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The Benefits of an Engineering Field Trip for Women Students

Dr. Kerry Meyers, University of Notre Dame

Dr. Kerry Meyers holds a Ph.D. in Engineering Education (B.S. & M.S. Mechanical Engineering) and is specifically focused on programs that influence student's experience, affect retention rates, and the factors that determine the overall long term success of students entering an engineering program. She is the Assistant Dean for Student Development in the College of Engineering at the University of Notre Dame. She is committed to the betterment of the undergraduate curriculum and is still actively involved in the classroom, teaching students in the First-Year Engineering Program.

Dr. Victoria E. Goodrich, University of Notre Dame

Dr. Victoria Goodrich is an Associate Teaching Professor in the Chemical and Biomolecular Engineering at the University of Notre Dame. She holds a BS in Chemical Engineering from the University of Oklahoma and a MS and PhD in Chemical Engineering from Notre Dame. Her research focuses primarily on Engineering Education issues with specific interest in the first-year curriculum, experiential learning, and diversity and inclusion.

Taylor Maida, University of Notre Dame

Taylor Maida is a Computer Science major with an Engineering Corporate Practice minor in the class of 2023 at the University of Notre Dame.

Simran Moolchandaney, University of Notre Dame

Simran Moolchandaney is a class of 2023 undergraduate student at the University of Notre Dame majoring in Computer Science and minoring in Bioengineering. Outside the classroom, Simran is an NCAA Division 1 Fencer, and an active SWE member who zealously engages in community service work.

Gabrielle Tanjuatco, University of Notre Dame

Gabrielle Tanjuatco is a graduate of the University of Notre Dame in Mechanical Engineering in the Class of 2021.

Caroline Lubbe, University of Notre Dame

Caroline Lubbe is a Chemical Engineering student in the University of Notre Dame Class of 2023.

The Benefits of an Engineering Field Trip for Women Students

Abstract

This complete evidence based practice paper demonstrates the outcomes of an engineering field trip. There have been reported benefits of well-designed field trips, including better retention of classroom material, and skill development for engineering design including increased confidence when students are given opportunities to learn about how physical devices work. Therefore, two women faculty and 5 senior officers from the Society of Women Engineers student chapter, led a ski field trip for 30 students during the semester break in January 2020. This 3-day trip included travel to a ski resort from the medium sized, Midwestern campus focused on gaining exposure to the engineering in ski resorts including lift operations and snow making processes while building student-student and student-faculty relationships. During the 4-hour bus ride to the ski resort, students were asked to read a scholarly article on one of eight topics related to ski resorts. Students met in small groups with others that selected the same ski related topic and gave a report out to the larger group. At the ski resort, students had a behind the scenes tour of the lift operations and of the snow making process. Students had the rest of the day to ski or take a lesson with other women on the trip. The evening included a team building workshop which included reflection on the day's activities and how their experiences related to engineering. Pre and post surveys were conducted with the students in which there was a 100% response rate. The focus of the assessment was on: (1) learning gains for understanding engineering of a ski resort and (2) team building and meeting engineering women peers. Results show student gains in both educational and team building outcomes.

Literature Review

Coming into college, many students choose engineering because they excelled in math and science courses in their high school, but when they begin their first semester, they may be completely unsure of which engineering discipline they want to pursue. Ultimately, many of them might not even be aware of what a career in engineering entails. A study at Colorado State University shows just this, where students in their first semester of college in an Introduction to Engineering course were asked in a survey if they were confident in choosing which engineering discipline to pursue. Only 15% of the students responded that they were confident, and none of those students were female [1], pointing to a possible problem in the recruitment and retention of women. The gender gap and underrepresentation of minorities within the field of engineering has been a widely-reported problem specifically in the recruitment of talent and retention of existing students, as seen in many studies [2-6].

After going through a semester of discernment activities, where the students learned about the different disciplines and met different types of engineers, most students inevitably chose an engineering discipline, but the percentage of students confident in their decision to do so did not

significantly increase [1]. While not necessarily more confident, many of the students did report that the discernment activities from their Introduction to Engineering course did have a positive impact on their decision making. For the 82% of the students who remained in the engineering program at this specific university after the first semester, many reported that they were still not confident in their decision of which engineering discipline to pursue, and some even stated that they were not confident in their ability to complete their engineering degree. This shows that while discernment activities are important, especially because many students are not even aware of what an engineering career means for them, there are many factors that influence retention, and self-confidence is a major factor. Therefore, how can universities do a better job of, not only educating students about their career paths, but also supporting them in this career path and encouraging them to persist through obstacles?

Studies have shown that female graduation rates and percent of females in industry continue to suffer. Chopra [4] and many other studies have compared the industry gender disproportionality to that of a "leaky pipeline" whose both unappealing and unaccommodating nature disincentives women to stay despite the high barriers to entry [5]. Yet, fostering a sense of belonging and inclusion, while still in school, was shown to be a successful tool in the preservation of the female and minority populations in engineering. One of the main ways this was done was through the introduction of female mentors and the formation of connections with industry leaders to whom students shared a similar demographic [3], [7]. Engineering retention translates to practicing engineers in the workplace. Thus, improvements in women and minority retention translate to a more diverse engineering industry. Therefore, it stands to reason that improvements in student certainty, self-efficacy, and mentorship could increase diversity in the engineering workforce.

Self-efficacy correlates to positive outcomes in studying and pursuing careers in non-traditional fields, such as the case of women in engineering [8]. In fact, an increase in self-efficacy can lead to increased persistence levels and more women entering the engineering field [8]. The ongoing problem identified is that the gendering of certain school subjects, lack of senior women mentors alongside with the assumptions made revolving men and women's work have managed to drive women away from careers in engineering [9]. Research has shown that social forces are the main cause of women leaving their engineering education, whereas in men, poor academic performance is what causes their dismissal [10]. Therefore, there is a growing need to tailor the educational experience such that it includes more than just skilling for the job [9]. It would be best to implement strategies that would better prepare females for the workplace environment, by providing them with the tools to position themselves well as professional colleagues [9].

In order to revert the sense of an unwelcoming atmosphere felt by women in the engineering education realm, there has to be changes in the curriculum that enforce the quality of the classroom and extra-curricular climate [8]. One possible solution to increase women retention in engineering is to promote undergraduate women's engineering identity, as this is directly related

to their educational and professional persistence [11]. This can be done through different programs that provide engineering students with instances to hone their professional and leadership skills, find mentors, and develop strong social connections with their engineering peers, all in order to facilitate the development of the students' engineering identity [11]. Instances for professional development allow the creation of a support network which is a critical factor in degree completion for women, who value community and collaboration more than their male counterparts [12]. This sense of belonging positively impacts academic achievement and retention in college as it increases women's self-confidence and thus their self-efficacy [12]. An example of this is providing women students with the opportunity to engage with their peers and faculty during an Engineering Field Trip, which would provide them with an engaged STEM learning experience.

In the past, it has been difficult to prove the benefits of field trips to both the students and the field trip hosts [13]. In order to reap the benefits of field trips, previous studies emphasize the importance of preplanning [13-15]. When planning a good field trip, many instructors match the objectives of the field trip to the topics that the students are learning in class [16-18]. One common intended benefit of an engineering or technology field trip is to give students exposure to a specific industry and the subjects discussed in class [16], [17]. Field trips are also used in introduction courses to give the students hands-on experience with the unfamiliar subject [18], [19]. Numerous studies have found other benefits of field trips, including enjoyment of learning by the students [16], [17], [20] as well as an increase in students' passion and motivation to learn the subject [15], [16]. One study found other specific benefits, such as improvement in class grades and higher student participation in class [18]. In addition, field trips represent a shift from a "teacher-centered approach" to a "learner-centered approach" [17] which can be a change from traditional lecture courses.

Background

The field trip was sponsored by the College of Engineering at a medium sized, Midwestern, private institution. The university is largely residential with nearly all students between 18 and 22 years old. The College of Engineering is approximately 66% male and 34% female with variation of these ratios within each engineering discipline. The engineering disciplines offered for study are: Aerospace and Mechanical, Civil and Environmental, Chemical and Biomolecular, Computer Science and Engineering, and Electrical Engineering. Because many of the students matriculate directly from high school, few students have experienced significant work in an engineering setting upon entering the university. Therefore, an engineering faculty member reached out to an engineering alumni in the region that could provide direct engineering experience to students for field trips. A ski resort that is just over 200 miles from the university campus emerged as a likely location where students could view some of the background engineering process and participate in team building activities.

Planning the field trip

The ski resort hosted two engineering behind the scenes tours: (1) snow making and (2) chair lift operations. These activities were seen to map to chemical engineering and mechanical engineering topics, respectively. Therefore, the field trip was specifically designed with these two majors in mind. Senior women from each department were recruited to act as leaders in the planning and student recruitment of the process along with support from two engineering faculty and an administrative assistant. Trip planning included making transportation arrangements and hotel reservations, creating team building activities, and arranging ski lessons and rentals.

The planning team sought to lower the barrier for attending the field trip in several ways. First, all materials were paid for by the university, and the only cost was $20 to commit to your spot. Therefore, we anticipate that most students would not be limited by monetary considerations. Second, the field trip was set as a 3-day experience, starting on the Friday before the spring term began for the university based on input from the student leadership. Students would not miss class or other campus activities as the campus was still closed for the winter break. Third, the university also paid for optional ski rental and lessons for all students, so that ability to ski was not a prerequisite for attending. Finally, there was an in-person meeting for all attendees in December that was used to answer any questions and allow students to meet others attending the field trip. At this time, the group brainstormed what to bring on the trip, answered logistics questions, and signed up for their hotel rooms at the resort.

Trip Schedule and Activities

The engineering field trip was intended to give students insight into engineering processes and to foster student-student interactions with a goal of building student support networks within majors. Therefore, each day had a mix of activities that were intended to further these goals.

Students met on campus on Friday afternoon and departed for the ski resort on a charter bus arranged by the planning team. On the 3.5-hour drive, students were asked to review one scholarly article related to ski resorts. The papers included topics on the science of snow making, chair lift operations, ski resort economic analysis, and climate change effects on the future of ski resorts. In addition, students were asked to fill out a pre-event survey which is used in this paper. Once students checked into the hotel, a dinner was provided. At dinner, all students and faculty present introduced themselves and spent time meeting one another. After dinner, the students were broken into groups depending on which of the papers they read on the bus ride. Each group created a short presentation with a hand drawn poster as a visual aid and presented the paper to the other students. Finally, student leadership arranged teams based on major and academic year and held a short trivia game.

Saturday was spent largely at the ski resort. In the morning, students were given a behind the scenes tour of the ski resort with approximately 30 minutes focused on snow making operations

and engineering considerations. The next 30 minutes were spent at the ski lift with students able to climb into the mechanical room to see the operation up close. After the tour, students were able to pick up gear and ski or snowboard until the bus departed at 5 PM. Many students took a beginning ski lesson followed by open ski time. Students took breaks for lunch and to rest in the ski lodge throughout the day, and many spent time in small groups together. After returning to the hotel, students again ate dinner together followed by student led activities. The student leadership created teams and led several team building activities to foster student interaction. Students were given unstructured time in the evening where additional informal interactions took place.

Finally, on Sunday students were transported back to campus on the bus. The only formal activity during that time was for the students to complete the post-field trip survey before arriving on campus. The general schedule for the trip can be seen in Table 1, below.

Table 1. General Schedule of Field Trip Activities

Day	Time Range	Activity Name	Brief Description
Friday	2 - 6 PM	Transportation to Resort	Students selected and read an article on engineering logistics of ski resorts and pre-survey completed.
	7 - 9 PM	Evening Activities	Group dinner with introductions of all students and faculty. Students worked in small groups to create and give a short presentation on the paper they read.
Saturday	9 - 10 AM	Engineering Tours	Guided tour of snow making and chair lift operations with up front experience with the engineering units
	11AM - 5 PM	Ski Time	Students were given time to take a ski lesson, ski, or rest in the lodge until early afternoon.
	7 - 9 PM	Saturday Evening Activities	Student leaders created a number of team building games that were completed after dinner.
Sunday	10 AM - 2 PM	Transport to University	Students completed a post-survey during the ride back to campus.

Methods

In total, a group of 30 undergraduate engineering students participated in the educational weekend ski trip. The all women engineering group included: 4 first-years, 13 sophomores, 8 juniors, 5 senior SWE leaders, and 2 women faculty members. All participants were majoring in Mechanical or Chemical Engineering to make the benefits of learning about snow making and ski lift operations academically relevant. Figure 1 shows a summary of ski trip participants by graduation progress and engineering discipline. Students were asked to complete a pre-survey on-line through Qualtrics during the bus ride to the ski resort and a post-survey on the bus ride returning to campus. The surveys included a series of questions relating to learning gains and team building. There was a 100% response rate on both the pre and post surveys as the students were completing them during travel time.

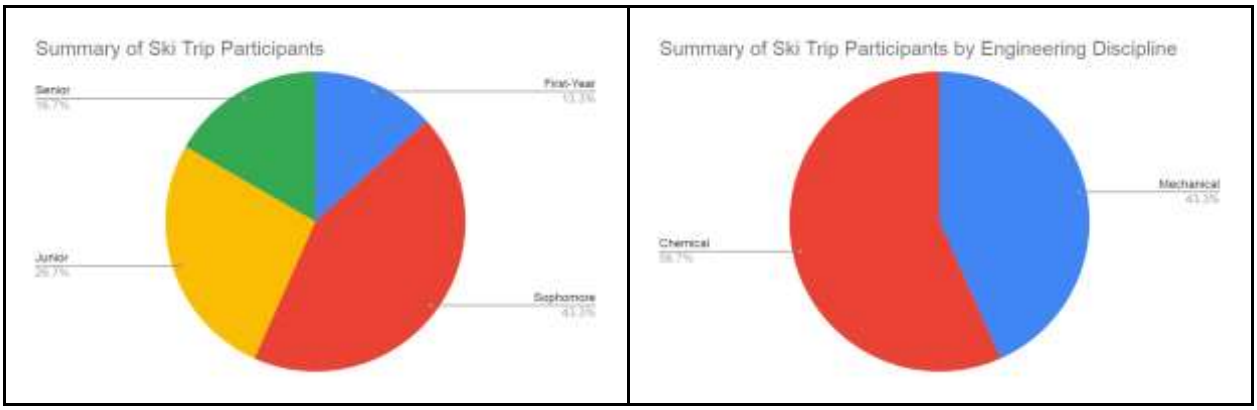

Figure 1. Summary of Ski Trip Participants

The de-identified pre and post trip data were analyzed using paired t-tests and results were reported to 95% confidence. Finally, the student responses to open ended questions were used to offer contextual understanding of statistical results. A summary of the survey questions is shown in Table 2.

Table 2. Summary of Pre and Post Survey Questions

Survey Question	Response Type	Pre-Survey	Post-Survey
What year are you?	Categorical (FY, Soph, Jr., Sr)	x	
What is your Engineering Discipline?	Categorical (Chemical or Mechanical)	x	
How many times have you been skiing before this trip?	Numeric	x	
How many women on this trip did you already know?	Numeric (list of participants given)	x	x

How many women on this trip did you already know that are in your engineering major?	Numeric (list of participants given)	x	x
Rate your knowledge of: Snow making processes Ski lift operations Ski resort operations in general	Likert	x	x
What was your primary motivation for participating in this trip?	Categorical	x	
Explain your motivation	Free response	x	
What did you enjoy most about this trip?	Categorical		x
Explain the aspect(s) you enjoyed most	Free response		x
Rate experiences for (1) educational benefit and (2) team building / networking: Transportation Friday evening activities Ski lift tour Snow making tour Open ski time Saturday evening events	Likert		x
Rate Trip overall	Likert		x
Final Comments	Free response		x

Results / Discussion

The pre and post surveys reveal that the participants on the field trip gained both educational and team-building / networking benefits. The educational benefits of the trip are quantified by comparing students' self-reported knowledge of certain topics before and after the trip. The students' activity ratings and their answers to the free response survey questions measured team-building and networking benefits. Figures 2-4 show summaries of the pre and post trip survey data of the students' knowledge of these three topics. In these figures, responses of "very knowledgeable" and "extremely knowledgeable" are combined.

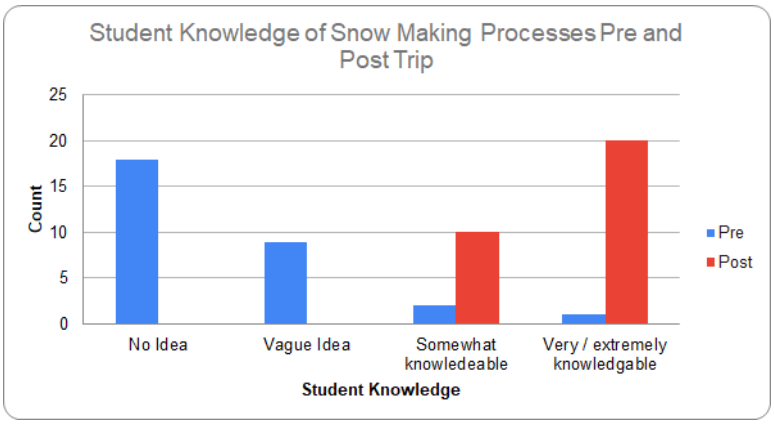

Figure 2. Student Knowledge of Snow Making Processes Pre and Post

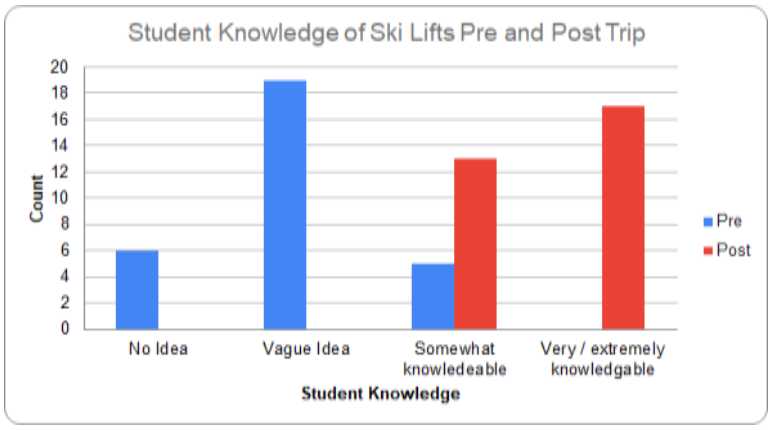

Figure 3. Student Knowledge of Ski Lifts Pre and Post

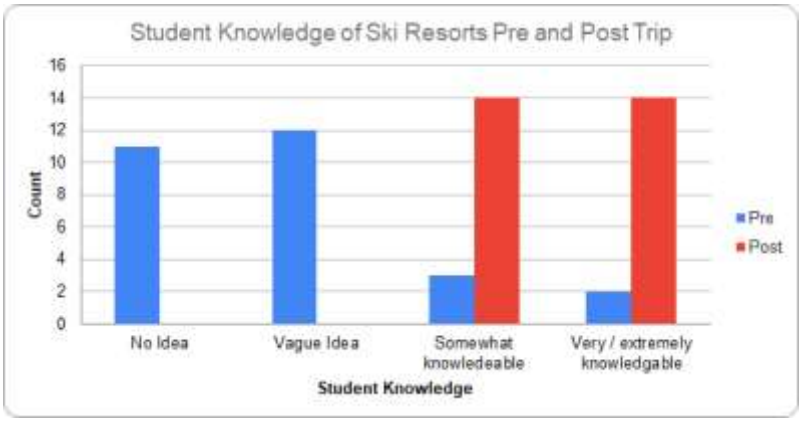

Figure 4. Student Knowledge of Ski Resorts Pre and Post

As shown in the graphs, before the trip, most students had “no idea” or a “vague idea” of all three topics. After the trip, however, all students considered themselves somewhat, very, or extremely knowledgeable on all three topics.

To quantify the statistical significance of these results, responses were coded with a number: “No idea” was 1, “Vague idea” was 2, “Somewhat knowledgeable” was 3, “Very knowledgeable” was 4, and “Extremely knowledgeable” was 5. We then performed a paired samples t-test on the pre and post data for each question. Table 3 contains the results of the statistical analysis of the student knowledge pre and post survey data.

Table 3. Statistical Analysis of Student Knowledge Pre and Post

Question	Mean value (pre)	Mean value (post)	Results of paired t-test
Rate your knowledge of snow making processes	1.53	3.73	$p<0.001$***
Rate your knowledge of ski lifts	1.97	3.60	$p<0.001$***
Rate your knowledge of ski resorts	1.86	3.50	$p<0.001$***

Due to fairly low knowledge expressed by the students in the pre-survey, all knowledge responses showed statistically significant increases yielding p values of less than 0.001.

Students also rated the educational and team-building benefits that they gained from the different activities on the field trip. They rated each activity on a scale of “Poor (1), Ok (2), Neutral (3), Good (4), Excellent (5).” Figures 5 and 6 summarize the student ratings (per activity) of the educational and team-building benefits.

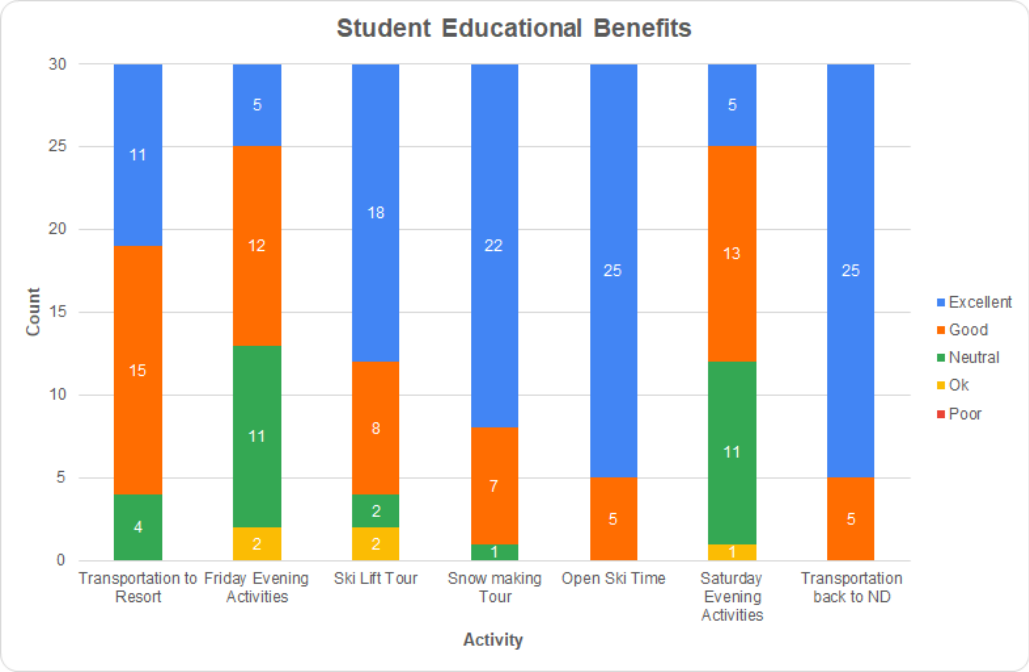

Figure 5. Summary of Student Educational Benefits

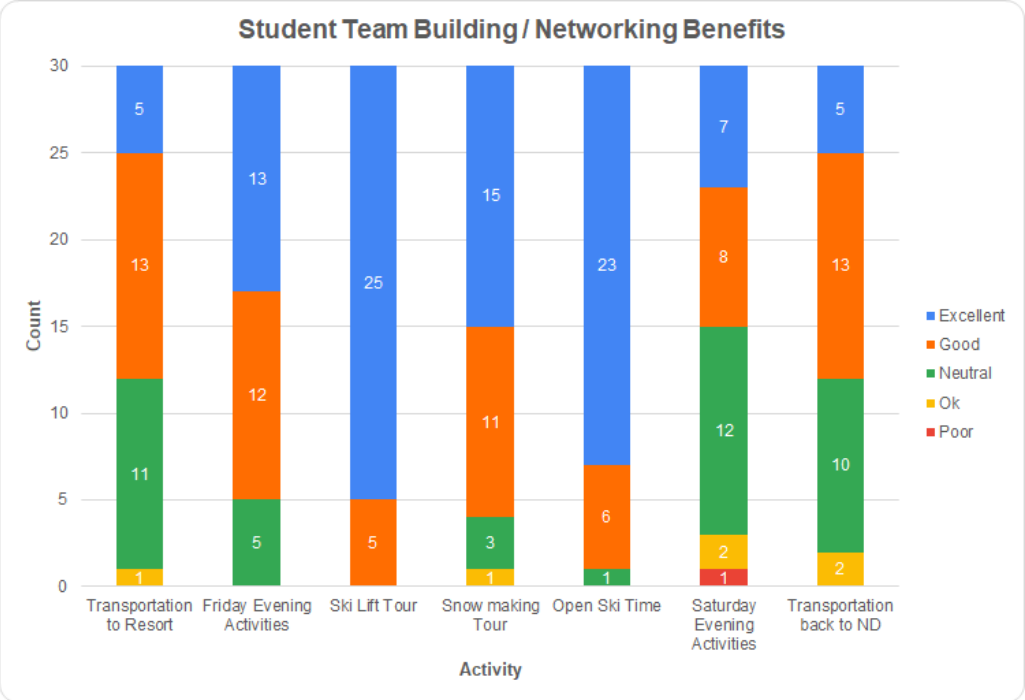

Figure 6. Summary of Student Team Building / Networking Benefits

Students gained benefits from all of the trip activities. The ski lift tour and snow making tour had the highest educational benefits for the students. The open ski time and evening activities had the highest team-building / networking benefits.

Another way to show the networking benefits of the trip is to look at the number of people that each student met. Based on the pre-survey, a desire to meet other female engineers was one of the most popular motivations for participating in the field trip. Students wanted to meet other engineering students to study with and network with. Analyzing the pre and post surveys found that students had the opportunity to network with other female engineering students and met many new people. Figure 7 is a summary of the pre and post survey results.

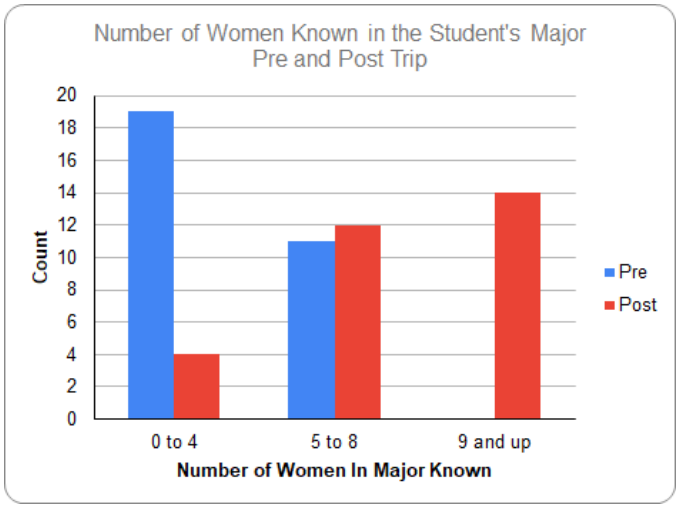

Figure 7. Women Known in the Student's Major Pre and Post

As shown in Figure 7, students left the trip knowing more women in their major than they had known before. By meeting other engineering students, the women on this trip gained potential networking opportunities.

Students enjoyed both the educational experiences and the interaction with other women engineers, as shown in their free response survey answers:

Educational comments:

"*I enjoyed learning about the mechanics of ski lifts and snow making. I also enjoyed skiing for the first time and learning how to ski with other women engineering students!*"

"*Learning about the ski resort operations processes was surprisingly fascinating! It was amazing how many of the important concepts directly translated to conceptual work we've done in class.*"

Team building comments:

"*This trip was extremely beneficial for meeting other women engineers and learning about the real life applications of mechanical engineering.*"

"Skiing was the perfect combination of getting to know people and having time to be social while not having to over socialize if you're shy. The games were great for bonding!"

These free response answers confirm the educational and team-building benefits quantified from the pre and post surveys. Students enjoyed the educational ski resort tours and the socialization with other women engineers. Overall, the students had a very positive experience on the field trip. In the final survey, every student rated the overall trip as either "Very Good" or "Excellent." In the final comments survey question, many students expressed interest in another trip:

"I had an amazing time hanging out with other female engineers just having fun skiing and laughing and watching movies! I would definitely do this again if I had the opportunity!"

"I really enjoyed it and would definitely go on future women in engineering trips!"

"Please run this again next year! Or do something similar! It's a great way to bring women in engineering together!"

Conclusions

As explored in this paper, field trips are positive experiences for women engineering students, both for technical education and networking purposes. Not only did the students leave with real world examples of how their majors could be applied, but they also were able to meet more women in their major. On a Likert scale, there seemed to be apparent benefits in the post-trip survey for educational and networking purposes. While the university discussed in this paper does have a higher percentage of women in their engineering program than a typical university, being a woman in engineering can feel overwhelming and unwelcoming because of the fact that they are in the minority. Giving women the opportunities to go on field trips that allow them to gain technical knowledge and a larger group of women to support them throughout their college experience could be a method universities use to increase self-efficacy within female engineering students, which is a key factor of being successful in engineering. Gaining hands-on experiences that are related to what these women are learning in class will provide a better understanding of what their major really means in the real world, which will likely increase their interest and confidence in their area of study. Field trips can give students a perspective on a given engineering discipline that discernment activities in class may not be able to provide. While these in-class activities aid students in their decision making process of which engineering major to choose, they still may not give students a high confidence level in this decision if they come into college unsure of what an engineering career entails. This is especially true for female students, who are shown to have less knowledge about the engineering field when entering their freshman year of college as an engineering student. All of this being said, universities should consider using field trips to support women in engineering in order to increase confidence in their abilities to choose an engineering discipline and, ultimately, persist through engineering and receive their degrees. Fostering a welcoming and supportive learning environment for female

engineering students is a crucial part of making engineering a field that women stay in, eventually making it a field where women are no longer the minority, and field trips are one of the ways that this can be done.

A few suggestions for successfully integrating a field trip such as this:

- Make it accessible
    - Schedule the trip / event so that it doesn't conflict with other class commitments
    - Make cost minimal. A small amount of money to shows a student is committed to attending but not prohibitive.
    - Make equipment / lessons free and available to all (so that skiing or the activity is not limited by prior experience)
- Make the trip / experience both social and educational
- Use undergraduate students as leaders / organizers to foster engagement with near peers

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