Mary Vollaro, Western New England College

Mary B. Vollaro is Associate Professor of Mechanical Engineering at Western New England College in Springfield, Massachusetts. Dr. Vollaro received her Ph.D. at the University of Connecticut, her M.S. at Rensselaer Polytechnic Institute, and her B.S.M.E. at Western New England College. She has held engineering positions in industry (in particular, the materials science area). She is the ASEE Materials Division Chair.
Engineering Exploration for Junior Girls Scouts:  
Partnership, Activities, Insight, and Reflection 

Mary B. Vollaro, Ph.D.  
Associate Professor, Mechanical Engineering,  
Western New England College, Springfield, MA 01119

I. Introduction

Western New England College (WNEC), School of Engineering has partnered for three years with the Western Massachusetts and Pioneer Valley Girl Scout organizations to present an “Engineering Exploration” program for Junior Girl Scouts, who are typically in 4th, 5th and 6th grades. The day’s program was designed meet two primary goals. The first is to educate young girls about the engineering profession and, the second is to provide an experience that would leave our participants with a positive impression about careers in engineering. WNEC faculty members highlight the creativity and problem-solving traits of engineers with examples from all disciplines of engineering. These ideas are put into action with a hands-on engineering design project, such as looping roller coasters or Lego™ vehicles, to fit the capabilities of girls in our target age group. A workbook, which contains the basic steps in the engineering design process and the specific instructions to complete the activity, was developed. The Girl Scouts work in teams of three or four, along with WNEC engineering students, who are the mentors for the activity. Insight to the success of this activity is gained from two surveys, i.e., 1) to determine if they had the qualities to be an engineer and 2) to see change in knowledge of the engineering profession (a before and after look). Overall, as all participants reflect on this activity, positive feedback from the girls is sensed by the excitement in the room as they share their design projects with others, enthusiasm of our WNEC engineering students as they leaving saying they would like to help again next year, and parents and Girl Scout leaders leaving the activity with smiles, and positive comments.

II. Objective

The objective of this yearly outreach program is to educate young girls in 4th through 6th grade about the engineering profession. Our activities are focused on providing an experience that would leave our participants with a positive impression about careers in engineering. Also included in our “Engineering Exploration” program is some basic information on the field of engineering, including the areas of mechanical, electrical, industrial and biomedical engineering (WNEC engineering programs), and the role engineers play in all aspects of our society.

Specifically, the program addresses the question, “Who is an engineer?”, with the very general answer of, “An engineer is a problem solver.”. With the assumption that all the girls in attendance have solved a problem, whether it is a technical one, disagreement between
friends or one posed in a science class, they have the innate ability to become engineers. Yes, our usual and formal definition is often stated as, “An engineer is a person who applies science, mathematics, and economics to meet the needs of humankind.”, but girls in this age group may not fully relate to these traditional topics. The program strives to make the girls feel comfortable with engineering by consciously relating their current skill set and experiences to real-world projects in engineering. In the introduction to the day’s program, WNEC engineering faculty will present engineering examples that include: 1) following a recipe to cook your favorite muffins as related to mixing an alloy and casting it into a mold (materials and mechanical engineering), 2) designing a wheelchair for a Barbie doll with physical disabilities (biomedical engineering), 3) mapping out the best route to a friend’s house and then to the mall as related to routing materials through the factory (industrial engineering), and 4) programming their personal electronics, e.g., cell phones, iPods, and computers (electrical engineering). To help the girls determine if they have what it takes to become an engineer, the series of questions, shown in Table 1, are posed to the girls at the start of the program. Notice the responses are overwhelming “Yes”. All participants would like to make the world a better place and, notice in this context nearly all of the girls feel they are good at math and science. The most negative responses were in the writing and details. The positive responses in problem solving and group interactions will be highlighted in the hands-on activity and as an important and positive trait of engineers. As the details of the activity are outlined in this paper, it is important to keep in mind the broad objectives and the profile of our participants.

Table 1. Profile of the participants: Sample from year 1 of our partnership
Survey Reference: “Three Cheers to Engineers”, by Patricia J. Paddock

<table>
<thead>
<tr>
<th>QUESTIONS</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you consider yourself an inventor?</td>
<td>36</td>
<td>8</td>
</tr>
<tr>
<td>Do you want to make the world a better place?</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>Are you good with the nitty gritty details?</td>
<td>36</td>
<td>12</td>
</tr>
<tr>
<td>Do you have a major imagination?</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>Do you like being a problem solver?</td>
<td>39</td>
<td>5</td>
</tr>
<tr>
<td>Do you enjoy group projects?</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>Are you interested in drawing, sketching or building things?</td>
<td>46</td>
<td>3</td>
</tr>
<tr>
<td>Do you like to show people how things work?</td>
<td>38</td>
<td>9</td>
</tr>
<tr>
<td>Did you ever get good grades in science and math?</td>
<td>45</td>
<td>4</td>
</tr>
<tr>
<td>Are your writing skills pretty good?</td>
<td>38</td>
<td>11</td>
</tr>
</tbody>
</table>
a. **Philosophy of “Engineering Exploration” program**

The philosophy of “Engineering Exploration” program is grounded in the partnership between WNEC and local Girl Scout organizations and their desire to introduce young girls to the opportunities available in engineering. As an educator of engineers, WNEC recognizes that females are underrepresented group in the profession and the Girl Scouts strive to develop bright, talented and well-educated young women through the activities and programs presented to their membership. In Figure 1, the schematic diagram of the partnership illustrates the groups who have input to “Engineering Exploration” program and play a vital part in its success.

The program is developed to give the Junior Girl Scouts the opportunity to learn about engineering and role play as an engineer to solve the problem presented in the hands-on engineering design project. As shown in Table 2, the activities planned for the day are outlined.
### Table 2. Activities for “Engineering Exploration” program

<table>
<thead>
<tr>
<th>TIME</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 – 9:15 a.m.</td>
<td>Welcome and schedule for the day</td>
</tr>
<tr>
<td>9:15 – 9:45 a.m.</td>
<td>“Engineering: What is it and who does it??” – Faculty presentations</td>
</tr>
<tr>
<td>9:45 – 10:15 a.m.</td>
<td>Introduce the project!! And design.</td>
</tr>
<tr>
<td></td>
<td>- Meet the DESIGN TEAM and pick a name!</td>
</tr>
<tr>
<td></td>
<td>- Work on paper! Start the project in the workbook</td>
</tr>
<tr>
<td>10:15 – 11:50 a.m.</td>
<td>• <strong>Build a Roller Coaster or Lego™ Vehicle</strong></td>
</tr>
<tr>
<td>Noon – 12:45 p.m.</td>
<td>• Lunch – Video – Pictures</td>
</tr>
<tr>
<td>12:45 – 1:15 p.m.</td>
<td>• Add the ‘final touches’ to your project! Name and ‘personalize it’!</td>
</tr>
<tr>
<td>1:15 – 1:45 p.m.</td>
<td>• Design review.</td>
</tr>
<tr>
<td>1:45 – 2:15 p.m.</td>
<td>• Wrap up activities &amp; certificates.</td>
</tr>
</tbody>
</table>

### b. Girl Scout Organization

WNEC partners with the Western Massachusetts and Pioneer Valley Girl Scout organizations, whose role is to advertise the program and take care of the logistics of registration and distribution of the program itinerary. This includes parent information and permission packets, publicity release forms, transportation, adult leadership and supervision, and the policy on bringing their own lunch. The girls, themselves, are expected to uphold the rules and regulations for behavior in troop activities. The value of these services should not be underestimated (in terms of time and knowledge of current policies dealing with youth activities) and are a key factor the success of this program.

### c. Girl Scout Leaders and Parents

The leaders not only provide guidance for their troop, but support programs such as ours, by encouraging all members to attend. During the program, they also help organize the groups of Girl Scouts, monitor their behavior and assist with any personal problems that arise. Parents in attendance also do the same. Although they do not actively participate in the design activity, parents provide encouragement, reassurance and a ready audience to review the girls’ final designs. Their reaction is almost always positive and enthusiastic and this translates to the girls’ positive impression of engineering as a career choice. Without supporting data, a mother’s positive words of encouragement may open the door to an engineering career for their daughter. Also, the grapevine between mothers and leaders, i.e., word of mouth, is good advertisement for the program the following year.
d. **WNEC School of Engineering Faculty**

WNEC faculty provide the girls with insight and examples of the engineers in today’s workplace through brief presentations. The theme of problem solving is woven throughout the professor’s talk and care is taken to select a variety of applications or products that girls may encounter in their daily lives.

With experience in engineering education, the faculty member can develop or adopt the age appropriate activities for the program. Also, the educational materials to describe and facilitate the hands-on design activity are developed as a project workbook. The two design projects, as well as the assessment, implemented for “Engineering Exploration” program are described in the following sections of this paper. The benefit of the partnership is that the professor can focus their attention on the activity rather than registration and recruitment of participants, the task that could make this time prohibitive (based on past experience.)

e. **WNEC Student Mentors**

WNEC engineering students volunteer to assist the Girl Scouts throughout the program. The student mentors guide a team of three or four girls through the design activity, making sure the steps in the design process are executed properly. This gives the girls focus on the engineering methodology rather than just building something in a manner similar to an arts and crafts project. Student mentors encourage the girls to brainstorm ideas, sketch a couple of designs in the workbook and focus their attention on teamwork. They also help keep the girls on task and within the time constraints set in the program. It is noted that the student mentors are able to participate in a community service activity and always have positive comments on their experiences.

**IV. Activities**

a. **Education**

The education portion of the program focuses on the challenges of problem solving and the skills and personal traits required in the engineering profession. The faculty presentations highlight the wide range of applications that include industrial and consumer products. Making the connection to the girl’s daily lives and expanding the range of their current career aspirations is reflected in the talks by the faculty. Also discussed are the types of classes the girls must take in school, such as math and science, and the participation in school sponsored activities such as science fairs, math team, etc., is strongly encouraged.

b. **The Workbook**

The workbook was developed to guide the girls, as well as the student mentors, through the activities of the day. As illustrated in Figure 2 a-d, the workbook contains; a) the basic steps in the engineering design process, b) blank spaces to execute the steps in design process, c) specific instructions to complete the activities and, d) reflection exercise focusing on the traits and skills associated with engineers. The girls, as well as the student mentors, utilize this workbook to maintain structure in the activity and maintain an engineering flavor to the hands-on work. Additionally, the workbook becomes a souvenir to take home and share with parents.
Engineers work on design problems.

😊 To solve them requires creativity, teamwork and broad knowledge.

So, engineers have a plan or method to search for the best solutions!

- Identify the need and define the problem.
- Assemble a design team.
- Brainstorm lots of ideas and possible solutions.
- Select your best ideas and designs.
- Build prototypes based on your best designs.
- Analyze and test each prototype.
- Evaluate and redesign by combining the best ideas from each prototype.
- Make improvements, use experience of your team and build your optimum design.
- Demonstrate your optimum design.
- Share your solution and design with everyone!

Figure 2a. Sample page of the workbook outlining the design process.

Identify the need and define the problem.

Your problem
Today, you are an engineer designing the Girl Scout Dream Scream looping roller coaster! You want to hear your friends screaming all the way across the amusement park, so you must design a roller coaster with the biggest loop-de-loop! Your problem is to design and build a looping roller coaster from materials you can find around the house!

Your design criteria

Materials:
- 6' lengths of pipe insulation
- Masking tape
- Tooth picks
- Marbles
- Stickers
- Scissors
- Pencils
- Measuring tape

General criteria:
- The marble must travel the entire length of the roller coaster to be considered a good run!
- The loop-de-loop must be vertical and the marble must travel through a loop.
- Use only the materials listed above.

Figure 2b. Sample page of workbook stating the problem for the hands-on activity.
Adopted from [1] Making the Connection, M. Cyr Tufts University, CEEO, C. Schade The University of Texas at Austin, Copyright © 2000 WEPAN

In alternate years of the “Engineering Exploration” program, the hands-on activity has utilized the Lego™ Mindstorms kit (available courtesy of our First Year Engineering program.) The design problem is to develop a vehicle so unique and exciting, that 4th, 5th, and 6th grade kids will spend their allowance money to buy it! The criteria for the design is as follows: 1) travel in a straight line for 10 feet, 2) move forward and backward, 3) use power from the motor/RCX brick, 4) mount RCX brick on vehicle, 5) use a touch sensor on front of vehicle, and 6) name the vehicle something descriptive yet catchy. Through observation, this activity is more difficult for
the girls in the time frame allotted. And from the organizational point of view, the logistics are significantly more involved, e.g., equipment inventory, set-up, and accommodations for equipment malfunction. The workbook for the Lego<sup>TM</sup> vehicle followed the same format as the roller coaster project, guiding the girls (and student mentors) through the activity.

**Assemble a design team.**

Team name: ___________________

Team members: ___________ ___________ ___________ ___________

- **Brainstorm lots of ideas and possible solutions.**
  
  Sketch or describe your ideas in the boxes!

Design idea #1

Design idea #2

Design idea #3

Design idea #4

- **Select your best ideas and designs.**

  **Circle your best idea and possible solution!**

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**Figure 2c.** Sample page of workbook: The teams and brainstorming sketches.

The workbook for roller coaster activity guides the participants in a stepwise fashion through “Challenge Levels”, as shown in Table 3. (Similar challenge levels were developed for the Lego<sup>TM</sup> vehicle project.) With the ultimate goal of a “positive impression of engineering”, these levels allow the girls to work at their own pace and get positive feedback at various points during the project. It is noted most teams achieve Challenge Level #3, however, those that to not still express satisfaction with their design.
Table 3. Summary of Challenge Levels specifically for the roller coaster activity

<table>
<thead>
<tr>
<th>Challenge Level #1 : Your Prototype</th>
<th>Design and build a roller coaster with the biggest diameter loop you can possibly manage! The roller coaster can be supported any way you want!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge Level #2 : Improved Model</td>
<td>Evaluate and redesign by combining the ‘best’ ideas from each prototype. Improve or modify your original design and make your roller coaster stand all by itself!</td>
</tr>
</tbody>
</table>
| Challenge Level #3 : The Ultimate Coaster | Make improvements, use the experience of your team and build your ‘optimum’ design.  
  a) Improve or modify your original design and build roller coaster with two loops. It can be supported any way you can or make it stand all by itself!  
  b) Combine two single looping roller coasters to make a double racer (i.e., side-by-side tracks)!! |

The final page in the workbook, shown in Figure 2d, provides a guided exercise for the girls to reflect on their experience. The skills and traits characteristic of engineers are listed to promote a group discussion. The student mentors assist with this task to assure the loop is closed, i.e., the theme that “An engineer is a problem solver!” is reinforced. It is also noted that the girls have expressed that they have these traits in the initial surveys, done at the beginning of the program.

<table>
<thead>
<tr>
<th>Let’s review!!!</th>
<th>How did you do??</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘An engineer is a problem solver!’</td>
<td></td>
</tr>
<tr>
<td>What kinds of skills and traits do engineers need to be good problem solvers?</td>
<td></td>
</tr>
<tr>
<td>CREATIVITY</td>
<td>IMAGINATION</td>
</tr>
<tr>
<td>PERSERVERANCE</td>
<td>LIKE MATH</td>
</tr>
<tr>
<td>LOGICAL THINKING</td>
<td>TEAMWORK</td>
</tr>
<tr>
<td>LIKE TO SHARE IDEAS</td>
<td>LIKE TO LEARN NEW THINGS!</td>
</tr>
<tr>
<td>☺ _____________________</td>
<td>☺ _____________________</td>
</tr>
</tbody>
</table>

Hope you had fun at “ENGINEERING EXPLORATION”!!

Figure 2d. Sample page of workbook on which girls reflect on their experience (with prompting from the student mentors).
V. Insight
At the conclusion of the program, participants were asked three general questions in order to gain insight into their learning and the effectiveness of our program. Just prior to dismissal, the student mentors sat down with their groups, asked the questions, and recorded the girl’s verbal responses. The questions and tabulated responses are shown in Table 4 and 5. An overview of the responses in Table 4 provides evidence that our first goal, which states “to educate young girls about the engineering profession”, is realized. The responses indicating their new awareness of the design process and problem solving versus the “fixing your car”, is encouraging.

Table 4. Assessment of Survey Responses
Sample from year 1 of our partnership

<table>
<thead>
<tr>
<th>Now, what do you think an engineer does?</th>
<th>By the way, before you came here today, what did you think an engineer did?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Designs and makes stuff (12)</td>
<td>• Fixed cars or worked on engines (7)</td>
</tr>
<tr>
<td>• Designs things to help people (8)</td>
<td>• Built things, e.g., buildings, bridges. (5)</td>
</tr>
<tr>
<td>• Problem solving (4)</td>
<td>• Not sure /don’t know (5)</td>
</tr>
<tr>
<td>• Invents (4)</td>
<td>• Drive trains (3)</td>
</tr>
<tr>
<td>• Builds models and improves things (7)</td>
<td>• Work on computers (1)</td>
</tr>
<tr>
<td></td>
<td>• Invent stuff (2)</td>
</tr>
</tbody>
</table>

Table 5. Assessment of Survey Responses
Sample from year 1 of our partnership

<table>
<thead>
<tr>
<th>Do you see yourself as an engineer?</th>
<th>Number of responses</th>
<th>Why or why not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes response</td>
<td>15/27</td>
<td>“I am good at solving problems, making things and math.” “Because I made this roller coaster.” “like math, brainstorming and teamwork.” “Love to invent and create things.”</td>
</tr>
<tr>
<td>Maybe response</td>
<td>3/27</td>
<td>“Want to be something else.” “not good at building things.”</td>
</tr>
<tr>
<td>No response</td>
<td>8/27</td>
<td></td>
</tr>
</tbody>
</table>
The responses in Table 5 were typical of the group questioned. It can be surmised that the second goal of the program is met. It stated “to provide an experience that would leave our participants with a positive impression about careers in engineering.” Although not quantitative, the Girl Scout office has had many inquiries about the program the next year and verbal complements were expressed at this time. Another endorsement for this program comes from the repeat participants, thus the two different hands-on activities.

VI. Reflection
The keys to success of the “Engineering Exploration” program for Junior Girl Scouts at Western New England College are simply highlighted in the list below.

- Organization prior to event
- Committed partnership
- Appropriate facility
- Selection of project
- Great group of girls
- Student mentors
- Support from college (WNEC) and Girl Scout organization

This program provides an educational and interactive program for girls to become better acquainted with the engineering profession in a positive light. The education portion of the program attempts to correct some of the negative perceptions, and even misconceptions, the girls have about engineering and replace them with new, broader information. Connecting engineering applications to products used in their everyday lives, and focusing on the traits and skills that the girls believe they already have, creates an exciting environment for learning. The hands-on design activity provides an opportunity for the girls to discover for themselves, that they should consider exploring the engineering profession as a future career choice.

VII. Summary
In summary, the feedback from the all participants in this activity was overwhelmingly positive based the results of our assessment surveys. Therefore, our two goals were met. The girls learned about engineering and what engineers do on the job, and then used their creativity and ingenuity to become an engineer for the day!

VIII. Future work
Briefly, ideas for future work will be to adopt new projects from the K-12 literature including the NEW: National Educators Workshop proceedings and present them in this format. WNEC students may have opportunities to increase their community service and learning beyond the classroom requirements by bringing a version of this program to Girl Scout troops. Also, there may be opportunities to train adult leaders (in our region) to conduct engineering activities with their own troops. The “Engineering Exploration” program has become a yearly event at Western New England College and it is hoped that our partnership will continue to thrive.
X. Acknowledgements

The author would like to acknowledge Judith Bullock, Director of Programs for the Girl Scouts of Pioneer Valley, for her dedication to this event. Also, I would like to acknowledge Dean Carl Rathmann for kicking-off this partnership and the staff at Western New England College for their help with the logistics. Thanks are extended to WNEC Profs. Judy Cezeaux, Diane Testa, Bill Brown and Steve Northup and Mike McCarthy. Also a very special thanks to the student mentors, who volunteered their time and shared their enthusiasm for engineering with the Girl Scouts.

XI. References

[1] Survey Reference: “Three Cheers to Engineers”, by Patricia J. Paddock
[3] Making the Connection, M. Cyr Tufts University, CEEO, C. Schade, The University of Texas at Austin, Copyright © 2000 WEPAN