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Strengthening the Engineering Pipeline One Field and One Woman at a Time: The Role of a Single-Discipline, Single-Sex Engineering Camp

Abstract

The shortage of women in technology-related education programs has led to a national shortage of workers, costing the high tech industry an estimated $4 billion a year (CCAWMSETD, 2000). Consequently, the field of chemical engineering parallels this trend. In 2002, 16.5% of chemical engineers in the workplace were women (U.S. Department of Labor, 2002). In light of the escalating need to increase the number of women in chemical engineering, The Ohio State University’s Women in Engineering program (WiE) offered its first single-discipline pre-college summer program, CheME & YOU @ OSU.

CheME & YOU @ OSU is a six-day, residential camp for rising ninth-grade girls designed to introduce young women to chemical engineering. By focusing specifically on the need for more women in the chemical engineering pipeline, CheME & YOU @ OSU moved away from the traditional multi-discipline engineering camp to a single-discipline camp. As a result, the focal point of this paper is the development and assessment of a single-discipline engineering camp. First, the authors discuss the content, goals, and structure of a single-discipline engineering camp and the need for assessment tools that collect immediately useful data as well as data to produce meaningful program evaluations over the long term. Next, the paper provides a summary of the development and implementation of the four assessment tools (i.e., pre-camp student questionnaire, activity evaluation cards, post-camp student questionnaire, and post-camp parent/guardian questionnaire) used for the camp. Drawing on the data collected during Year 1 of CheME & YOU @ OSU, this paper reports results on attitudes toward and awareness about chemical engineering. Lastly, the paper concludes with a discussion of the prevalence of single-discipline engineering pre-college summer programs and the role that this type of program currently plays in the growth and development of the engineering pipeline at the authors’ home institution.

Introduction

In the U.S., the economic growth, military capabilities, and living standards depend heavily on innovation, science, and technology. To advance further in these areas and to thrive in a global economy, the U.S. will have to rely on engineers and companies to develop innovative and high value-added products and services, as well as improve productivity through the use of technology-based tools. While other countries such as China, India, and Singapore produce twice as many engineers as the U.S., there are currently over 300,000+ U.S. technology-related jobs that remain vacant due to the lack of qualified workers. This discrepancy highlights the country’s urgent need for a stronger engineering pipeline if the U.S. is to remain competitive in the global markets.

Given that engineering jobs are among the hardest to fill in the U.S., the demand for qualified engineers far exceeds supply. To address this shortage, many educators, researchers, and
practitioners are looking to attract more women to engineering. Women make up nearly 50% of the U.S. workforce; however, only 22% of the jobs in the science, technology, engineering, and math (STEM) fields are held by women\(^3\). The shortage of women in technology-related education programs has led to a national shortage of workers in the technology industry, costing the high tech industry an estimated $4 billion a year\(^4\). Consequently, the field of chemical engineering parallels this trend. In 2002, 16.5% of chemical engineers in the workplace were women\(^5\). In light of the escalating need to increase the number of women in engineering, pre-college engineering outreach interventions are being used to spark women’s interest in engineering and related career fields.

**Role of pre-college engineering outreach interventions**

Pre-college engineering outreach interventions are vital to the maintenance of the engineering pipeline and to the continued success of the engineering profession as a whole. In addition to combating the decline in the number of U.S. engineers, these programs seek not only to increase engineering enrollment but also to diversify the field of engineering\(^6\). To meet these objectives, outreach programs introduce K-12 students to engineering through fun and engaging, hands-on activities and interactions with engineers, scientists, and students in engineering.

At The Ohio State University (OSU), pre-college engineering outreach interventions play an important role in attracting women to the university’s undergraduate engineering programs. Since 2003, OSU’s Women in Engineering program (WiE) has provided an innovative summer camp for high school students interested in learning more about the field of engineering and engineering-related careers. Known as **WiE RACE (Reaching A Career in Engineering)**, this program is a six-day, residential camp for 34 male and female students who are rising tenth and eleventh graders. In 2008, WiE also assumed responsibility for a middle school program, **WiE GROW**, which had been run by a faculty member in the university’s Department of Civil and Environmental Engineering and Geodetic Science since 2002. **WiE GROW** is a five-day, non-residential program for 30 female students who are rising eighth graders. Both of these summer programs take place on the university’s main campus in Columbus, Ohio, and over the past seven years, they have offered approximately 380 middle and high school students the opportunity to explore the field of engineering through a variety of age-appropriate hands-on activities, interactive demonstrations, and presentations led by OSU engineering faculty, staff, and graduate students, as well as professionals from area industries and corporations. Beginning in 2009, WiE extended its summer program offerings to include **CheME & YOU @ OSU**, a single-discipline, single-sex pre-college engineering program that offers 30 female students who are rising ninth graders the opportunity to spend six days living on campus and learning about the field of chemical engineering. Beginning in 2010, **CheME & YOU @ OSU** will be renamed, becoming **WiE CHEER (CHEmical Engineering Rocks!)**.

**Motivation and purpose**

The rationale for focusing on a single discipline, rather than exposing young women to a variety of engineering areas, was to target an engineering field that historically has attracted a significant number of OSU female engineering undergraduates. By introducing female students to chemical engineering prior to their enrollment in high school, **CheME & YOU @ OSU** sought to
strengthen the engineering pipeline one girl and one discipline at a time. Recently, chemical engineering has seen a greater increase in its female ranks than other engineering fields, underscoring its attractiveness to women, many of whom are looking for careers that have a societal impact in their pursuit of an engineering degree. Today’s chemical engineers hold positions in disciplines ranging from environmental engineering, biochemistry, material science, finance, consulting, to corporate law. No longer limited to the traditional careers centered on fuels or chemical process, chemical engineers have such broad and diverse career opportunities that there are any number of ways for women (and men) to leave a lasting impact on society.

In 2008, the OSU College of Engineering reported that of the 14 engineering majors available to undergraduate students, chemical engineering had the highest female enrollment with a total of 152 women (35.5%). The next highest enrollment by number of women was mechanical engineering at 100, but these 100 female students only represented 8.5% of all mechanical engineering students. The next highest enrollment by percentage was industrial and systems engineering with 87 female students (33.7%). Given the number of female engineering undergraduates who are drawn to the field of chemical engineering once they are made aware of its existence, WiE decided to introduce this discipline to pre-college female students who might otherwise be unaware of it and related fields like chemistry. Thus, CheME & YOU @ OSU was designed to capitalize on chemical engineering’s attractiveness to female students as a way of increasing the overall number of women in the engineering pipeline.

Outside of summer camps in computing and computer science very few reports have been made on single-discipline and single-sex summer camps in engineering. As a result, the purpose of this paper is three-fold: 1) to provide an overview of the development of a single-discipline, single-sex pre-engineering camp; 2) to discuss a formative evaluation plan for assessing the pre-engineering camp; and 3) to reveal anecdotal lessons learned to assist future camp directors. In the next sections, this paper uses CheME & YOU @ OSU as an exemplar single-discipline, single-sex pre-college engineering outreach program designed to attract young women to chemical engineering.

CheME & YOU @ OSU

The CheME & YOU @ OSU program plays a crucial role in strengthening the engineering pipeline one girl and one field at a time. The goals of this single-discipline, single-sex camp are to: 1) introduce young women to important concepts in chemistry and chemical engineering through a series of hands-on activities and demonstrations led by members of the chemical engineering faculty and graduate-student cohort and 2) increase their awareness and interest in the fields of chemistry and chemical engineering. Additionally, CheME & YOU @ OSU enables participants to get to know a number of women who are currently enrolled in the OSU undergraduate and graduate programs in chemical engineering, as well as female chemists and chemical engineers who work in area industries. By providing a diverse group of potential female mentors and role models, CheME & YOU @ OSU encourages participants to view these career fields as viable options for women in general and for themselves in particular.
Camp overview

Held on OSU’s Columbus campus for the first time during the summer of 2009, CheME & YOU @ OSU is a six-day residential camp, designed to provide young women entering the ninth grade with an introduction to concepts in chemistry and chemical engineering through a series of hands-on activities, interactive demonstrations, lectures, and tours. Marketing for CheME & YOU @ OSU began approximately five months before the start of the program. Information about the camp was sent out through “OSU Today,” the university’s e-newsletter for faculty and staff, and the OSU P-12 Project listserv, which was developed to provide relevant program information to P-12 educators and reaches over 6,000 subscribers across Ohio. In addition, information about the camp was e-mailed to alumnae of WiE’s outreach programs for elementary and middle school students who were enrolled in the eighth grade during the 2008-09 academic year. Links to this same information were posted on the OSU College of Engineering’s homepage and the WiE website.

By the time the mid-May application deadline had passed, 72 completed applications had been received for the 30 spots available in the program. All applications were read and evaluated by the WiE assistant director. Evaluations were based on the following criteria: (a) how supportive the teacher recommendation was of the applicant, (b) the extent to which the applicant’s personal statement indicated an interest in attending a chemical engineering camp, and (c) the level of classes taken and grades earned by the applicant. After the assistant director had narrowed the pool of admissible applicants to those students who were highly qualified for and enthusiastic about the program, the WiE director reviewed this group of applications and collaborated with the assistant director to determine which students would be admitted into the program. All 72 applicants were then notified as to whether their application had been accepted, waitlisted, or declined.

Participants

A total of 30 rising high school freshmen women participated in CheME & YOU @ OSU. (One participant did check out of the camp early in the week due to illness.) The majority of the participants were from the greater Columbus area; however, over 20% lived in other locations across Ohio. Additionally, the group of campers was ethnically diverse, self-identifying across at least five different ethnic groups (Table 1).
Summer camp activities, tours, & field trips

The CheME & YOU @ OSU participants engaged in a variety of hands-on activities, tours, demonstrations, and field trips that were led by faculty and undergraduate- and graduate-level students in chemical engineering and industrial partners in the Columbus area. The schedule was structured such that Monday, Tuesday, and Wednesday, the students visited an off-campus facility in the morning and rotated through at least two on-campus activities over the course of the afternoon. On Thursday, the students spent the entire day on campus learning about sustainable energy research, fuel cells, and acid rain. On Friday, the students traveled to an off-campus site in the morning and spent the afternoon packing and putting the finishing touches on the presentations that they gave at the closing reception. Below are brief descriptions of the CheME & YOU @ OSU activities, tours, and field trips.

Activities

Introduction to the Field of Chemical Engineering: Participants were introduced to chemical engineering through an interactive overview of the discipline and related career fields. In addition to hearing about the research currently taking place at OSU, students learned how chemical engineers have made and continue to make a tremendous difference in people’s lives.

Introduction to Nanotechnology: The participants learned about the field of nanotechnology through a series of short, entertaining videos made by OSU undergraduates as part of their first-year engineering honors curriculum.

Lip Gloss Activity: The lip gloss activity introduced participants to the roles that waxes, oils, pigments, and flavors play in the composition of lip gloss and also to why these ingredients must be mixed together in a particular order. Participants then mixed their own lip gloss and developed a marketing plan for their new products.
DNA Extraction Activity: During the DNA extraction activity, students were introduced to the parts of a plant cell before engaging in the process of extracting visible DNA from strawberries.

Rheology Activity: As part of the rheology activity, participants were introduced to the physical property viscosity before going outdoors and mixing together water and corn starch to create a substance that allowed them to “walk on water.”

Ice Cream Activity: The participants had a follow-up activity to reflect on their visit to the Graeter’s ice cream facility. OSU graduate students in chemical engineering talked with the participants about the function of ice cream’s ingredients and what chemical engineers call the “unit operations” involved in manufacturing large-scale quantities of ice cream. Participants then developed their own production formula, which they used to make both vanilla and chocolate ice cream.

Enzymatic Cleaning Activity: During the introduction to the enzymatic cleaning activity, participants learned how chemical engineers use catalysts to facilitate the conversion of
reactants into products. The students then applied their understanding of enzymatic cleaning by staining pieces of white t-shirts with grass, tomato sauce, and lipstick and preparing six different kinds of cleaning solutions involving soap, enzymes, and commercial laundry detergent to determine which was most effective in removing each of the three different stains.

*Gas-Liquid-Solid Fluidization Activity:* The gas-liquid-solid fluidization activity introduced participants to a three-phase fluidized bed reactor. Students determined the minimum fluidization point of the reactor used in the university’s Koffolt Laboratories by graphing the height of the liquid in the glass tube for each change in gas velocity. Students also learned about the importance of three-phase fluidized bed reactors to the petroleum industry, where heavy oils have to be converted into high-quality gasoline.

*Sustainable Energy Presentation:* The sustainable energy presentation inaugurated a day-long series of lab tours and activities designed around Shell’s “More Energy, Less CO2” theme. This opening presentation provided students with an introduction to the world’s energy resources before focusing specifically on energy use in the U.S. Students learned about what constitutes “sustainable energy” and about the different production processes required to transform resources such as wind and water into usable energy.

*Acid Rain Activity:* During the acid rain activity, participants learned about acid rain and what chemical engineers are doing to reduce the amount of harmful emissions released from coal-burning power plants around the U.S. In addition to examining a map of the pH of precipitation in the U.S. and learning about how weather patterns determine the distribution of acid rain across the country, participants performed a precipitation reaction to produce a small amount of calcium carbonate. The students then engaged in a discussion of how this process might be scaled up such that large amounts of calcium carbonate would be available to capture the millions of tons of sulfur dioxide gas released into the atmosphere each year.

*Figure 3: Campers learning about acid rain.*
Preparation for Small-Group Presentations: Working in small groups, the participants prepared a five-minute PowerPoint presentation on one of the week’s activities or tours as assigned by members of the camp staff. The presentations were delivered at the closing reception on the last day of the camp, and each group member had a speaking role as part of her group’s presentation.

Lab tours

Faculty Lab Tour: The faculty lab tour gave participants the opportunity to visit a laboratory run by a faculty member in the OSU Department of Chemical and Biomolecular Engineering. During their visit, students learned about the faculty member’s research on transfusion medicine, tissue engineering, and therapeutic macromolecular delivery systems.

Fuel Cell Demonstration & Lab Tour: As part of this lab tour, the participants learned about hydrogen production for fuel cells and pollution control from undergraduate- and graduate-level students who assist with research undertaken in this area by a faculty member in the OSU Department of Chemical and Biomolecular Engineering. In addition to watching a fuel cell demonstration, participants toured the faculty member’s lab, where they learned more about heterogeneous catalysts.

Field trips

Graeter’s Ice Cream: The participants traveled to Graeter’s Ice Cream, a family-owned and Ohio-based company that makes French Pot ice cream. While at Graeter’s, the participants learned about and observed the company’s particular production process—the ice cream ingredients are chilled and thickened in a French Pot Freezer before being packed into pint containers by hand—which allows for the making of only two gallons of ice cream at a time. In addition to touring the facilities, students heard how liquid nitrogen is involved in ice cream production processes and talked with company employees about why the French Pot process produces ice cream that is much denser than that produced by large-scale, more modern methods. On the return trip, camp staff engaged the students in a discussion of manufacturing processes and the scaling up that takes place when a company moves from creating a prototype to producing a product in mass quantities.

Jackson Pike Wastewater Treatment Plant: During their visit to the Jackson Pike Wastewater Treatment Plant, participants listened to a plant employee’s presentation on the different steps in the two wastewater treatment processes—wet stream and solid handling—before embarking on an hour-long tour of the plant’s facilities. At the end of the tour, students engaged in a question-and-answer session with their tour guide and camp staff about the circulation, pollution, and sanitization of the world’s water resources.
Anthony-Thomas Factory: As a follow-up to the rheology activity, participants traveled to the Anthony-Thomas factory for an hour-long tour of the company’s chocolate production facilities. The company employee who led the tour shared with students how he applies his background in rheology on a daily basis. At the end of the tour, each participant received an Anthony-Thomas “buckeye,” a small round chocolate with a peanut butter center shaped to resemble a buckeye nut that is often associated in the state of Ohio with OSU.

Figure 4: Campers touring the Anthony-Thomas Factory.

Rumpke Recycling: During their visit to Rumpke Recycling, participants learned about the history of recycling, what sorting processes the company uses, and how the current economic downturn is affecting the recycling industry as a whole. Students also toured Rumpke’s Columbus recycling facility where they observed the sorting process up close.

Formative evaluation

The purpose of the formative evaluation was to develop assessment tools that would inform and guide on-going camp development and improvement. Questionnaires and evaluations were used to assess participants’ knowledge of engineering before and after participating in CheME & YOU @ OSU and the students’ and parents’ satisfaction levels with regard to the camp. The following five assessment tools were developed to evaluate CheME & YOU @ OSU: (1) a pre-program participant questionnaire, (2) a post-program participant questionnaire, (3) activity evaluation cards, (4) a post-program parent and guardian questionnaire, and (5) a past participant questionnaire. The following are descriptions of these five assessment tools and the timing of their administration:

1. **Pre-Program Participant Questionnaire**: Prior to their arrival on campus, all 30 participants in CheME & YOU @ OSU were asked to complete a questionnaire designed to collect information about their understanding of, enthusiasm for, and previous contact with the field of chemical engineering and about their plans for college and their interest
in OSU. In addition, this questionnaire asked students how they learned about the program and who or what prompted them to attend.

2. **Post-Program Participant Questionnaire**: On the last day of the program, all CheME & YOU @ OSU participants were asked to complete a questionnaire designed to measure the effects of the program on their interest in chemical engineering, as well as to find out what the students thought they had gained from the program. In addition, this questionnaire asked the students to rate the program accommodations, meals, and recreational activities and to provide feedback on the program staff and residential advisors. Participants also were asked about their interest in attending OSU now that they had spent six days on the university’s Columbus campus.

3. **Activity Evaluation Cards**: In addition to collecting information about the overall program from the CheME & YOU @ OSU participants using the post-program participant questionnaire, WiE asked each participant to fill out an evaluation card at the end of every on-campus activity/tour and off-campus field trip. These evaluation cards asked participants to rate the following four components of each activity on a scale of 1 to 5, with 5 being the highest possible score: (1) the overall quality of the activity, (2) how much the activity taught them, (3) how fun the activity was, and (4) the engagement level of the activity leader. Students were asked to fill out these evaluation cards immediately following the activities, tours, and field trips to avoid giving them time to discuss these events with one another and thus to influence one another’s responses.

4. **Post-Program Parent and Guardian Questionnaire**: To gather information from the participants’ parents and guardians about their daughters’ experiences at CheME & YOU @ OSU, WiE created a questionnaire through the online survey site surveymonkey.com, a link to which was e-mailed to parents and guardians several weeks after the conclusion of the camp. This questionnaire was designed to collect parents’ and guardians’ feedback on how the camp had affected their daughters’ interest in and excitement about chemical engineering and on the marketing, planning, and overall organization of the program.

5. **Past Participant Questionnaire**: In an effort to track the long-term effects of CheME & YOU @ OSU on students’ interest in and pursuit of careers and opportunities in the fields of chemistry and chemical engineering, a questionnaire will be distributed to those alumnae of the 2009 program who attend the reunion picnic that will be held during the 2010 camp. This questionnaire will collect information from past participants on their career and college plans, their CheME & YOU @ OSU experience, and whether or not they would recommend the program to other students. These questionnaires will be sent by e-mail and mail to any camp alumnae who are unable to attend the reunion picnic.

**Results**

WiE used the following four assessment tools to evaluate CheME & YOU @ OSU: (1) a pre-program participant questionnaire, (2) a post-program participant questionnaire, (3) activity evaluation cards, and (4) a post-program parent and guardian questionnaire. The following
section provides an analysis of the data collected. Results from the aforementioned past participant questionnaire will be discussed in a future paper.

Pre- and Post-Program Participant Questionnaires
As shown in Table 2, students’ knowledge of chemical engineering increased dramatically due to their participation in CheME & YOU @ OSU. The number of participants who agreed or strongly agreed with the statement “I understand what chemical engineering is all about” increased from 21% on the pre-camp questionnaire to 97% on the post-camp questionnaire.

Table 2

<table>
<thead>
<tr>
<th>Number of Students</th>
<th>Pre-Camp Questionnaire</th>
<th>Post-Camp Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

In addition to increasing participants’ knowledge, the program heightened the majority of students’ interest in the field of chemical engineering. As Table 3 shows, 62% of participants indicated on the post-camp questionnaire that they agreed or strongly agreed with the statement “I am more interested in chemical engineering as a result of participating in CheME & YOU.”

Table 3

Participant Responses on Post-Camp Questionnaire With Regard to the Statement: "I am more interested in chemical engineering as a result of participating in CheME & YOU"
Activity Evaluation Cards
The summer camp participants were asked to complete an activity evaluation card at the end of each activity, lab tour, and off-campus field trip. As shown in Table 4, all but one of the 14 participant-evaluated activities, tours, and field trips received an average participant rating of 3—“Good”—or higher with regard to overall quality. Indeed, 9 (64%) of the activities received an average participant rating of 4 or higher. The one activity with an average participant rating below 3 was the Jackson Pike Wastewater Treatment Plant Tour.

Table 4

| Activity Evaluation | Average Participant Rating
|---------------------|-----------------------------|
| Wastewater Treatment Plant Tour | Excellent
| Fuel Cell Demonstration & Lab Tour | Excellent
| Palmer Lab Tour | Excellent
| Sustainable Energy Presentation | Excellent
| Gas-Liquid-Solid Fluidization | Excellent
| Rumpke Recycling Tour | Excellent
| Acid Rain | Excellent
| Enzymatic Cleaning | Excellent
| Greeter’s Tour | Excellent
| Anthony-Thomas Tour | Excellent
| DNA Extraction | Excellent
| Lip Gloss | Excellent
| Ice Cream Making | Excellent
| Rheology | Excellent

Table 5 shows the average participant rating with regard to how much participants thought they learned from each camp session. All 14 activities and tours received a rating of 3 or higher, indicating that students felt like they learned “something” during every session. In fact, 11 activities (79%) received a rating of “4” or higher. The three activities that received an average participant rating between 3 and 4 were the Graeter’s Tour, the Wastewater Treatment Plant Tour, and the Lip Gloss activity.
Table 6 contains the average participant ratings with regard to how much fun the participants had during the *CheME & YOU @ OSU* activities and tours. All but one of the 14 activities and tours received a rating of 3—“Ok”—or higher, and 6 of the activities (43%) received a rating of 4 or higher. The one activity that received a rating lower than 3 was the Wastewater Treatment Plant tour.

Table 7 shows the average participant rating with regard to how engaging the participants found the leaders of the camp’s activities and tours. Of the 14 sessions, 100% received a rating of 3—“Good”—or higher with regard to the engagement level of the sessions’ leaders. Indeed, 11 (79%) of the activities and tours received a rating of 4 or above.
Table 7

Average Participant Rating With Regard to How Engaging Participants Found the Leaders of Individual CheME & YOU @ OSU 2009 Activities, Tours, and Demonstrations

<table>
<thead>
<tr>
<th>Activity</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater Treatment Plant Tour</td>
<td></td>
</tr>
<tr>
<td>Palmer Lab Tour</td>
<td></td>
</tr>
<tr>
<td>Fuel Cell Demonstration &amp; Lab Tour</td>
<td></td>
</tr>
<tr>
<td>Sustainable Energy Presentation</td>
<td></td>
</tr>
<tr>
<td>Acid Rain</td>
<td></td>
</tr>
<tr>
<td>Anthony Thomas Tour</td>
<td></td>
</tr>
<tr>
<td>Gas-Liquid-Solid Fluidization</td>
<td></td>
</tr>
<tr>
<td>Graeter's tour</td>
<td></td>
</tr>
<tr>
<td>Enzymatic Cleaning</td>
<td></td>
</tr>
<tr>
<td>Rumpke Recycling Tour</td>
<td></td>
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<tr>
<td>Lip Gloss</td>
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<tr>
<td>Ice Cream Making</td>
<td></td>
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<tr>
<td>DNA Extraction</td>
<td></td>
</tr>
<tr>
<td>Rheology</td>
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</tr>
</tbody>
</table>

Table 8

Percentage of Parent/Guardian Post-Camp Questionnaire Respondents (n = 12) Who Indicated That These Statements Applied to Their Daughters' Camp Experiences

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percent in Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>The camp helped my daughter better understand what chemical engineering is all about.</td>
<td>100%</td>
</tr>
<tr>
<td>My daughter is glad that she attended the camp and believes that it was a worthwhile learning experience.</td>
<td>100%</td>
</tr>
<tr>
<td>The camp helped better acquaint my daughter with OSU and the College of Engineering.</td>
<td>92%</td>
</tr>
</tbody>
</table>
Lessons Learned

The decision to establish a single-discipline as opposed to a multi-discipline engineering camp was backed by the higher percentage of women pursuing chemical engineering degrees compared to other engineering degrees at OSU. From a camp organizer’s perspective, implementing a single-discipline summer camp enabled WiE to offer participants a coherent learning experience with numerous opportunities for content review and reinforcement. A team of three OSU chemical engineering graduate students was hired to develop, organize, and manage all of the camp’s academic (as opposed to recreational) content. Because these graduate students determined not only what activities, tours, and field trips would be offered but also when the different events would occur, they were able to structure the participants’ learning experience such that concepts were introduced during one activity and then reviewed or expanded upon during another. In addition, since these three graduate students were present at all of the academic sessions, including field trips and tours, they were able to assist the participants in making connections across a wide array of concepts. Another advantage of having the graduate students plan and deliver all of the academic content was the opportunity this gave them to respond to feedback from WiE about the timing, delivery, and engagement level of the planned events both before and during the camp. Whereas WiE’s other summer programs rely on representatives from a variety of engineering departments to prepare and deliver a single two- to three-hour academic session, the content of which is not necessarily related to earlier or later sessions, CheME & YOU @ OSU allowed for the development of stronger connections across the different activities and between the graduate students, WiE staff, and the participants themselves.

In addition to offering a coherent, dynamic, and responsive learning environment, CheME & YOU @ OSU enabled WiE to husband its own and the College of Engineering’s limited resources. By relying on three graduate students from a single department to provide the camp’s content, WiE was able to add CheME & YOU @ OSU to its current summer program offerings without either exhausting the personnel time required to coordinate a camp that relies on multiple
engineering departments or drawing further on the goodwill and resources of faculty and staff from across the College. This was a tremendous advantage given WiE’s small staff and the fact that departments repeatedly call on the same faculty and staff to participate in WiE’s outreach and recruitment programs from year to year.

Although there were advantages to offering a single-discipline, as opposed to a multi-discipline, camp, the amount of instructional time that the three graduate student organizers devoted to CheME & YOU @ OSU may have been overwhelming. The camp’s academic day ran from approximately 8:30 am to 4:30 pm, resulting in the graduate students spending some 40 hours with the participants, in addition to the time required to adjust the curriculum to better meet the participants’ needs from day to day. WiE’s multi-discipline camps usually only require department representatives to prepare and deliver a few hours of curriculum instruction, and these representatives have an advantage in that they can draw on a repertoire of activities and demonstrations previously developed by themselves or other members of their department. Thus, the multi-discipline camp allows WiE to avoid burdening any one group of faculty, staff, or graduate students with producing and delivering a full, five-day curriculum.

In addition to possible burnout on the part of the graduate student organizers, CheME & YOU @ OSU may have risked overexposing participants to a single field of engineering. Given that rising high school freshmen have likely had only a little, if any introduction to chemistry or engineering, a week-long program focused solely on chemical engineering may alienate participants who discover within the first day or so that they dislike or are uninterested in this particular field but who otherwise might enjoy learning about alternative engineering disciplines. The following CheME & YOU @ OSU events served to counteract this issue: (1) an interactive presentation on the kinds of undergraduate engineering programs offered across the College of Engineering that concluded with a conversation about college life between the participants and two female engineering undergraduates, one of whom was not a chemical engineering major; (2) an icebreaker activity designed around concepts in industrial and systems engineering; (3) the presence of a residential advisor (one of three) who was a graduate student in materials science and engineering; and (4) the involvement of two WiE student assistants who were majoring in mechanical and industrial and systems engineering, respectively.

**Discussion and conclusion**

CheME & YOU @ OSU succeeded in introducing young women to the field of chemical engineering through a series of hands-on activities, tours, and field trips and increasing their awareness and knowledge of this field. Based on the formative evaluation, the majority of the participants indicated that the camp helped them understand more about chemical engineering and they were more interested in chemical engineering as a career as a result of their participation in CheME & YOU @ OSU. One camper wrote on the post-program participant questionnaire, “I really liked this camp. I felt like it was really helpful in teaching me about chemical engineering and all its different jobs. I enjoyed learning about how chemical engineering can be used with the human body like the DNA extraction.” Another young woman recognized that she could learn more about chemical engineering through courses already offered at her high school, commenting, “I had no idea that some of my favorite things that I learn at school can be studied, if I were to pursue a career in chemical engineering.” One student was
motivated to take more classes related to chemical engineering as indicated by her declaration, “I love chemical engineering now and will be taking courses in high school to learn about more.” Another participant was fascinated with the presence of chemical engineering in everyday life: “CheME and You showed me what chemical engineering really is and how awesome it is and where it can be found in everyday life. After seeing chemical engineering demonstrations and learning briefly about other kinds of engineering I am almost sure that I would like to be an engineer and most likely a chemical engineer.”

In the future, WiE will expand the evaluation plan for CheME & YOU @ OSU to include a more summative evaluation to assess and evaluate the camp’s efficacy. In other words, the summative evaluation will be designed to determine if the camp is meeting its goals and objectives. For example, the summative evaluation will answer questions such as, “does the camper apply to OSU,” “does the camper pursue a degree in engineering,” and “does the camper choose to major in chemical engineering.” This approach is intended to measure the true impact of the experience on the participant’s commitment to studying engineering. To capture this type of feedback, WiE will administer and track student behavior beyond the end of the camp. Past participant questionnaires will be administered over a longer period, in the years following the students’ participation in the program, when the initial excitement has worn off.

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