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Examining the Experiences of First-Year Honors Engineering Students in Service-Learning

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Abstract

While research projects and skill-based courses are critical in engineering and computer science curricula, service-learning has been additionally highlighted as a worthwhile pursuit. This qualitative investigation explores the experiences of two cohorts of Honors students in an Introduction to Engineering course in the Fall 2016 and Fall 2017 semesters. As part of their service-learning experience, students were required to create a presentation and prepare a hands-on activity to expose underserved adolescents to Science, Technology, Engineering, and Math (STEM). Student-participants were surveyed to evaluate the efficacy of service-learning in helping them to develop skills in effective communication and strategic teamwork, while cultivating a clear self-concept as engineers or computer scientists. Learning how to communicate with a non-technical audience was cited as a key takeaway by both cohorts of participants, while the second cohort of students noted teamwork as one of the major challenges that they had to work through to successfully complete a quality project. Students voiced a sense of duty to improve access to higher education for adolescents in the surrounding underprivileged community, viewing themselves as peers with a humanitarian obligation to improve access to education, rather than focusing on their technical skills and self-concept as future professional engineers and computer-scientists.

Introduction

The pedagogy of service-learning has been implemented in engineering curricula throughout the country to strengthen engineering students' professional development. Dr. Barbara Jacoby describes service-learning as a method of "experiential education in which students engage in activities that address human and community needs" in a fashion that encourages "student learning and development"[1,2]. In the university-level engineering programs in which it has been incorporated, service-learning has been recognized as beneficial to engineering students' educational formation for its emphasis on "cooperative learning" and "community engagement"[3]. Specifically, this method has been shown to be especially effective in teaching first-year engineering students the principles of engineering design. When engineering students work with underprivileged individuals as they practice implementing the engineering design process, students gain exposure to working in a more diverse context closer to that which they might encounter post-graduation, rather than working with a solely technically-minded team[4].

Among its 2016-2017 Criteria for Accrediting Engineering Programs, ABET includes "an ability to communicate effectively," "an ability to function on multi-disciplinary teams," and an "understanding of professional and ethical responsibility" as key Student Outcomes, those skills which engineering students are expected to have learned upon graduation[5]. According to a study conducted by Riley, Furth, and Zelmer regarding the factors determining engineering alumni's professional success, engineering graduates recognize communication as crucial to their success as professionals, but feel that this is the area in which they are least prepared by their college education in engineering[6]. The integration of engineering and communication studies through college courses, projects, and campus resources was concluded to be beneficial in helping engineering students strengthen their communication skills[7]. Similarly, it is widely

acknowledged that more than technical skill is required to set engineering students up for success upon graduation. Due to the increased rate of globalization that continues to evolve with modern technology, the skills of "communication, teamwork and leadership" and "societal and global awareness" are particularly in demand by industry[8].

To successfully achieve the ABET Student Outcomes related to effective communication and teamwork, according to Shuman, Besterfield-Sacre, and McGourty, "active and cooperative learning" are among the necessary components. They specifically espouse service-learning as a valuable means of doing so for its ability to connect the principles of engineering design with community enrichment[9]. Past research has shown that engineering students' communication skills and capabilities in working with a team substantially improved following their participation in service-learning opportunities, along with their motivation to continue their studies in engineering[10,11].

Not only has service-learning been shown to be beneficial to engineering students' abilities to hone their skills in communication and teamwork, but it also provides students with a context conducive to developing their identity. Personal identity is cultivated thorough active participation in one's society and culture. Johri and Olds highlight situative learning, which places great emphasis on "context" and action in the learning process, as beneficial to engineering education. Based on this pedagogy, engineering educators are encouraged to allow their students to learn in a context that will let them cultivate their identity as it relates to their future in engineering, fulfilling the ABET Student Outcome of allowing students to understand their professional and ethical duties by framing their role as engineers in the context of the bigger picture of life[12].

The development of communication skills, teamwork capabilities, and a clear self-concept are not the only areas of engineering education that are intriguing. The well-known underrepresentation of women in engineering and engineering-related fields continues to be of particular research interest. The percentage of bachelor's degrees in engineering awarded to women was less than 20% in the year 2014[13]. Although a medley of factors is responsible for this gender disparity, the stereotypes that degrade women's roles and abilities to succeed in engineering and engineering-related fields are major contributors[14]. For the minority of women who do pursue their studies in engineering, service-learning has been noted as a particularly positive experience. In a study conducted at Purdue University, it was shown that female engineering students demonstrated significant interest in a service-learning based program titled Engineering Projects in Community Service (EPICS). The female participants sampled specifically cited "team learning" and community engagement as the highpoints of their service-learning experience[15].

Our qualitative study examines the experiences of first-year engineering and computer science students enrolled in an Honors section of Introduction to Engineering across two semesters: Fall 2016 and Fall 2017. For both cohorts of students, participation in a service-learning project was required in support of the University of San Diego's (USD's) mission to be what is referred to as an "anchor institution," or an active and accessible resource within the larger community[16]. The efficacy of service-learning as a means of improving students' self-perceived abilities to practice

effective communication and strategic teamwork, along with its contribution to their self-concept as engineers, was examined.

Methods

Participants

All twenty-five first-year students enrolled in an Honors Introduction to Engineering course at the private, faith-based University of San Diego, twelve who were enrolled in Fall 2016 and thirteen in Fall 2017, were invited to participate in this study. Our actual participant pool was composed of eleven students, four from the Fall 2016 cohort (two men and two women) and seven from the Fall 2017 cohort (four men and three women). Of the eleven participants, only four respondents, three women and one man, reported that they had prior engineering experience before starting their first-semester of college. It is important to note that one of the female participants enrolled in the Fall 2016 section of Honors Introduction to Engineering was the principal investigator, classifying this investigation as an example of participating observation[17].

As part of their first-year experience, all incoming students at USD are placed into a living learning community (LLC) with a theme to be explored through one assigned course and on-campus events linked to their residence halls. For both cohorts of students, Honors Introduction to Engineering was their LLC course. For the first cohort of students, "peace and conflict" was the theme, while "equity and access to high education" was theme for the second cohort.

Service-Learning Project Description

Although students' participation in this study was voluntary, all twenty-five students enrolled in Honors Introduction to Engineering across both fall semesters were obligated to participate in a service-learning project as a course requirement. The guidelines and objectives for students' service-learning project were the same for both semesters. Students worked in groups of approximately four to design a team presentation and corresponding hands-on activity to teach a group of middle school-aged adolescents attending an after-school program at a local community center for teenagers about engineering design. This middle-school aged audience was primarily composed of individuals from low socioeconomic backgrounds as this center for teenagers is situated in a low-income, low-access local community. The partnership between the college students and this community center was facilitated by the Karen and Tom Mulvaney Center for Community, Awareness and Social Action (CASA) at USD. All student presentations were required to focus on one of three main Next Generation Science Standards for middle school level science: Motion and Stability: Forces and Interactions, Energy, and Engineering Design[18,19,20]. The major goal of this project was two-fold. The learning objectives for the college students were to: effectively communicate with a nontechnical audience, demonstrate strategic teamwork by preparing a presentation and hands-on activity, and gain a better understanding of engineering and computer science and their reasons for pursuing these fields. While the learning objectives for the teens varied among groups, the main community needs include: learning about Science, Technology, Engineering, and Math (STEM)-related topics, keeping students interested in math and science, and facilitating interactions between local adolescents and college students to increase knowledge about and interest in pursuing higher education and, potentially, careers in technology.

Data Collection

The methods of data collection for the two cohorts of students differed slightly across the two years in which this study was conducted.

For the first cohort of students, pre- and post-presentation web-based surveys were send to all twelve students enrolled in Honors Introduction to Engineering. The Preliminary Survey focused on the extent of students' project preparation, along with their outlook and perceptions of service-learning. The Post-Presentation Survey encouraged students to reflect upon the efficacy and relevance of their experience as far as preparing and presenting their service-learning project.

For the second cohort of students, data was gathered through the use of surveys, a one-on-one student interview, and a class discussion that encouraged students to reflect on their experience by illustrating their self-perceived status within the broader community. While a Preliminary Survey was sent out to students to complete prior to their service-learning presentation, we did not receive any responses. As a result, the Post-Presentation Survey prompted students to reflect on what worked well and what challenges they faced in working with their team to prepare their presentations, along with what they gained from their experience.

To acquire further insight, a semi-structured interview, which is guided by both planned questions and the insights shared by the interviewee, was conducted with one female student from this cohort[21]. This interview format was chosen as semi-structured interviews are useful for digging deeper into the interviewee's experiences and sparking new questions to explore[21]. By coupling closed-ended questions, which allow for comparison with survey responses, and open-ended questions, which allow for a more detailed account of an interviewee's thoughts, perceptions, and experiences, semi-structured interviews are both flexible and versatile. Although only one student in this cohort was willing to participate in an interview, choosing to conduct a semi-structured interview based around a "general script" of talking points allowed this student's perspective and experiences to be both better understood and comprehensively explored[21].

Further insight on students' self-concept was obtained during an in-class discussion facilitated by the University's Director of Community Engaged Learning, which the primary investigator observed. This reflection session aimed to help students process their service-learning experiences in light of their LLC theme of "equity and access to higher education". As part of the reflection process, students were asked to illustrate how they perceived themselves in relation to their community. Observing this in-class reflection allowed the primary investigator to frame the data for how students perceived themselves in the broader context of their experiences working with their local community, offering a more comprehensive explanation of how they see themselves as they fit into the bigger picture.

For all survey and pictorial data obtained for both cohorts, the anonymity of all students was maintained, and the responses of the student interviewee from the second cohort were kept confidential. This study was approved by the Institutional Review Board (IRB) at USD.

Projects

Fall 2016 Cohort

The Fall 2016 section of Honors Introduction to Engineering was composed of three groups of four students.

One of these groups of students aimed to teach their middle-school aged audience about the concept of force, the benefits of teamwork, and the applications of the engineering design process. They did so by grouping these adolescents into teams and tasking them with building a tower solely out of marshmallows and raw spaghetti to protect their fictional kingdom from attack in a simulation based on the animated film *Shrek*.

Another group of students chose to teach their adolescent audience about the concept of force in terms of lift, friction, and Newton's Laws of Motion; expose them to mechanical, electrical, and industrial engineering; and help them to understand and apply the engineering design process. They did so through an activity mimicking highway construction. After instructing them how to create a simple hover disk from a balloon, CD, and plastic nozzle, the college student presenters tasked the adolescents with working in teams to construct a barricade capable of halting the motion of their hover disk once it was in motion.

The final group of students focused their presentation on teaching their audience about the Law of Conservation of Energy and various forms of energy and how they can be transformed. They did so by instructing the adolescents how to construct a rubber band-powered car using materials that could be found around the house. The goal was that the adolescents would be able to understand and explain the inner workings of their cars in the context of the Law of Conservation of Energy.

Fall 2017 Cohort

The Fall 2017 section of Honors Introduction to Engineering was composed of two groups of four students and one group of five students.

The group that presented first chose to introduce the middle-school students to the engineering design process by having them design, build, and test a catapult. As part of the design process, they had the students brainstorm ideas for designs before they distributed materials and helped students implement their designs. In the contest, one team's catapult successfully launched a play-doh ball 74 inches.

Another group thought that it would be beneficial to teach their adolescent audience about computer programming. While teaching them actual coding would not be possible given the constraints of the project, this group of students aimed to teach the adolescents the basics of thinking in the mindset of a programmer. The adolescents were paired up and seated back to back, taking turns attempting to draw a series of pictures based solely on the verbal instructions of their partner without asking questions, an activity that mimics the relationship between a coder and their computer as they attempt to translate their vision into a functional program.

The last group of students focused on engineering design and energy conservation and conversion. They reviewed some concepts from the first group with the catapults about kinetic

and potential energy using analogies from everyday life. Then, they provided detailed instructions on building a rubber-band powered car and guided students in building these cars.

General Project Takeaways

According to the participants, the impact of the experience of preparing their service-learning project on their abilities to communicate effectively, demonstrate strategic teamwork, and develop a clear self-concept was particularly significant.

Both cohorts of students noted the ability to effectively communicate with a non-technical audience as a key takeaway from their service-learning experience. They not only cited this as a skill that they feel they learned from their experiences, but also one that they felt was applicable to other areas. One student in the first cohort highlighted the importance of being able to "present [material] in a way so everyone can understand." Similarly, a student in the second cohort described this aspect of the project as a challenge that their team had to work through as "while it may make sense in your mind it is tough to put it into words that others… will understand." Students in the second cohort emphasized that they discovered the general importance of "know[ing] your audience" and "consider[ing] audience and context when making a presentation" to ensure their engagement and understanding.

Two students from the first cohort cited teamwork as an applicable takeaway from their experiences, and many of the students in the second cohort reported effective teamwork as one of the major challenges that they had to work though in preparing their presentation. Challenges that these students reported encountering included finding times to meet, discovering the importance of "discussing and negotiating," resolving in-team problems, and coping with a team that "did not help as much as they could have." One student in this second cohort who cited their team's excellent dynamic as something that worked well in preparing their project noted the success that abounds from effective "communication and enthusiasm" within a team.

As first-year engineering students who had the opportunity to teach adolescents from a local underserved community an engineering or computer science-related concept through their service-learning project, the ways in which students perceive themselves and their goals at this stage of their careers is particularly interesting. Following their service-learning experience, students expressed a general need for greater integration of communities of lower socioeconomic status into those of higher socioeconomic status, especially to improve access to higher education. Based on their survey responses, students seemed to express a perceived social responsibility to help achieve equity for adolescents like those they interacted with. One student from the second cohort specifically mentioned the need to encourage these adolescents to pursue higher education by "showing them that it is possible" for them due to the many resources available to assist them in achieving this milestone. Another student noted that adolescents such as those they interacted with at the community center for teenagers have the "same potential as anyone else" and advocated for greater integration between lower and upper-class communities. Although students did not report that they walked away from this experience with insights as to the work that they would be doing as professional engineers, their shared responses indicate a self-concept that goes much deeper. These participants appear to view themselves as fellow students with a duty to their peers within their community.

Project Through the Eyes of a Student

While the data obtained from the surveys collected from both cohorts shed light on students' experiences in general, further deeper insight was obtained through the responses of the one student who agreed to share more about her experience via the semi-structured interview. This student was a member of the group who chose to teach their adolescent audience the principles of engineering design through constructing a catapult.

In deciphering the best way to effectively communicate with their audience, this student shared that her group chose a visual approach, incorporating pictures and demonstrations as a means of holding the audience's attention and heightening their excitement. Additionally, they considered their younger brothers and sisters when attempting to figure out the best way to peak their audience's curiosity, with the interviewee noting that her own interests in building both as a child and today influenced the group's project design. Although the audience was highly receptive to this strategy, the interviewee noted that her group learned the importance of being adaptable in a presentation. Her group approached the experience collaboratively, noting that there were no major team conflicts. Although she was the only woman working in a group with four other males, she did not feel any exclusion on part of her teammates, noting that all team members worked together on all parts of the project with no division of tasks based on gender. The interviewee expressed that her group worked flexibly, opting to work independently or in pairs on various tasks if the entire group was unable to meet at a given time. Despite their positive group dynamic, the interviewee noted one of the pitfalls of everyone working together on every task: keeping all team members focused and on the same page. To combat this lack of centralization, the interviewee suggested the need for a group leader to tie the entities of a project together and stay organized when working with a team.

The interviewee's most interesting thoughts, however, came from her view of herself and her goals in engineering in relation to this project. Like her peers from the first and second cohorts, this student certainly voiced a sense of duty to inspire these underprivileged adolescents to pursue higher education. She specifically noted that as the only woman in her group, she felt that the young women in the audience really looked up to her based on their interactions. In connecting with the members of her audience, the interviewee described how she put herself in their adolescent shoes, noting that she would have wanted someone to approach and assist her in the activity rather than passively standing by. She specifically emphasized planting the seeds in these adolescents' minds that going into a STEM field is a possibility for them as a highpoint of her service-learning experience. However, this student's self-concept goes beyond that of someone to be looked up to. While she enjoys the hands-on nature of engineering and is fascinated by "how things work," the interviewee expressed great interest in being a STEM teacher after completing her studies in engineering. She explained that although her interests in teaching began prior to completing this service-learning project, working with the young men and women from the community center for teenagers strengthened this career goal, noting that she wants to get more involved with the center in future semesters.

Results

The research goals of this study were to gain a deeper understanding of how service-learning is beneficial to engineering and computer science students' ability to communicate effectively, work strategically with a team, and develop a clear self-concept regarding their motivations and goals in engineering and computer science. Initially, students' experiences were intended to be analyzed with particular attention to how they differed based on gender, past experience, and future goals. However, due to the small sample size, there did not seem to be a significant difference in students' experiences based on these three categories. Although the participant pool included six men and five women, and four students with and seven students without engineering experience before starting college, gender and past engineering experience did not appear to contribute to differences in their reported service-learning experiences. Additionally, while all thirteen students in the second cohort were given the opportunity to participate in a focus group session to dig deeper into their future goals, only one student expressed interest in doing so, preventing reasonable comparisons among students. This led the primary investigator to conduct a semi-structured interview with this student, rather than a focus group session.

A summary of the number of responses received for each survey from each cohort appears in Table 1. Because the methods of data collection and range of questions differed slightly across the two year span of this study, a distinction will be made between the results obtained from the first cohort and those obtained from the second cohort for the remainder of this paper.

Table 1: Summary of Responses to Surveys by Both Cohorts

	Cohort 1 (Fall 2016)	Cohort 2 (Fall 2017)
Preliminary Survey	4	0
Post-Presentation Survey	3	7

Despite the limited sample size, valuable insights were obtained from the eleven participants with regard to the light their experiences shed on service-learning's ability to promote effective communication and strategic teamwork and contribute to students' self-concept within engineering education.

Effective Communication

In preparing their service-learning presentation geared towards their adolescent audience, the majority of participants noted communication with a nontechnical audience as a key takeaway from their experience. Learning how to explain concepts in such a way that others unfamiliar with the topic at hand can understand was a highlight from both cohorts of students, and the development of preparation, presentation, and public speaking skills, were among the parts of their experience that students in the second cohort felt were applicable elsewhere. Students in the second cohort stated that they learned the importance of considering their audience in choosing the best way to conduct their presentation and instruct the adolescents during the activity portion of the presentation, from creating their physical presentation, to choosing their language, to selecting an appropriate hands-on activity for their audiences' age group. They specifically

highlighted the use of "PowerPoint" and "visual aid[s]" as tools that allowed them to reach their audience. The interviewee further described the successful use of visuals within her group's presentation as a means of keeping their audience engaged. Additionally, she relayed that her group used their own interests, along with those of their younger siblings, to choose an activity that the adolescents would find interesting and enjoyable. Through their experience with their adolescent audience on presentation day, students from both cohorts learned how to adapt and tailor their pre-prepared plans in response to the needs and interests of their audience to execute a successful presentation and make for an enjoyable, engaging experience for the adolescents.

Strategic Teamwork

One of the most important parts of preparing a successful presentation was students' ability to work well with the three to four other classmates that comprised their group. Students from the first cohort highlighted teamwork a key takeaway from their experience. Students in the second cohort cited teamwork as one of the major challenges that they had to work through to successfully execute their presentation. Through their struggles, students gained experience with using negotiation and group discussions in their quest to resolve their in-group issues for the greater good of preparing a quality project. It is important to note that the diverse array of skills that comes from working with a team was noted in the second cohort as something that worked well in preparing their projects. The success that comes from a proper balance of work among all team members, along with a team's willingness to assist in all areas and remain flexible, was described by the interviewee from the second cohort who reported that her team performed well. Despite the positive experiences some participants had with their groups, students in the second cohort tended to cite learning how to strategically work with their teammates to fulfill their task of implementing their service-learning project as the major challenge that they had to overcome during their experience.

Self-Concept

In reflecting on their service-learning participation, students were encouraged to think about their experience in the context of their future goals. Prior to their service-learning experience, students from the first cohort stated that bringing their ideas to life and solving problems were their primary reasons for specifically choosing to pursue engineering. After completing their presentation for the adolescents, all participants in the first cohort cited instances of engaging with these adolescents from their local community as the most enjoyable part of their experience, placing themselves in the broader context of their community. All three of the participants that responded to the Post-Presentation Survey in cohort 1 shared that they would be interested in participating in future service-learning opportunities.

The second cohort offered further insights into how they viewed themselves in the context of this project. Students in this cohort specifically mentioned that they walked away from their service-learning experience with a sense of duty to help encourage their adolescent audience to pursue higher education, noting the potential, eagerness, and drive to learn on part of their audience. Five of the seven students in this cohort expressed interest in participating in future service-learning opportunities.

This point was explored further through the eyes of the interviewee from the second cohort. This student shared the gratification she felt from her perceptions that some of the adolescents looked

up to her and that the possibility of pursuing a career in STEM was planted in their minds. This student further described her goals in engineering, noting that while building finished products and examining their inner workings enticed her to pursue engineering, she hopes to pursue teaching in STEM after completing her studies in engineering. Although this was a path she considered prior to her service-learning experience, the interviewee shared that her experience strengthened her desire to pursue a career as a STEM teacher, framing her goals in a broader context than engineering itself.

Students' responses regarding their service-learning experiences did not appear to differ based on gender; however, it is interesting to note that the existing gender gap was on some students' minds. During the second cohort's in-class discussion, some of the students depicted scenes of gender-based inequality. One student illustrated a bright future for men upon graduation, while post-graduate women were drawn to have a more difficult path ahead, complete with insecurity and a lack of encouragement. Another scene drawn by a student showed a group of young women receiving attention and aid during a classroom activity while a group of young men sat above them without such assistance. While the stories that students were attempting to tell through these images cannot be stated with certainty, it is evident that gender-based inequality was a topic relevant to how some students viewed themselves in relation to their community.

Discussion and Conclusion

An analysis of both cohorts of student responses demonstrates the efficacy of service-learning as a means of developing skills in effective communication, strategic teamwork capabilities, and a clear self-concept from the viewpoint of students.

Consistent with past research, learning how to communicate technical concepts to a non-technical audience in a way that they can understand was frequently acknowledged by both cohorts as a skill that they felt was applicable in other areas. That is, students' perceptions of their growth through their service-learning experience parallel the ABET Student Outcome of effective communication[6]. This suggests that students did achieve this specific learning objective of the activity.

Although prior research highlights teamwork as a benefit of service-learning experiences, our participants in the second cohort noted both pros and cons of working with a group. Students relayed that while the diverse perspectives of each member of their team were beneficial, working out in-group issues, resolving disagreements, and finding times to meet constituted the major challenges associated with preparing their project. However, in working through these team challenges, students were exposed to real-world working dynamics in which negotiations and compromise are essential to creating a successful deliverable. This finding supports that students achieved the ABET Student Outcome of gaining experience working in a team-based environment to fuel future professional success[6].

Perhaps the most surprising aspect of participants' responses was their reported self-concept. It is noteworthy that following their service-learning experiences, students identified as student peers of their adolescent audience, rather than future engineering professionals. They relayed a sense of duty to improve access to higher education and STEM-related fields for underprivileged adolescents. Participants examined their identities from a global perspective within the context of their local set of circumstances. That is, they identified that they felt a sense of duty to improve

the circumstances for those less fortunate in their community, but in the context of students helping students, rather than engineers improving the world around them as professional engineers. We can infer that this is likely due to their status as first-year engineering students who have yet to delve deeper into the world of engineering. While they may not yet have a clear self-concept regarding their future goals as professional engineers, their service-learning experience supports the achievement of the ABET Student Outcome of developing a sense of ethical responsibility through the early stages of their engineering education[6]. Furthermore, students' aligning of their experience with the larger goal of improving their community, which goes beyond their day-to-day goals as students and future professional engineers, illuminates the relevance of situative learning to engineering education[12].

Future Directions

It is important to note the limitations of this study. While the small sample size offered the chance for a deeper exploration of students' perspectives, it limited the possibilities of comparing and analyzing students' responses. With only eleven students participating in the administered surveys and only one student in an interview, the scope of the data obtained was too narrow to be generalized to engineering and computer science students. That being said, the insights shared by the participants are still highly valuable in shedding light on the benefits and efficacy of service-learning within engineering and computer science curricula.

Given that this study is a work-in-progress, further exploration in the years to come is both possible and necessary. While differences in students' responses based on gender were not seen in the data obtained from this study, such variations are a worthwhile exploration. Past research has pointed to service-learning as being a particularly impactful experience for women pursuing engineering[15]. Based on their anonymous drawings of how students perceive themselves in relation to their community, it appears that the existence of a gender gap is relevant to some students' experiences. Future research should focus on how the skills and personal growth that engineering students develop from participating in service-learning opportunities vary according to gender given the underrepresentation of women in engineering.

Acknowledgments

References

1. Duffy, J., Tsang, E., & Lord, S. (2000, June). *Service-Learning in Engineering: What, Why, and How?* ASEE Annual Conference and Exposition, St. Louis, MO.
2. Jacoby, B., & Assoc. (1996). *Service Learning in Higher Education* (p. 5). San Francisco, CA: Jossey-Bass.
3. Paquin, J. L., (2006). *How Service-Learning Can Enhance the Pedagogy and Culture of Engineering Programs at Institutions of Higher Education: A Review of the Literature* (Doctoral dissertation). Retrieved from http://digitalcommons.unomaha.edu/slcedt/19
4. Oakes, W., Duffy, J., Zoltowski, C.B., & Huff, J. (2014, July). Engineering Service-Learning: A Model for Preparing Students for Engineering Practice While Meeting Needs of the Underserved. *International Journal of Engineering Education, 27*, 46-57.
5. Tsang, E., Van Haneghan, J., Johnson, B., Newman, E.J., & Van Eck, S. (2000, Mar.). A Report on Service-Learning and Engineering Design: Service-Learning's Effect on Students Learning Engineering Design in 'Introduction to Mechanical Engineering.' *International Journal of Engineering Education, 17*, 30-39.
6. ABET. (2015, Oct. 16). *Criteria for Accrediting Engineering Programs, Baltimore, MD.: Engineering Accreditation Commission*. Retrieved from http://www.abet.org/wp-content/uploads/2015/10/E001-16-17-EAC-Criteria-10-20-15.pdf
7. Riley, L.A., Furth, P., & Zelmer, J. (2000). *Assessing Our Engineering Alumni: Determinants of Success in the Workplace*. ASEE/ Gulf-Southwest Section Annual Conference, Las Cruces, NM.
8. Ford, J. D., &Riley, L. A. (2003). Integrating Communication and Engineering Education: A Look at Curricula, Courses, and Support Systems. *Journal of Engineering Education*, *92,* 325–28. doi:10.1002/j.2168-9830.2003.tb00776.x
9. Shuman, L.J, Besterfield-Sacre, M., & McGourty, J. (2005). The ABET "Professional Skills" – Can They Be Taught? Can They Be Assessed? *Journal of Engineering Education, 94,* 41-55. doi: 10.1002/j.2168-9830.2005.tb00828.x
10. Lord, S.M. (1999, Nov.). *Service-Learning in Introduction to Engineering at the University of San Diego: First Lessons.* ASEE/IEEE Frontiers in Education Conference, San Juan, Puerto Rico.
11. Duffy, J., Barrington, L., Moeller, W., Barry, C., Kazmer, D., &West, C. (2008). Service-Learning Projects in Core Undergraduate Engineering Courses. *International Journal for Service Learning in Engineering*, *3*, 18-41.
12. Johri, A., & Olds, B. M. (2011). Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences. *Journal of Engineering Education*, *100*, 151–85. doi:10.1002/j.2168-9830.2011.tb00007.x
13. National Science Foundation. (2004-2014). [Table shows number of bachelor's degrees earned based on gender and major from 2004-2014, along with percent distribution for females]. *Women, Minorities, and Persons with Disabilities in Science and Engineering.* Retrieved from https://nsf.gov/statistics/2015/nsf15311/tables.cfm
14. Cheryan, S., Master, A., & Meltzoff, A.N. (2015). Cultural stereotypes as gatekeepers: increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology*, *6,* 1-8. doi: 10.3389/fpsyg.2015.00049
15. Matusovich, H.M., Oakes, W., & Zoltowski, C. B. (2013). Why Women Choose Service-Learning: Seeking and Finding Engineering-Related Experiences. *International Journal of Engineering Education*, *29*, 388-402.
16. Dubb, S., McKinley, S., & Howard, T. (2013). Leveraging Anchor Institutions to Benefit Community. In *The Anchor Dashboard: Aligning Institutional Practice to Meet Low-Income Community Needs*. Retrieved from http://democracycollaborative.org/content/anchor-dashboard-aligning-institutional-practice-meet-low-income-community-needs
17. Spradley, J. (1980). *Participant Observation*. New York: Holt, Rinehart and Winston. (Reissued Long Grove, IL: Waveland Press, 2016).
18. Next Generation Science Standards. (2013). *MS-PS3 Energy*. Retrieved from http://www.nextgenscience.org/dci-arrangement/ms-ps3-energy
19. Next Generation Science Standards. (2013). *MS-PS2 Motion and Stability: Forces and Interactions*. Retrieved from http://www.nextgenscience.org/dci-arrangement/ms-ps2-motion-and-stability-forces-and-interactions
20. Next Generation Science Standards. (2014). *MS-ETS1 Engineering Design*. Retrieved from http://www.nextgenscience.org/dci-arrangement/ms-ets1-engineering-design
21. Bernard, H.R. (2006). Interviewing: Unstructured and Semi-Structured. In *Research Methods in Anthropology: Qualitative and Quantitative Approaches* (4th ed.) (pp. 210-250). Lanham, MD: AltMira Press.