
AC 2011-1949: INTRODUCE ENGINEERING TO 6TH GRADERS VIA "SPEED DATING"

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Dr. Vibhuti Dave joined Penn State Erie, The Behrend College as an Assistant Professor in the Electrical, Computer, and Software Engineering program in Fall 2007. She received her undergraduate engineering degree in the field of Electronics and Communication from Nirma Institute of Technology, India in 2000. She received her M.S. in Electrical Engineering and Ph.D. (2007) in Computer Engineering from the Illinois Institute of Technology, Chicago, IL.

Dr. Dave's research interests lie in the field of High Speed Computer Arithmetic and Computer Architecture. Her research has been focused on the design high-speed multi-operand adders. In addition, she is also interested in performing research in VLSI implementation of signal processing algorithms, and low power integrated circuit design.

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Kathryn Holliday-Darr is a Senior Lecturer in Engineering Graphics in the School of Engineering at Penn State Erie, the Behrend College since 1985. She also taught Industrial Arts at the high school level for seven years. She received her BA in Industrial Arts at the University of Northern Colorado, and her MS in Industrial Arts Education at the State University of New York at Buffalo. Her research and teaching interests include engineering graphics, visualization, K-12 outreach and working with freshmen enrolled in engineering technology programs. She is the author of Applied Descriptive Geometry and was the 2000 Oppenheimer Award Winner. Holliday-Darr also was awarded the Council of Fellows Outreach Award in 2010.

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Introduce Engineering to 6th graders via “Speed Dating”

Abstract

The School of Engineering at Penn State Erie, The Behrend College offers several outreach programs to the P-12 community impacting more than a 1000 students over the past year. The goal of this paper is to describe the presentation and implementation of a unique outreach program specially designed for sixth grade students. The program incorporated hands-on activities from all the engineering majors offered at this school into a fun interactive day within a limited amount of time. This paper will provide the details of each workshop as well as results from the assessment surveys given to the students and the teachers at the end of the program.

Workshops were designed to be hands-on and focus on either computer, software, electrical, mechanical or plastics engineering. Topics covered included binary math, electrical circuits, boat design, the properties of plastic materials and bridge designs. The event was sponsored by a local company through an Educational Improvement Tax Credit program. They presented a workshop on the properties and uses of magnets which is the specialty of this particular company. One hundred and twenty-eight sixth grade students from three different elementary schools participated in this program.

The challenge was to design a program for a large number of attendees and still showcase the engineering majors mentioned above to every single participant within a time duration of 3 hours. A distinctive feature of this event was how the workshops lasted for a short duration and still managed to be fun and interactive. Students were divided into groups of 11-12 and were rotated through the activities every 15 minutes.

This paper will detail the program and each of the activities. The paper will be concluded with results from surveys taken from participants as well as teachers at the end of the event.

Introduction

According to the National Science Board (2008), the need for more workers in the next five years in the areas of science, technology, engineering and math otherwise known as the STEM fields is predicted to grow twice as fast as the overall rate of growth for workers in all occupations in the United States.¹ Will there be enough workers or qualified people to meet this demand? The National Center for Education Statistics predicts that the growth of undergraduate enrollments in the STEM fields will be half the rate of growth for the demand of workers over these five years (NCES, 2008).² We must encourage and educate the younger generation about these STEM fields to prevent a shortage of engineers and scientist in the United States in the future.

Colleges and universities across the nation are looking at ways to increase the supply of qualified students coming out of high schools. A variety of STEM outreach programs have been created and developed. Many such programs are one-day long with a focus on introducing students in several age groups to the STEM disciplines. This paper focuses on describing the presentation and implementation of a unique outreach program specially designed for sixth grade students.

The program incorporated hands-on activities from all the engineering majors offered at Penn State Erie, The Behrend College into a fun interactive day within a limited amount of time.

Penn State Erie, The Behrend College (Penn State Behrend) a stand-alone college of the Penn State University has 4,700 students and is located in Pennsylvania. Penn State Behrend's first K-12 women and minority outreach event, Minority College Experience/Women in Science and Engineering (MCE/WISE), was launched in 1988 with 20+ incoming high school seniors participating. The students compete for a slot, take a college course and attend workshops that showcase STEM majors. Students earning a B or higher in their college course are automatically accepted to Penn State Behrend. In 1996 a one day event was started for 7th and 8th grade girls called Math Options Career Day. Last year 38 and 243 students respectively attended these events. Also during this time period, engineering faculty would visit public schools as requested by teachers. It was in 2006 that Penn State Behrend's outreach program blossomed. The majority of the events developed focus on middle school and high school females. Students participate in various hands-on activities that demonstrate to them how they could positively impact the society and community by choosing a STEM career. Allowing them to perform various practical activities can also aid in removing misconceptions they might carry regarding STEM fields, such as engineering is only about math. While it is well known that short 'shot gun' approaches have little impact on recruiting female students into engineering, the goal is repeated exposure. For instance, there is now a week long summer camp for 9th and 10th girls interested in science and engineering³ and a Women in Engineering Career Day for 10th and 11th grade girls. Enrollment reports indicate that the School of Engineering at Penn State Behrend has increased its female enrollment by 60% over the last five years. In 2009, due to our budding success, a K-12 engineering outreach lab was created and in 2010, the Engineering Outreach Center was established.

One of the questions that now comes up is 'what about the boys?' Therefore our school now hosts Cub Scouts as well as Girl Scouts and entire classes are involved in one to three hour events rather just females. In the last year alone, more than a 1000 students belonging to a variety of age groups from local schools have been invited to campus for several outreach events.

Another event started in 2006 is PLASTCar in which participants from two local elementary schools design Matchbox® sized cars. This program is an interdisciplinary semester long program with students from business, engineering and psychology areas that work with the elementary students over a semester.⁴

In 2010 a local school district proposed an event that would include all of the district's sixth graders. The decision was made to expose the students to the different engineering fields offered at Penn State Behrend. Due to the short amount of time allowed, The "TE" in STEM (aka "Speed Dating" in Engineering) was born. During each workshop, careers in engineering were discussed as they related to the hands-on workshop. This paper presents a detailed account on the days' activities followed by a section on what kind of changes and improvements can be made to the program. The last section provides an assessment of the program based on student and teacher evaluations.

Program and workshops

The "TE" in STEM
 20-May-10
 Harbor Creek School District
 Sponsored by: Eriez Magnetics

Schedule of the day

Arriving between 9:00 - 9:15am		
Time	Groups A- E	Groups 1-5
9:30 - 9:45	Burke 001 Presentation/Show -n- Tell	1 - Burke 201 - What is your bit?
9:45 - 10:00		2 - Burke 204 - Shrinky Dinks
10:00 - 10:15		3 - Burke 205 - K'NEX a Bridge?
10:15 - 10:30		4 - Burke 203 - Will it float?
10:30 - 10:45		5 - Burke 202 - Snap it up!
10:45 - 11:00	A - Burke 201 - What is your bit?	Burke 001 Presentation/Show -n- Tell
11:15 - 11:30	B - Burke 204 - Shrinky Dinks	
11:30 - 11:45	C - Burke 205 - K'NEX a Bridge?	
11:45 - 12:00	D - Burke 203 - Will it float?	
12:00 - 12:15	E - Burke 202 - Snap it up!	
12:15 - 1:00pm	Lunch in the Burke 180	

Table 1: Schedule of the Day

Table 1 shows the schedule of the day’s events. As the students arrived they were randomly divided into two groups and each was assigned either a letter (A-E) or a number (1-5).

While one group participated in the 5 “speed rounds” of hands-on activities, the other group had a longer presentation and hands-on demo that featured magnets and how they are used by companies. This presentation was sponsored by Eriez Magnetics which is a world leader in the metalworking industry. At the half-way point, the groups swapped and participated in the other half of the program.

The program is dubbed “Speed Dating with Engineering” because of the fact that the instructors led five engaging hands-on activities lasting for 15 minutes. The sound of a whistle marked the end of a 15-minute session which is when students in the second group were escorted to the next workshop.

What is your bit?

This workshop was designed to teach participants about binary math. By introducing the concepts of bits, 0s and 1s, the basic concepts of computer and software engineering were introduced. Attendees were given a brief lesson on what binary math is and how each letter of the alphabet is represented by a numerical value and a series of 0s and 1s in the computer. For example, the letter A is 65 and in binary it is 1000001.

Using this information the students calculated what their initials would be in binary. For example, Joanna Engineer would be JE or 74 and 69 and in binary that would translate to: 1001010 and 1000101.

The students used the results to make key chains for their backpacks using cording and beads. Blue colored beads were used to represent 1, white ones used to represent 0 and a clear one to separate the initials. Figure 1 shows Joanna Engineer's initials in binary using beads.



Figure 1: The initials JE in binary. Blue = 1, White = 0 and Clear separates letters.

Shrinky Dinks

Shrinky Dinks⁵ is a phenomenon that started in the 1970s becoming popular in the 1980s. The concept behind it is to create a design with color on a piece of plastic, shrink it in an oven. The plastic shrinks to one-third of its original size preserving the shape and color.

This workshop focused on promoting plastics engineering as a possible engineering major. By using Shrinky Dinks it was demonstrated that a particular kind of plastic, called polystyrene, has a form of “memory” which means when heated, it can retain its same shape but just at a different size.

Figure 2 below shows an original design on the left and the design on the right after it has been shrunk.



Figure 2: On the left a design before and on the right, design after placed in toaster oven.

Each participant was given a piece of polystyrene plastic and Sharpie® markers to make a design. Most participants drew their initials or a school mascot symbol. Every design was hole punched so that they could hook it on a keychain or a backpack. Figure 3 was taken of a Shrinky Dinks in a toaster oven in the middle of the process.



Figure 3: Shrinky Dinks design in the toaster oven during the process.

K'NEX a bridge?

Focusing on the mechanical engineering concepts the students were introduced to bridge designs using the K'NEX Education: Real Bridge Building construction sets⁶ that utilizes rods and connectors. Faculty instructors had some classic bridges like London Bridge, Astoria, etc., already built or photos available in order to discuss the design concepts behind them.

Students in every session worked on constructing a K'NEX bridge that spanned 20 feet and the group got to see the final results at the end of the program. See Figure 4 below.

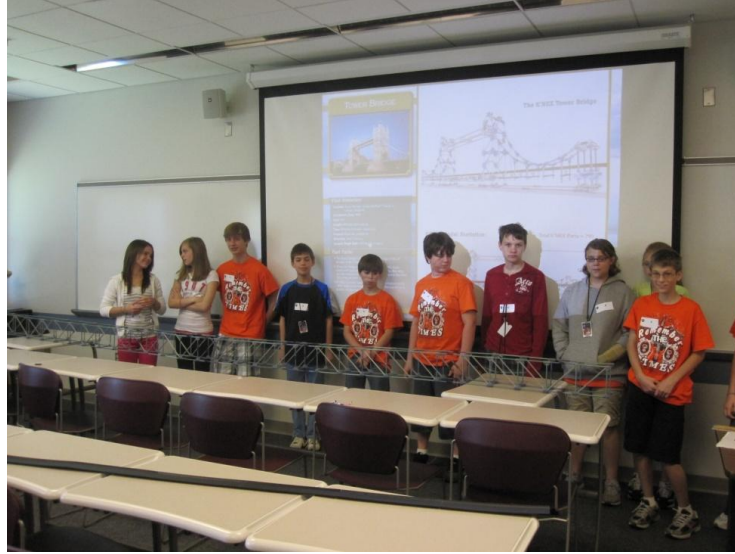


Figure 4 Students with part of the completed bridge.

Will it float?

This particular workshop was created to bring an element of design to the day, demonstrating an important part of engineering. Students were given 2 pre-cut sheets of aluminum foil, 4 craft sticks and a Life Saver® (must have a life preserver on the boat). Figure 5 is an example of one of the boat designs. Students worked in teams of three with each team given 5 minutes to design a boat that would float on water and hold ball bearings.



Figure 5: Testing a boat design.

As seen in Figure 5, teams had to load up their boat with ball bearings and see which design held the most. The students were able to see what others did with their design and discussed which design strategies worked relatively better.

Snap it up!

In order to introduce fundamentals of electrical engineering, Snap Circuit® kits⁷ from Elenco® Electronics Inc. were provided to the participants. Again, students were placed in teams of three with a kit and instructions on how to build a 2-speed fan. Figure 6 shows a completed 2-speed fan.

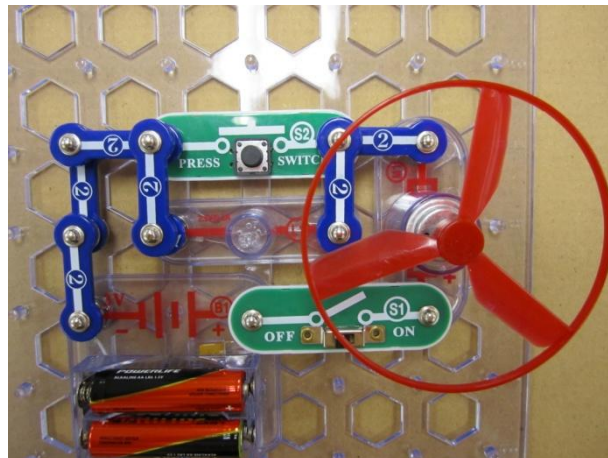


Figure 6: 2-Speed fan using Snap Circuits®.

While the participants built the fan, instructors talked about the basics of circuits such as voltage, current and resistance. Once the design of basic fans was complete, the idea of incorporating a switch to the circuit was introduced there by resulting in a complete design of a fan with 2 speeds.

At the end of the last workshop groups A-E and 1-5 switched so that all students experienced all of the workshops and the presentation by the sponsoring company.

Lunch/wrap-up

At the end of all workshops and the presentation made by the Eriez Magnetics lunch was served. The wrap-up session was just simply a time for attendees to reflect on the day, for organizers to gather some survey data and thank them for coming.

Discussion

Student evaluation

The workshops were evaluated using quantitative and qualitative questions. There were 128 male and female 6th graders. The students filled out a brief assessment questionnaire at the end of their visit.

For each workshop the participants used a rating scale of 1 = strongly disagree to 5 = strongly agree, as to whether the workshop was interesting. Yes/No questions asked were 1) I am glad I attended The TE in STEM Day, 2) Would you recommend this program to other students?, and 3) Do you now have a better understanding of engineering?. Open ended questions asked were 1) What did you like **most** about this workshop?, 2) What did you like **least** about this workshop? 3) My favorite part of the day was, and 4) Please give us suggestions on what we can do to improve any future **The TE in STEM** program, followed up with an Other Comments section.

Table 2 shows the questions, the means (M), and the standard deviations (SD) of the responses, along with the most common comments about each workshop. The most enjoyable workshops were the Shrinky Dinks and Aluminum Boats. The least favorable workshops were the K'NEX Bridges and Eriez Magnetics.

		Interestin g	Liked the Most	Liked the Least
Eriez Magnetics	M	3.66	the magnets	sitting too long
	SD	1.04	the slide show	the slide show
Binary Code	M	3.80	making the keychain/bracelet	the math
	SD	1.07	learning my name in binary code	figuring out the code
Shrinky Dinks	M	4.22	coloring/drawing	teacher talking about plastic
	SD	0.98	making them	not enough time
K'NEX Bridges	M	3.63	creating/connecting the bridge	building
	SD	1.20	the bridges	boring
Aluminum Boat	M	4.18	making boats	watching it sink
	SD	0.95	getting lifesavers	we weren't first/losing
2 Speed Fan	M	3.94	making it	making it
	SD	1.11	the fan flew	lecture/learning

Table 2: Results of the Student Surveys

Overall assessment

Of the 117 students that filled out the back side of the survey, 99% stated they were glad they attended The TE in STEM Day. Eighty nine percent of the students surveyed said they would recommend this program to other students. 91% of the students said they now have a better understanding of engineering. When asked what their favorite part of the day was, the Shrinky Dinks workshop was the top choice, followed the food (pizza), and the aluminum boats workshop.

Teacher evaluation

Seven teachers attended the day with their students. They were asked four open ended questions, 1) What did you like most about this program?, 2) What did you like least about this program?, 3) How could we improve this event?, and Other comments?

While, the majority of the teachers liked that the short activities were hands-on, they felt the activity time allowance was too short. They also agreed with the students that the magnetic workshop was too long. Just under half of the teachers liked the wide range of engineering majors covered; however, several teachers felt the activities needed to be tied into occupations more.

Future recommendations

This section provides some ideas that can be incorporated into the program in the future based on our first-time experience. As can be see in Figure 1, no time was allotted for students to change sessions. Even though all workshops were scheduled in classrooms in the same hallway requiring the escorts and students to walk a short distance, time was still required to switch rooms. After the first session at 9:45am, all of the instructors of the workshops shortened their presentation to 12 minutes to allow 3 minutes to change rooms. However for the future a better option would be to allow 15 minutes or more for the presentations and including a few extra minutes as part of the schedule to swap classrooms and bathroom breaks.

The sponsor company's presentation was a show-n-tell session and did not have a hands-on portion. In the future, it would be advisable to ensure that every session has an applied segment in addition to the presentation of theoretical ideas. The sponsors specialize in magnets and use them in manufacturing; an engaging activity could be of along the lines of having the students sort different materials using magnets just like in a manufacturing setting.

Student evaluations show that the Shrinky Dinks workshop was the one they enjoyed the most. Improvements need to be made to the "What is your bit?" workshop. It could be modified to introduce similar concepts but work with bar coding instead.

Students also seem to carry certain misconceptions regarding what engineers do. Addressing this issue is a key component missing in such events. Organizers are currently working on a video project involving alumni explaining what they do in their jobs. The expectation is that this video

will appeal to the audience and hearing from a real engineer will answer some important questions students might have regarding engineering as a career option.

Both student and teachers were asked to make suggestions for future improvements. Twenty percent of the student comments stated the magnet presentation was too long, 16% stated the 15 minute workshops were too short, and 12% would have liked more activities and workshops. Half of the teachers agreed the shorter workshops were too short and recommended an additional five minutes be added to each workshop.

Conclusion

The TE in STEM Day was an overall success. The survey results show both the 6th grade teachers and students enjoyed the day. This was evident when looking at the “Other Comments” section in the survey. These comments ranged from “fun”, “amazing”, “can’t wait to come back”, to everything was “fun and educational.”

One might argue that such one-day events do not have a significant impact on a student resulting in him or her considering a STEM career. However, it should be noted that although this program as a stand-alone unit might not be enough, the fact that it ties in with all the other outreach events organized at Penn State Behrend is what makes the difference. Each event at Penn State Behrend targets kids from specific age groups and attempts multiple event contacts with the same groups. Our goal is that the kids will attend events over a span of years and show them how STEM fields could be viable career options. We hope that this does have a positive impact that the country is looking for as well as our school. It is necessary to target as many bodies as possible and as early as possible. The idea behind this program was for both males and females students to attend since there are already a few events targeting the female population.

This is a fun event that will hopefully result in students attending other similar workshops and seminars helping them understand the wide variety of career options that lie ahead of them if they choose to pursue a degree in either science, technology, engineering or math (STEM) fields.

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