provided with lesson plans which are tied to national educational standards in the United States. Each activity is designed to be inexpensive (often less than $10 for a classroom). [1]. This program has been successfully implemented throughout the United States for over ten years and has expanded to other countries, including Malaysia, South Africa and Chile. Recent 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 are translated into 8 languages, including Spanish. Post-workshop 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 whom Ohio Northern University (ONU) has partnered on a number of initiatives, including medical, education and engineering projects. They operate exclusively in the Dominican 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, each highly sought after given the state of public education. Most of these schools are within an hour of each other in the western half of the country. They include:

- Two schools in San Juan de la Maguana
- 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

A team of faculty from engineering, education and communication accompanied a team of eight engineering students, including two majoring in Engineering Education. [5] These individuals conducted a series of three workshops in the Dominican Republic in May 2012. The team selected three lesson plans available from tryengineering.org for which materials may be obtained by local teachers. Some possible lessons include:

- Assembly Line: Students design a manufacturing line to build a 'colored brick' efficiently.
- Robot Arm: a similar material list results in a robot arm that can transport a water bottle.
- Rotational equilibrium: students calculate the balancing point of a stick with a series of distributed weights.

The team discussed the required materials with Solid Rock staff in San Juan de la Maguana to ensure all materials could be acquired in the future, purchased sufficient materials to conduct the workshop and leave extra with each school and brought the materials to the Dominican Republic. In addition to preparing to offer each of these three activities, an additional set of 5 workshops were printed in Spanish and distributed each teacher.

Schools were not in session during the workshops due to the Presidential election, allowing an "in-service day". 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 School 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. 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.

ASSEMBLY LINE

The workshop began with introductions and an explanation of incorporating engineering concepts into the curriculum, concentrating on the engineering design process.

The first activity was *The Assembly Line*. In this task, the teachers were given a scenario that we need to deliver 3 million blocks; 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.

The concept of the assembly line followed; teams were formed, and more blocks were developed more efficiently. One of our students observed that the assembly lines weren't as efficient as they could be for the first two days; we asked her to present on day three and results were vastly improved. Each assembly line could produce approximately 8-10 blocks in the same amount of time, depending on the efficiency of the team.

Figure 1: Teachers working individually

Figure 2: Teachers working in an assembly line

ROBOT ARM

The *Build a Robot Arm* lesson focuses on 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.


Figure 3: Robot Arm testing

With three days of workshops, we had the opportunity to allow one of the first-year students in engineering education to lead this section of the workshop.

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

ASSESSMENT

Immediately following each workshop, the teachers were asked for feedback. 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.

Additionally, post-workshop surveys were distributed to all teachers in attendance. 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, written in Spanish. Responses were then translated and evaluated. Overall, the response across all schools and all instructors was highly positive.

The first question asked: **Did you find this workshop beneficial? Please explain.** All 95 respondents answered this question, and all answered in the affirmative. 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. One of the key reasons given for why these workshops were beneficial 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.
- Yes, it helps the creativity of the students and they learn in a fun way.
- Yes, because we are able to see the benefit it is to be creative and to work in a group, as well we are able to achieve greater benefits and results.
- Yes, because they are strategies that help the class be more enjoyable and creative.

A third theme that resonates through these teachers' responses to the value of the workshops and activities is the emphasis on teamwork and the positive experiences that can have for students. The comments above clearly show the importance of teamwork as a learning construct from these TISP activities they were learning to use in their own classrooms.

The second question asked: **Which activities from this workshop will you use in your future classes?** While all teachers received a packet with five different activities in Spanish, and reference was made to the different activities in the packet, 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.

Question 3 asked: **Is there any reason you would not use these activities in your classes in the future?** Of those who answered this question, 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." This question received just over a 50% response rate, so several teachers chose not to answer this question.

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?"** The response rate for this question was about 92%. Most responses to this question were positive and revolved around students having to perform various measurements or calculations, certainly necessary within engineering. The following are representative comments:

- 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.]
- Through the calculations, they will create figures, etc.
- It will help because it will have them do measurement using numbers; calculating.

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:

- You should use logical reasoning to calculate the positioning to get the product.
- 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 exercises will require reflection [critical thinking] in order to complete them, and that reflection is necessary for mathematics.
- This activity is going to motivate and interest them to solve the exercises.

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. It is the hope of the researchers that seeing multiple benefits to the activities will increase the likelihood that they will be implemented in the classroom in the future.

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 were in the affirmative and the reasons given 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.
- Yes, because they are able to put to a problem their creative capacity.
- It awakens their interest for the creation of new things and satisfaction of achieving them; it is gratifying.
- Yes, because they will see their capabilities.
- Yes, they are incentivized to see what they possess.
- Because I will be able to awaken in the children desires to elaborate and construct some piece or object.
- 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.

Again, these responses seem to indicate that the teachers see some value for their students in using these activities in the classroom. Again, the hope is that this insight translates into implementation of the TISP activities in classroom instruction in the future.

The final question asked: **Would you recommend this workshop to others?** We really did not expect any negative responses, simply due to the social desirability phenomena, and we indeed received a 100% positive response rate saying that each teacher clearly would recommend the workshop to others. However, the "Comments" section of the survey provided even additional insight into what these instructors liked and found beneficial about the workshop.
In the "Comments" section of the survey, one response that appeared numerous times was that the workshop was not long enough. These teachers were at the workshop from 9:00 a.m. until 2:00 p.m. on a non-work day. To have people state that they would like to have spent more time in the workshop provides some 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:

- We hope that you return soon so that we can acquire more knowledge with other workshops that you bring.
- To make a series of these workshops for new experiences.
- Thank you for this workshop. We hope that next time we work on another project.
- I would like you to return and teach new techniques. God bless you greatly.
- This workshop was excellent to me. I hope you will return to share with others about this, and congratulations and thanks. God bless you.
- I hope you continue to do similar workshops and that last longer about more things.
- None. The only thing I have to say is very good and very enjoyable. I hope you will repeat this another time.

While the results of this survey likely show some degree of bias from social desirability effect, there are enough trends among the independent comments to provide support that

this workshop was indeed beneficial and perceived to be useful for these teachers. Follow-up surveys with these teachers to ascertain which, if any, activities are being used in the classroom, what results the activities are yielding, and teacher satisfaction with the TISP methodology will be necessary as part of the ongoing work to integrate these learning techniques in international classrooms.

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 make an impression on the students?

To assess these questions, a future visit is being 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 additional activities to the schools in the first cohort, or alternatively, repeat these activities to the schools that have not been visited. More than one student observed that, to avoid a perception that "the Americans are here 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.

Figure 4: Teachers from San Juan de la Maguana with ONU faculty and students

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