Board 308: Impact of Engineers Without Borders USA Experiences on Professional Preparation

Dr. William "Bill" C. Oakes, Purdue University, West Lafayette

William (Bill) Oakes is a 150th Anniversary Professor, the Director of the EPICS Program and one of the founding faculty members of the School of Engineering Education at Purdue University. He has held courtesy appointments in Mechanical, Environmental a

Paul A. Leidig P.E., Purdue University, West Lafayette

Paul A. Leidig works in learning and organizational development within the architecture, engineering, and construction industry. He received his B.S. in Architectural Engineering from the Milwaukee School of Engineering, M.S. in Civil Engineering from the University of Illinois at Urbana-Champaign, and Ph.D. in Engineering Education from Purdue University. Dr. Leidig is licensed as a Professional Engineer in the state of Colorado and has six years of structural engineering consulting experience. He has focused on community-engaged engineering and design for over fifteen years.

Dr. Eric Holloway, Purdue University, West Lafayette

Dr. Eric Holloway currently serves as the Sr. Director of Industry Research in the College of Engineering at Purdue, where he focuses on industry research in the College of Engineering. He also holds a courtesy faculty appointment in the School of Engineering Education and the School of Mechanical Engineering.

Impact of Engineers Without Borders USA Experiences on Transition to Practice and Professional Development

Abstract

Experiential education is becoming a more important part of engineering education. Experiences range from within the classroom to extra-curricular activities. Within experiential education, community engagement is particularly promising, given its alignment with diversity research and the leveraging of university resources to address needs within our society. One of the largest engineering engagement organizations is Engineers Without Borders USA (EWB-USA), which recently celebrated 20 years of student and community engagement. This poster presents the results of a sequential mixed-methods study consisting of surveys followed by interviews for each of the alumni of EWB-USA. Surveys were designed and the results show positive impact on alumni transition into a wide range of industry settings. Interviews have identified themes of impact. These include: becoming a connected part of a larger whole, portions of the volunteer experience that participants connect with particular learning outcomes, and more.

Introduction

In the 2018 MIT-sponsored report on the global state of the art in engineering education, Dr. Ruth Graham identified the international leaders in engineering education. [1]. A common theme amongst the leaders was active learning and in particular a move to more experiential education. Many leaders in our field are exploring how to integrate experiences that have been traditionally outside the curriculum with core academic learning outcomes. One form of experiential learning is community-engaged learning. In engineering, this often involves design experiences.

Community-engaged design partners students and universities or colleges with local or global community partners. These partners may be non-profits or non-governmental organizations (NGO's), schools, museums, or governmental agencies. Together they identify and address needs within the community, offering opportunities for students to learn through authentic experiences as well as impacting the community and broader society. Community-engaged learning offers a context to support the broad learning needed for the 21st-century engineer [2-7]. The pedagogy has shown benefits to student learning [8-11], motivation, and retention [12-14]. Additionally, evidence shows that community-engagement can improve diversity within engineering programs [2,15-16]. With these benefits and the possibilities for impacting engineering programs on a larger scale, more research into successful programs is needed.

This paper describes the early steps in analyzing data from an NSF-funded project being conducted in partnership with Engineers Without Borders USA (EWB-USA), the largest community-engaged engineering learning organization in the U.S., with 5,600 current student participants, over 40% of whom identify as female. A number of previous studies have reviewed aspects of the impact of EWB-USA involvement on its student members and argue that this experience helps them develop skills and attributes valuable for the engineer of 2020 and beyond, including: teamwork, leadership, effective communication, decision-making, project management, appreciation for other cultures, and increased awareness of the role of ethics in

engineering [2, 17,18]. A large mixed-methods NSF-funded study of students and professionals both with and without experience in EWB-USA found that "[e]ngineers involved with engineering service may gain strong professional engineering skills that do not compromise their technical skills" [19]. The authors indicate this may be attributable to the "realistic, complex, and contextualized learning experiences within engineering service activities."

The overall study will expand previous work and will investigate five research questions through gathering data from two different populations: alumni of EWB-USA undergraduate experiences and individuals who have interacted professionally with EWB-USA alumni. Alumni are defined in this context as people who participated in EWB-USA as an undergraduate, completed their undergraduate degree, and have professional work experience post-graduation. In each case, we will be taking a sequential mixed-methods approach consisting of surveys followed by interviews. The five research questions are:

(1) What professional competencies do alumni identify as most developed through their EWB-USA experiences as undergraduates?
(2) What is the nature of how undergraduate participation in EWB-USA may bridge the experiences of formal post-secondary engineering education and professional practice?
(3) How do variations in the nature of involvement with and/or the structure of EWB-USA programs impact the above elements?
(4) How are Alumni of EWB-USA perceived by other members of industry, relative to their peers?
(5) How do the above elements vary between female versus male students, among students of different races and ethnicities, and for first-generation college students?

This paper focuses on the preliminary analysis of the survey results of EWB-USA alums. The survey and its development were presented at the 2022 ASEE Annual Conference [20]. These data are the first step in the ongoing project.

Engineers Without Borders USA (EWB-USA)

Engineers Without Borders USA (EWB-USA) is the largest community-engaged engineering organization in the U.S., with 165 university/college student chapters along with 74 professional active EWB-USA chapters. Their stated mission is to build a better world through engineering projects that empower communities to meet their basic human needs. Their highly skilled volunteers work with communities to find appropriate solutions for their infrastructure needs. At its core, EWB-USA's model is rooted in practical and sustainable engineering solutions. To be successful, EWB-USA considers the socio-cultural dimensions of the community, local project ownership, and other requirements for long-term sustainability. EWB-USA programs are developed as full partnerships with a host community and one or more local non-governmental organizations (NGOs). EWB-USA members work alongside local community members to successfully build, maintain, and monitor each project.

The integration of engineering and addressing community needs is a factor that has drawn a more diverse population to EWB-USA, with over 40% of the 5,600 student participants being female, which is consistent with literature [21-23]. Litchfield and Javernick examined how EWB-USA serves as an example of multi-faceted retention of engineers, particularly females [17]. Since 2002, EWB-USA has worked in 52 countries around the world, 27 U.S. states and territories, and impacted more than 2.6 million lives through EWB-USA projects. Example projects are shown in Table 1.

Figure1: EWB-USA students in the field with community partners

Table 1: Example EWB-USA student chapter projects.

EWB-USA Gateway Professional Chapter partnered with EWB-USA Southern Illinois University Project Location: Pimienta, Honduras	Members of student and industry partnered to complete construction project that diverts water under a roadway though a culvert system and built a bridge over a ravine for both vehicles and pedestrians.
EWB-USA University of Pittsburgh Student Chapter Project Location: Makili, Mali	Students made three trips to the community to assess community needs before building the farm in planning and constructing a fish farm 2010. The farm has been a success, adding an additional source of protein to local diets, and has proved to be self-sustainable.
University of Maryland College Park Student Chapter Project Location: Addis Alem, Ethiopia	Students and community members worked together to build a bridge that allows community inhabitants to safely access the local market. UMCP students were mentored by industry professionals
Purdue University Student Chapter (Integrated with EPICS Program) Project Location: Colquechata, Bolivia	Students and community members are working collaboratively to design and construct a water system to deliver safe and reliable water to the homes in the community

Survey Methods

The survey is a retrospective design, allowing the exploration of possible associations and relationships with outcomes that have already occurred. The survey has 36 self-report items.

All questions throughout the survey targeted information from the individual respondent's perspective, rather than that of a whole EWB-USA chapter or project. This approach is intended to make the questions easier for participants to answer accurately, as they have greater knowledge of their own experience than that of a larger group [20].

The survey was developed using accepted frameworks within engineering and included ABET Criterion 3 [24], ASCE's *Civil Engineering Body of Knowledge* (CEBOK3) [25], NSPE's *Professional Engineering Body of Knowledge* (PEBOK) [26], and IEA's *Graduate Attributes and Professional Competences* (GAPC) [27]. The survey contained questions on the impact of the alums experience as undergraduates. 38 items were included with the same overall question, *To what extent has your EWB-USA experience as an undergraduate contributed to the following in your professional practice?*, and Likert scale (1-6) but with different statements focusing on different aspects of impact as related to the frameworks. The items drew mainly from ABET Criterion 3 and secondarily with CEBOK3 adding on the professional attitudes and professional responsibilities topic areas. For validation, a final pass was made to verify the inclusion of all appropriate professional competencies in the PEBOK and GAPC. The distribution of statements among the frameworks is illustrated in Table 2. Table 3 contains the actual impact statement and associated question number.

Table 2: Impact Data Statements Distribution

Primary Framework Element	Number of Statements
ABET Student Outcome 1	3
ABET Student Outcome 2	8
ABET Student Outcome 3	3
ABET Student Outcome 4	4
ABET Student Outcome 5	3
ABET Student Outcome 6	2
ABET Student Outcome 7	1
CEBOK3 Risk and Uncertainty	1
CEBOK3 Sustainability	1
CEBOK3 Critical Thinking and Problem Solving	2
CEBOK3 Professional Attitudes	3
CEBOK3 Professional Responsibilities	3
Career	3

Table 3: Impact Statements

Question Number	Framework	Impact Statement
Q16_1	ABET 1 (Complex Problems)	an ability to identify problems or formulate objectives clearly/precisely
Q16_2		an ability to apply knowledge from my undergraduate discipline to my work
Q16_3		an ability to apply knowledge from several disciplines or fields to solve a problem
Q16_4		an ability to design a system, component, or process from start-to-finish

Q16_5	ABET 2 (Design)	an appreciation for the important role of the customer / client / partner in design
Q16_6		an ability to take into account economic constraints in design
Q16_7		an ability to generate or prioritize criteria for evaluating the quality of a solution
Q16_8		an ability to recognize when changes to the original understanding of the problem may be necessary
Q16_9		an ability to use what you know about different cultures, social values, or political systems in developing engineering solutions
Q16_10		an ability to recognize that not all engineering problems have purely technical solutions
Q16_11		an interest in incorporating equity or social justice considerations into designs
Q17_1	ABET 3 (Communication)	an ability to effectively communicate with diverse audiences
Q17_2		an ability to ask questions to understand what a client / customer / partner really wants in a product / service / project
Q17_3		an ability to communicate effectively with people from different cultures or countries
Q17_4	ABET 4 (Ethics & Societal Impact)	an ability to recognize ethical issues in my work
Q17_5		an ability to apply appropriate reasoning or make informed judgments to resolve ethical issues in my work
Q17_6		an ability to recognize the active role engineering can play in society
Q17_7		an ability to understand the connections between technological solutions and their implications for the society or groups they are intended to benefit
Q17_8	ABET 5 (Teamwork and Leadership)	an ability to demonstrate leadership in a team environment
Q17_9		an ability to work in teams of people with a variety of skills or backgrounds
Q17_10		an ability to foster inclusion of diverse perspectives, cultural backgrounds, knowledge, or experience
Q18_1	ABET 6 (Experiments and Data)	an ability to develop or conduct appropriate experimentation
Q18_2		an ability to analyze or interpret data
Q18_3	ABET 7 (Lifelong Learning)	an ability to acquire new knowledge, skills, or attitudes in my work
Q18_5	CEBOK3 Risk and Uncertainty	an ability to apply concepts of risk, reliability, or uncertainty to design or decision making
Q18_6	CEBOK3 Sustainability	an ability to apply concepts and principles of sustainability to the solution of complex problems
Q18_7	CEBOK3 Critical Thinking and Problem Solving	an ability to stop and reflect about where I might be missing something or going wrong
Q18_8		an ability to know when my own biases are getting in the way of my understanding of a problem or finding a solution
Q19_1	CEBOK3 Professional Attitudes	the confidence that I have in my work
Q19_2		the practice of professional attitudes including creativity, curiosity, flexibility, or dependability
Q19_3		an ability to employ empathy in my professional practice
Q19_4	CEBOK3 Professional Responsibilities	the interest I have / had in becoming a licensed Professional Engineer
Q19_5		an ability to innovate a new idea, process, or device
Q19_6		an ability to understand the wide variety of relevant legal or regulatory responsibilities that pertain to a project
Q19_7	Career	being sought after or having an advantage when seeking employment
Q19_8		the general preparedness for the beginning of my professional practice

Q19_9		an ability to advance within my career

Results

In order to begin addressing RQ1 through the quantitative results, descriptive statistics were found for the impact data Likert scale question responses. These questions contained statements, as listed in Table 3, to which the participants indicated their response on the 6-point scale: 1) Not at All, 2) Small Extent, 3) Some Extent, 4) Moderate Extent, 5) Great Extent, and 6) Very Great Extent.

The descriptive statistics began by gathering means, standard deviations, and normality information for each statement across the full survey sample. The data was found to be not normally distributed. The average mean across all the items and participants was 4.26, corresponding to moderate extent on the response scale. Other results of note included particularly low responses to the questions about experimentation, data, legal or regulatory responsibilities, interest in becoming a licensed Professional Engineer, and applying knowledge from ones' undergraduate discipline to their work. On the other hand, the items with means above 5.0 addressed the appreciation for the important role of the customer, client, or partner in design.

Figure 1 shows the individual statement means plotted by gender. Overall, the responses from male and female participants were quite similar. The largest difference between these two groups was in response to the statement regarding their EWB-USA experience as an undergraduate impacting their interest in incorporating equity or social justice considerations into designs, with female participants rating this more highly.

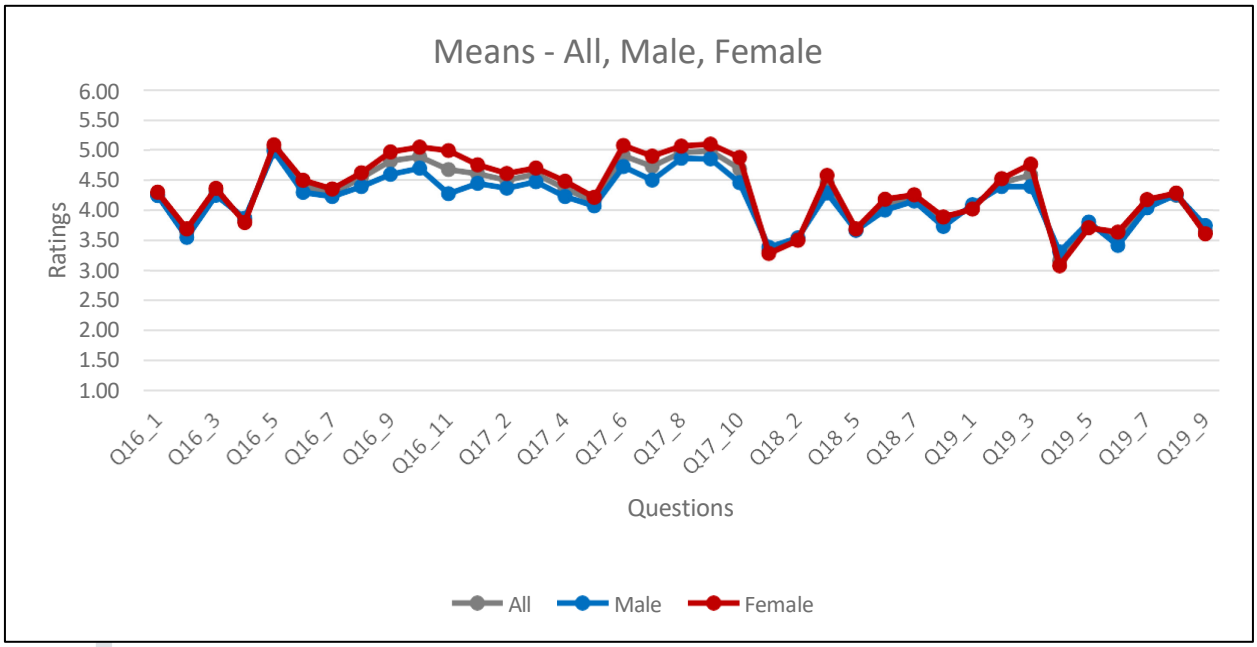

Figure 1. Impact Means Per Individual Statement

When the data is sorted by those who have traveled in Figure 2, differences arise. EWB-USA policies limit the travel teams to eight people and that often means their faculty advisor, the

responsible engineer in charge and six students. The students who have travelled and taken multiple trips show higher impact across multiple dimensions.

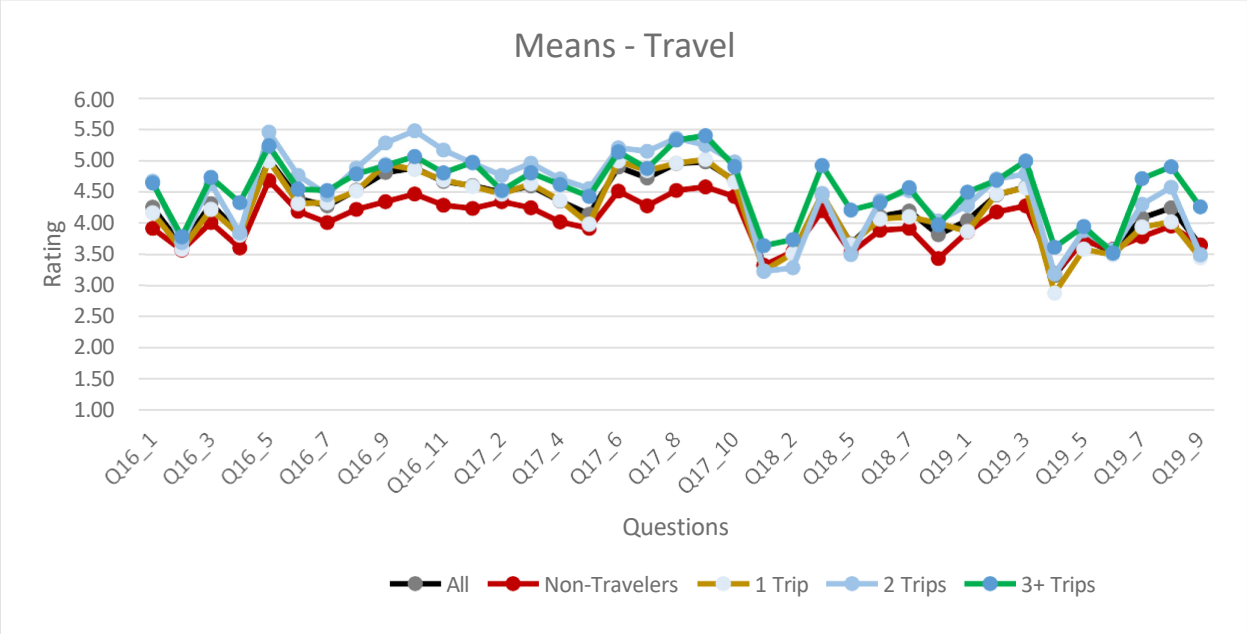

Figure 2. Impact Means by Travel Experience

132 out of the 268 respondents continued to be involved in EWB-USA after graduation as a professional. Those who continued to be involved as professionals showed a slightly higher responses for their perceived benefits from their undergraduate experiences in Figure 3. Since the survey is retrospective, it is unclear if their later experiences biased their recollection of the impact as undergraduates. The overall shape of the responses is very similar to those who did not continue.

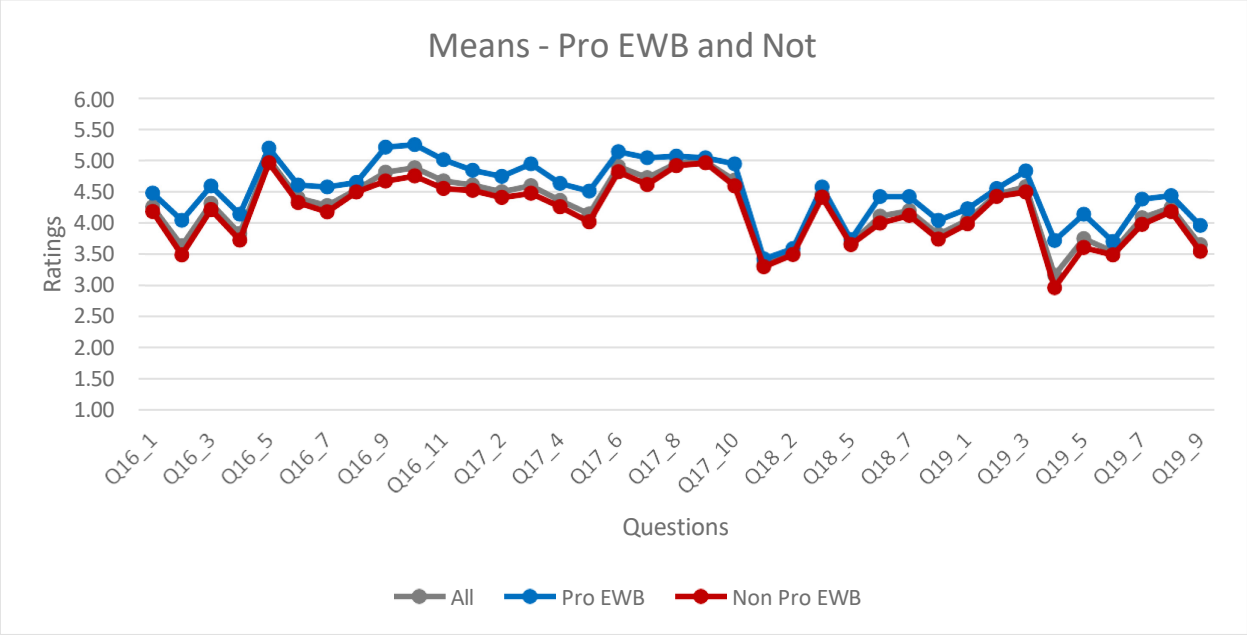

Figure 3. Impact Statements by Professional Engagement

EWB-USA has undergone significant changes over the 20 years of its existence. When the participants were sorted by graduation years, there was no significant differences. Figure 4 shows the comparisons for graduation before and after 2017. A similar comparison for the first ten years of the organization showed no differences either. The impact as reported by graduates retrospectively appears very stable and implies that the evaluation of graduates five years after entering the workplace would provide an accurate assessment of their experience.

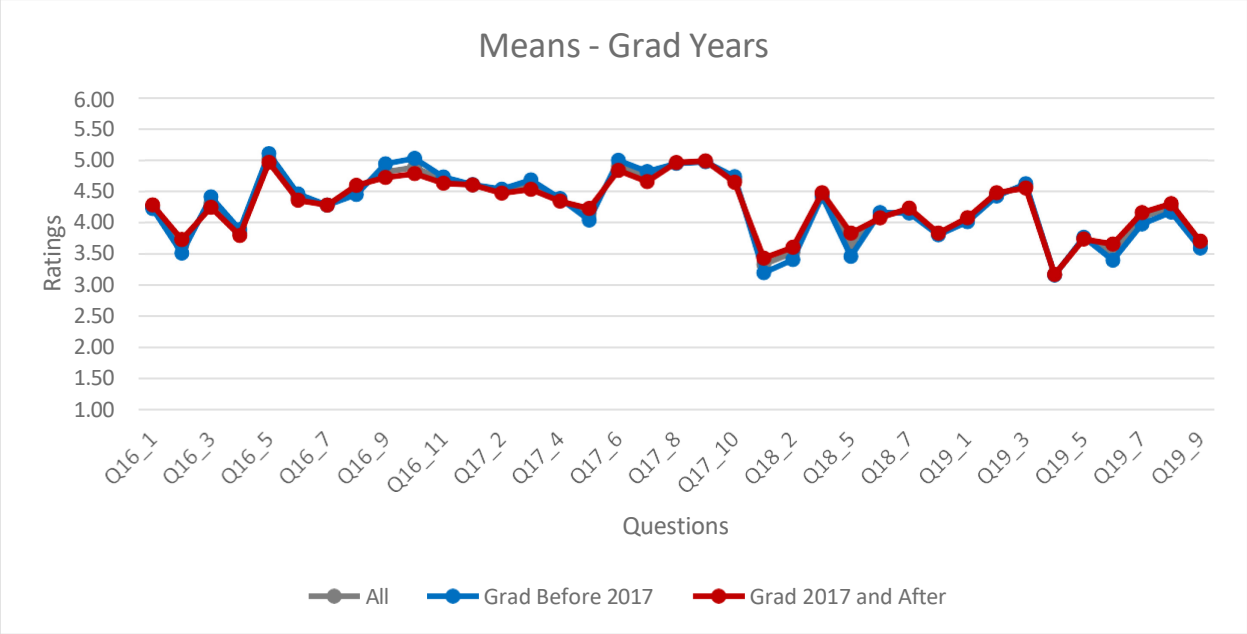

Figure 4. Impact Statements by Graduation Year

Open Ended Questions

The survey also included four open-ended questions to triangulate the survey results and help guiding the purposeful sampling for interviews for the qualitative portion of the study. The first question *How did your EWB-USA experience as an undergraduate help bridge between school and your professional practice*?" elicited responses that offered insights into what they found valuable. One talked about learning how to work with more senior professionals and getting an idea into an actual finished product.

> *My undergraduate experience with EWB USA helped prepare me for professional practice by giving me early opportunities to work with experienced mentors and PE's on real-world projects. When starting my professional practice I understood how to work with more senior engineers, the steps required to move a concept to an approved design and how to identify the limits of my own skills. EWB USA also helped me understand the importance of my clients.*

EWB-USA has nearly a gender-balanced participation rate and one aspect that showed up in the data was how the confidence developed in EWB-USA helped transition into practice where the ratios are much different by gender.

Almost 10 years after completing my undergraduate degree I still remember more lessons learned from EWB than from the classroom. EWB made me feel prepared to enter engineering as a professional. I had a lot of confidence in my adaptability, which as a woman in engineering I feel this was critical to my success in a professional engineering setting (I was hired into a group of about 15-20 as the only woman).

A second question probed specific activities and experiences by asking *Which specific activities, processes, interactions, etc. from your EWB-USA experience as an undergraduate most supported the bridging described in the previous question?* One theme that emerged was leadership and working as a team as illustrated by this quote:

I was a team lead for our distribution piping and storage system, so I had to work with the community to develop a route that avoided farmland, burial sites, roadways and buildings while also working with the groups in charge of designing the solar array for our pump and the chlorination system to ensure that all of the pieces of the design fit together. Working as a team lead not only did I get to design certain aspects but I also got to discuss/learn about/make decisions on all aspects of the project. In a class room you might learn about individual pieces of the design but not the process of how each stage fits together and how to communicate with all stakeholders to get results.

Participants also discuss experiences that they carried with them and applied to their later practice as engineering, although the contexts changed from their EWB projects. An example of this type of response is:

The main activity I learned was that changes in the field should always be evaluated prior to moving forward with implementation. During our EWB-USA implementation project, there was a strong desire to re-route a pipe being laid; however, that would have diminished the hydraulic head available. We had to stop and reevaluate to find a new path. That experience has stuck with me ten plus years later, that some field changes are okay and others need to be evaluated in more detail.

Beyond professional preparation, participants also wrote about cultural and societal development in their EWB experiences through the activities of the organization. One example of this is:

One other thing that helped with this was initiating what we called "Cultural competency presentations" that defined things like white saviorism and voluntourism and opened up to discussion difficult questions about our projects. Talking through with our chapter things like "why should we exist as an EWB chapter?", "are we effectively meeting our mission?", and "what are some potential negative socio-political impacts of our projects" really helped to shape my opinions on the organization, our work as a part of it, our community partners, and about development projects in general. I continue to reflect on these things to this day.

The third question was *In what ways has your EWB-USA experience as an undergraduate influenced you personally and/or professionally?*. The responses included valuable experiences that impacted how they do their work and well as situating engineering within the broader context of benefitting others.

It has helped, and influenced how I approach problems, especially with an eye toward who is requesting a project, who will benefit, and who will keep it going. The approach I

take when assessing a new project and the depth and breadth of information I seek. the importance of stakeholder engagement to make a project successful. My flexibility and ability to adjust as circumstances dictate. Because of EWB I see my work, and all engineering work, as service work where I have the trust of the project partners, the responsibility to listen to their needs, and the ability to help them realize their goals.

The experiences exposed participants to new people and ideas that have carried over after graduation.

EWB has been one of if not the single most influential experience of my adult life. I changed majors from Mechanical to Civil engineering because I felt it would be more applicable to EWB type projects once I graduated. It has influenced my area of specialization (water/wastewater). It shaped the network of people and professionals that I came to know and later got jobs from. It exposed me to worldviews and concepts and philosophies that have impacted the type of person I am today. EWB has taught me about my weaknesses, my strengths, and taught me to see to what strengths others possess that I lack. It has forced me to grow and become a better engineer than I would have been without it.

The impact of the experiences influenced future professional activities and personal views of service and charity.

too many to fully list ... My experience with EWB has become a pillar in my personal morals and ethics. It was instrumental in evolving my religious views. It helped me refine what effective charity is and what ineffective charity is. Professionally - it gave me experience early on in my undergraduate working on projects through the entire engineering life cycle which enabled me to have a systems perspective and quickly become a project lead. I can confidently say I would not be the person I am today without EWB.

In some cases, the experience impacted career trajectories and choices. In one case the participant wrote about career and even choosing where to live based on the insights gained from the experiences.

My experience with EWB-USA helped me to gain a heightened appreciation for inequity in the world both in terms of socioeconomic advantage, but also in terms of the distribution of engineering services in the Global South. This has inspired me to transition my lifestyle in service of developing communities. I've moved neighborhoods to live closer to people in need. I've switched careers to have more direct impact on energy poverty and lack of access to electricity in the Global South. I've enrolled in graduate school programs to better understand engineering in global context. I've started two engineering firms focused on environmental non-profits, renewable energy, and social justice.

Conclusions

The impact of EWB-USA on graduates is significant and spans many dimensions associated with the practice of engineering. Graduates associate gains in the broader professional skills needed for engineering rather than the technical skills. While the EWB-USA organization and student

experiences have evolved significantly over the years, the reported gains follow a very similar pattern. There were not large differences among participants by gender or whether they continued as EWB volunteers after graduation. The travel experiences did show differences which will be explored in the later interviews that are part of the larger study. The populations and differences in groups will be further explored by developing impact factors and comparison populations. Those results will be reported in future publications.

The quantitative and open-ended responses show lasting impact of their EWB-USA experiences. The impacts were reported on professional preparation, mostly in the professional skills. They also included career and personal impacts beyond traditional engineering. The diversity of EWB-USA by gender has the potential to create a sense of community among female students within male dominated disciplines. These findings and others will be explored in the subsequent analyses of the larger project.

NSF Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. 2121450. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

1. R. Graham, The global state of the art in engineering education. *Massachusetts Institute of Technology (MIT) Report, Massachusetts, USA, 2018*.
2. B. Jaeger, & E. LaRochelle, E.. EWB – "Engineers Without Borders: Educationally, a world of benefits" . 2009 *American Society for Engineering Education (ASEE) Annual Conference Proceedings*, Paper AC 2009-740, Austin, TX, 2009.
3. E. J. Coyle, L.H., Jamieson, W. C., Oakes, "EPICS: Engineering Projects in Community Service", *International Journal of Engineering Education* Vol 21, No. 1, Feb. 2005, pp. 139-150.
4. J. L. Huff, C. B. Zoltowski, and W. C. Oakes, "Preparing Engineers for the Workplace through Service Learning: Perceptions of EPICS Alumni", ", *Journal of Engineering Education*, Vol. 105, No. 1, January 2015, pp. 43-69
5. A. R. Bielefeldt, K. Paterson, C. Swan Measuring the value added from service learning in project-based engineering education. *International Journal of Engineering Education*, *26*(3), 2010, pp. 535-546.
6. O. Pierrakos, R. Nagel, E. Pappas, J. Nagel, T. Moran, E. Barrella, E., et al. . A mixedmethods study of cognitive and affective learning during a sophomore design problembased service learning experience. International Journal for Service Learning in Engineering, Special Edition(Fall), 2013, pp. 1-28.
7. K. Litchfield, A. Javernick-Will, and A. Maul. "Technical and professional skills of engineers involved and not involved in engineering service." *Journal of Engineering Education* 105.1, 2016, pp. 70-9
8. J. Eyler, "Reflection: Linking Service and Learning—Linking Students and Communities", Journal of Social Issues, Vol. 58 Issue 3, 2000, Pages 517 – 534

9. D. E. Giles, & J. Eyler, The impact of a college community service laboratory on students' personal, social, and cognitive outcomes. *Journal of Adolescence*, *17*, 1994, pp. 327–339.
10. Eyler, J., & Giles, D.E. *Where's the learning in service-learning?* San Francisco: Jossey-Bass, 1999.
11. A. W. Astin, L. J. Sax & J. Avalos, J. Long-term effects of volunteerism during the undergraduate years. *Review of Higher Education*, *22*(2), 1999, pp. 187–202.
12. W. Oakes, James Huff, Carla B. Zoltowski, and Devendra Canchi. "Impact of the EPICS model for community-engaged learning and design education." *The International journal of engineering education* 34, no. 2, 2018, pp. 734-745
13. L. Piket-May, and J. Avery, Service-learning First Year Design Retention Results, *ASEE/IEEE Frontiers in Education Conference*. October 10-13, 2001, Reno, NV.
14. B. Ropers-huilman., Carwile, L., and Lima, M. "Service-learning in engineering: a valuable pedagogy for meeting learning objectives", *European Journal of Engineering Education,* Vol. 30, No. 2, pages 155 - 165
15. H.M. Matusovich, W. Oakes, C. B. Zoltowski, Why women choose service-learning: Seeking and finding engineering-related experiences. International Journal of Engineering Education, Vol. 29, No. 2, 2013, pp. 388-402.
16. W. C. Oakes, M. C. Hsu, C. B., Zoltowski, Insights From A First-Year Learning Community To Achieve Gender Balance, *Proceedings of the 2015 Frontiers in Education Conference*, El Paso, Texas, October 2015.
17. K. Litchfield, & A. Javernick-Will, Investigating Gains from EWB-USA Involvement. *Journal of Professional Issues in Engineering Education and Practice*, *140*(1), 4013008, 2014.
18. S. Savage and D. Knight, *An ethnographic investigation into the development of engineers without borders USA students during the monitoring and maintenance of a potable water system in Peru*. IEEE Frontiers in Education Conference (FIE). http://dx.doi.org/10.1109/FIE.2018.8658676, 2018.
19. Litchfield, K., Javernick-Will, A., & Maul, A. (2016). Technical and Professional Skills of Engineers Involved and Not Involved in Engineering Service. *Journal of Engineering Education*, *105*(1), 70-92
20. P. Leidig,., William C, Oakes, , "Designing the Engineers Without Borders USA Professional Preparation Study Surveys" *Proceedings of the 2022 ASEE Annual Conference*, Milwaukee, Wisconsin, USA, June 2022
21. S.V. Rosser, *Female-friendly science*. Pergamon Press. Rosser, S. V. (1995). *Teaching the majority: Breaking the gender barrier in science, mathematics, and engineering.* Teachers College Press, 1990.
22. E. Seymour & N. Hewitt *Talking about leaving: Why undergraduates leave the sciences*. Westview Press, 1997.
23. E. Seymour, & A. Hunter (Eds.), *Talking about leaving revisited: Persistence, relocation, and loss in undergraduate STEM education*. Springer International Publishing. https://doi.org/10.1007/978-3-030-25304-2 2019.
24. ABET, *Criteria for accrediting engineering programs,* 2019. https://www.abet.org/wp-content/uploads/2020/09/EAC-Criteria-2020-2021.pdf
25. Civil Engineering Body of Knowledge 3 Task Committee, *Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer (Third Edition)*. American Society of Civil Engineers, 2019. https://doi.org/10.1061/9780784415221

26. Licensure and Qualifications for Practice Committee, *Professional Engineering Body of Knowledge*. National Society of Professional Engineers, 2013.
27. IEA, *Graduate Attributes and Professional Competences (Version 4)*. International Engineering Alliance, 2021. http://www.ieagreements.org