ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #45012

Lessons Learned: Looking Back at Ten Years of Student Engagement in Malawi through Engineers Without Borders

Miss Charlotte Gottilla, University of Delaware

Charlotte Gottilla is a junior undergraduate student in the Department of Chemical and Biomolecular Engineering at the University of Delaware with minors in Mathematics and Computer Science. She is a current Project Manager and the incoming President for Engineers Without Borders at the University of Delaware and has led two student trips to Malawi, overseeing the implementation of two borehole wells. Her work with Engineers Without Borders has fostered an interest in humanitarian engineering for international development, particularly related to energy access and sustainability, which she hopes to further pursue after graduation.

Lessons Learned: Looking Back at Ten Years of Student Engagement in Malawi through Engineers Without Borders

Abstract

The Engineers Without Borders (EWB) program at the University of Delaware (UD) has supported a water access project in Malawi since 2014, assessing, constructing, monitoring, and repairing borehole well projects in four communities. UD's EWB chapter, a student-run, faculty-advised organization with professional engineer mentors and nonprofit partnerships, has completed projects in Guatemala, Cameroon, the Philippines, and Bolivia. As the chapter's longest-running project, the ongoing program in Malawi offers a case study of a student-led engineering project that has endured for ten years, impacting the quality of life of over 7000 community members in Malawi and the professional development of dozens of undergraduate students. In this paper, the author outlines the model used at UD and highlights key factors in the program's success in facilitating student learning and producing community benefits for partners in Malawi. The paper examines the impact of project ownership and accountability, effective onboarding, and annual travel on student engagement and learning. Additionally, an emphasis on sustainability, a strong relationship with in-country partners, and the development of technical understanding among students are key to the longevity of this program and the success of implemented projects. The author also presents the impact of EWB work in Malawi on graduates and identifies durable skills developed as students working on this project. This paper will provide insight to the engineering education community in the areas of student engagement, professional development, and project-based learning for both international and domestic service learning projects.

Introduction

Organization background

The University of Delaware Chapter of Engineers Without Borders (EWB-UD) was founded in 2006 by Dr. Steven Dentel, a professor in the Department of Civil and Environmental Engineering, as a student chapter of Engineers Without Borders USA (EWB-USA). Since its founding, the program has expanded to include approximately 60 students per year, with one or two international student trips running annually.

The group functions as a registered student organization within the university, with students involved on a voluntary basis. However, international travel aspects of the organization are coordinated separately through the College of Engineering. The chapter runs one or two international projects at a time, with past work having been completed in Cameroon, Guatemala, the Philippines, and Bolivia, along with local service projects and a research team. The student group is governed by an executive board, which includes two to four project managers (PMs) from each international team and a research project. The chapter is advised by two faculty members and one graduate student, who oversee technical decisions, provide project management support, and coordinate group finances for international travel and construction

expenses. International projects are also advised by technical mentors in industry who approve construction plans and accompany students during travel.

Project overview

The chapter's work in Malawi has been active since 2014, with six borehole wells drilled in four rural communities in the Sakata region outside Zomba. There are also plans to partner with two additional communities over the next five years. EWB-UD's work is coordinated through a local non-governmental organization (NGO), Villages in Partnership (VIP), with technical support provided by a group of four hydrogeologist professional mentors. Students run implementation trips in Malawi every other year, with trips during non-implementation years focused on monitoring previously drilled wells and assessing potential sites for future wells. A team of roughly six students and one professional mentor travels to Malawi for two to three weeks each August. Project work is coordinated during the academic year through weekly general body, executive board, and PM meetings along with as-needed conferences with VIP and the professional mentor team. Weekly student meetings continue through the summer and during the university's five-week winter session. As EWB-UD's longest-running project, and the only project to operate both pre- and post-pandemic, this work in Malawi offers a case study of a sustainable, student-run project-based learning program. The group structure encourages student ownership of the project and incorporates a large leadership team. These organizational aspects, along with annual student travel, foster increased student engagement. Additionally, students adhere to best practices for international engineering projects by focusing on maintenance and sustainability and growing a strong relationship with in-country partners. Finally, while borehole drilling and geology are often outside the scope of students' coursework, project members develop a technical understanding of their work in order to improve construction outcomes.

Key features of project success

Student ownership of the project

Students engage with the organization on a voluntary basis, receiving no academic credit for involvement, and the group does not have strict attendance requirements. As a result, EWB-UD attracts students who are intrinsically motivated to work on their projects, which is favorable for student learning [1] along with being critical to developing a sense of ownership [2]. Because students are involved due to their own interest in the project and pride in the work being completed, their intrinsic motivation is key to situating student leaders rather than faculty advisors as the project owners [3]. Over the course of their involvement, PMs volunteer time and effort outside the commitments typically demanded by student organizations at the university, reflecting the indication that increased ownership of the project improves student investment [3].

PMs have a large amount of autonomy in their work, with students responsible for their projects from inception through completion. Students identify partner communities in conjunction with VIP, evaluate contractors and negotiate drilling prices, draft construction plans and choose well locations, and monitor wells post-construction. Through this process, students' confidence in their ability to make project decisions increases [1]. When students feel qualified to guide their own work and make choices about the project's future, these feelings support their sense of project ownership [3]. Increasing students' competence in making these choices safeguards the future of the project by developing leaders who make strategic decisions [2].

Accountability

Due to the role played in guiding their projects, students are responsible for project outcomes and the satisfaction of multiple stakeholders. Students must meet report deadlines for EWB-USA, maintain communication with in-country partners and professional mentors, fundraise for project expenses, coordinate timely financial transfers to contractors, and produce construction plans for functional wells, with real-world consequences when those objectives are or are not achieved. Students must therefore take the initiative to ensure project success, building higher-order thinking skills and encouraging the development and sharing of knowledge [4].

Large student leadership team with effective onboarding

EWB-UD's student leadership is separated into executive board members, who oversee chapter obligations, and PMs, who manage project-specific tasks. Executive board members are elected by the entire organization membership each fall, and new PMs are chosen by the current PM group following an application and interview process; they will hold their positions until graduation. While PMs require board approval for major decisions or expenditures, projects are otherwise self-governed by PMs responsible for communication, planning, and project-specific fundraising. Similarly, while PMs attend executive board meetings and participate in board votes, tasks such as general fundraising campaigns, recruitment, and social events are delegated to executive board chairs. This system improves role clarity for both executive board members and PMs, avoiding dissatisfaction with one's role or conflict between leadership team members [5].

A beneficial side effect of the delegation system is the creation of a large leadership team with nine executive board positions in addition to several PM positions per project. This creates leadership roles for more students in EWB-UD, as students in leadership positions exhibit increased interest and engagement [6]. Additionally, the system fosters opportunities to train underclassmen through increasing levels of delegated responsibility, creating future EWB-UD presidents and PMs.

Mentorship

The Malawi project benefits from having a large number of PMs, as many as five at a time, in order to allow the mentorship of incoming students before they assume full PM responsibility. Students are made PMs as underclassmen, ideally as first-year students, and hold increasing responsibility as they gain experience and travel to Malawi. During this period, they shadow and are mentored by senior members, avoiding competition for authority within a large project management team [4]. Furthermore, newcomers are integrated into the social fabric of EWB-UD and introduced to in-country partners while gaining knowledge and being onboarded into project-related tasks. During this process, experienced PMs provide social and task-related support and answer questions related to the project or EWB-UD at large, helping newcomers become confident in their roles and comfortable in the organization [5].

Continuity

An unavoidable issue in any university organization is that students graduate after four years, causing frequent leadership turnover and introducing continuity issues [7]. Frequent turnover makes the effective handover of knowledge and authority critical to the ongoing success of EWB-UD. When choosing new PMs, consideration is given to the graduation years of applicants and current students in order to allow a sufficient onboarding period; generally, it is ideal for a new PM to have one year of experience, including travel to Malawi, before assuming full responsibility. Succession planning cultivates confident, qualified replacements for graduating PMs and makes project teams better able to transition between leaders [8]. EWB-UD projects in Malawi are also designed to last a minimum of five years, as a plan spanning longer than any individual student will be involved necessitates the handover of knowledge and mentorship of new students.

Yearly international travel

Study abroad is widely appreciated as a driver of individual growth among students and a developer of global mindset [9]. Though not officially a study abroad program, the EWB-UD Malawi team travels for two to three weeks each August, with all PMs and several general body members traveling together. Travel is free to student members and provides a source of intrinsic motivation for students to become more engaged with project objectives and Malawian culture [9]. This aspect makes EWB-UD unique among student organizations at the university, with opportunities for international travel providing an additional incentive for student engagement [7]. The benefit of the students' international travel is maximized as travel team members continue to engage with the project upon trip completion [9]. Travel team members are more invested in the project after seeing the impact of their work, with this increased engagement reinforcing what they learned during travel.

Students on the travel team adopt the additional responsibility of planning their trip over the preceding summer, with PMs coordinating flights, vaccinations, visas, lodging, and in-country transportation along with a detailed work schedule to maximize time in Malawi. Regardless of

whether a faculty member travels with the students, PMs are responsible for leading the travel team and resolving in-country issues. Students experience the benefits of international travel, including an expanded worldview and increased cultural awareness [10]. Students also learn specific skills useful for international engineering work, such as overcoming language barriers with contractors, navigating different construction and safety standards, and applying low-resource, user-centered design principles.

Travel to Malawi allows students to perform field work and, during implementation trips, participate in the construction of their projects. Students take and test water samples, conduct geological surveys, oversee borehole drilling, and assist in the construction of the concrete well pad. This is a valuable opportunity for hands-on experience, which improves technical understanding, adaptability, teamwork, and communication [11]. Furthermore, seeing their projects implemented is a key motivator for student engagement with EWB, as students see the real-life benefits of work done during the academic year [12].

Commitment to project outcome

For EWB-UD projects in Malawi, proactive steps to ensure functioning wells are vital, as it is estimated that 40-50% of borehole wells in Sub-Saharan Africa are not functional [4]. One point of potential failure for borehole wells is an improperly drilled borehole, which may never produce a sufficient yield rate or may fail during the dry season [13]. The geography in Zomba is challenging for drilling, especially when villages are located at the foot of the many large hills in the area [19]. As EWB-UD students have experienced, holes drilled too close to a hill may be dry for dozens of meters and must ultimately be abandoned. To improve the outcome of drilling attempts, EWB-UD students utilize electrical resistivity data to select hydrogeologically viable borehole sites within a target area selected by the community, which are then confirmed during transect walks [19]. Finally, weather conditions in Malawi necessitate drilling during the dry season, when the ground is firm enough to transport the heavy drilling rig to remote sites. This schedule follows best practices for borehole drilling in Sub-Saharan Africa, as wells drilled in the wet season are more likely to fail [13].

Once a viable borehole is drilled, the most common reason for failure is problems with the handpump [4]. EWB-UD implements wells with Afridev pumps, which is a standard practice across Sub-Saharan Africa [14]. Students have explored the possibility of implementing solar-powered well pumps, but chose to continue using Afridev pumps because they can be locally manufactured and maintained [15]. EWB-UD students sponsor maintenance training through VIP, the partner NGO, to train community members, with village water committees responsible for supervising maintenance. This structure improves outcomes by empowering community leaders to have responsibility for the maintenance of their water sources rather than outside organizations [19]. Water committees collect a monthly fee from each family that uses the well, with this money going to stockpile spare parts or pay for a retained area mechanic.

Proactively collecting fees for well maintenance, even when pumps are functioning properly, improves maintenance outcomes as compared to a collection approach that occurs only when replacements or repairs are needed [20].

Engagement with student concerns over sustainability

EWB-UD has seen positive responses from students as a result of the group's focus on project sustainability. Students engaged with Engineers Without Borders highlight the differences between their work and "voluntourism" as a factor in choosing to remain with EWB [12]. Student desire to see their projects continue to serve community needs into the future is also a factor in the organization's sustainability practices, with travel teams returning to monitor previously drilled wells and visit long-standing partner communities on each subsequent trip to Malawi. This informal monitoring goes beyond the requirements of EWB-USA and reflects the idea that sustainability is an ongoing state of the project and not an objective to be achieved once and forgotten [15]. The four Malawian communities where EWB-UD has drilled borehole wells have a combined population of approximately 7,100, meaning that the continued functionality of these projects impacts hundreds of households.

Strong relationship to in-country partner NGO

Over the past ten years, EWB-UD has built a strong relationship with VIP, our partner NGO. One valuable result is the increased capacity for remote work, which improves the efficiency of student time in-country and adds flexibility to implementation timelines. Remote work was first explored by necessity during the COVID-19 pandemic when students organized the inspection and rehabilitation of 14 wells across two communities. Since this initial experience working remotely, students have worked with VIP to carry out remote sanitation surveys, camera borehole inspections, and pump tests to determine well yield. Remote work requires a higher level of communication and the students must have clear coordination of responsibilities, financial transfers, and technical objectives [16].

Additionally, a strong EWB-UD VIP partnership improves the quality and frequency of communication between parties. Students communicate with VIP on a semi-weekly basis through WhatsApp, emails, and Zoom calls, creating opportunities for input from in-country partners into every aspect of the project and encouraging students to think of the Malawi project as a joint enterprise [15]. Travel to Malawi improves communication between travel team members and in-country partners after personal relationships are formed during trips and maintained upon the traveling students' return to campus. As this partnership has grown over the past ten years, EWB-UD and VIP have developed vital aspects of a successful NGO-university partnership, including (1) shared objectives, (2) clearly delegated roles, (3) honest and frequent communication, and (4) material benefits for both parties [17].

Through VIP, EWB-UD students receive input from community stakeholders, replicating the customer relationship of a professional engineering project [18]. As students iterate through technical plans, design decisions are shaped by VIP's input so that EWB-UD projects may fit within the community's needs, cognizant of the framework of existing practices and technology [15]. Furthermore, VIP works year-round in EWB-UD's partner communities and supports a range of educational, economic, medical, and social initiatives. EWB-UD students, as outsiders, must gain the trust of community leaders before a productive project may begin; association with VIP is critical to this end [17]. Working through a local partner with deep community connections helps establish user ownership of the well, encouraging the village to invest in maintenance [19].

Development of technical understanding among students

Technical understanding among EWB-UD students is crucial due to the necessity of making in-country decisions quickly, and sometimes with incomplete information. Literature [13] reports that approximately half of boreholes drilled in rural Africa have dry holes, which is consistent with the experience of EWB-UD drilling attempts. When a drilling attempt is unsuccessful, the travel team must quickly select new potential sites, analyze new resistivity data, and decide how to proceed for a second attempt. Due to differing time zones and the constrained in-country travel schedule, students have limited opportunities to conference with US-based professional mentors; therefore, the travel team must be prepared to make decisions independently. As teams travel with at least one professional mentor, this decision is still guided by a technical expert, but students must have basic knowledge of the hydrogeological principles and conditions that influence their decisions.

EWB-UD students also develop an understanding of water quality and testing methods as part of monitoring and evaluation programs for previously drilled wells. Students perform field tests for *E. coli*., pH, alkalinity, conductivity, nitrate/nitrite, and chlorine using test strips or portable testing kits. These tests address potential water quality issues, such as bacterial contaminations and signs of fertilizer or human waste entering the water supply, that are possible in rural Malawi [20]. Students draft hand-written water quality reports for village chiefs, allowing communities to receive results within a few days and requiring students to analyze test results quickly and potentially without internet access. For this to occur, students must be familiar with the water testing process and learn to interpret test results, then apply these skills in-country.

Finally, student technical knowledge enables the travel team members to advocate for design choices with in-country contractors and participate fully in the construction process. Travel teams experience problems including price changes, schedule conflicts, and construction setbacks and must navigate work-related disagreements with contractors. In doing so, students must find solutions that compromise neither the team's intended construction plans nor the contractor partnership, a vital skill in any professional engineering project [21]. EWB-UD's

professional mentors help develop this skill in students through their own participation in conversations with contractors, with such real-world skill-building being a key benefit of industry mentorship for engineering students [22].

Impact on participants

To assess the impact of this project on participants, a voluntary survey was sent to ten previous students as well as presented at meetings of the general body membership and the chapter's executive board. Responses from nine current students, including two PMs for the Malawi project, show that communication and teamwork skills, networking opportunities, and exposure to a real-life engineering project are valued benefits of EWB-UD membership. Students highlighted specific communication skills, including technical writing for a non-scientific audience and cross-cultural communication, as takeaways from their EWB-UD involvement. One PM responded that he learned how to teach himself the technical skills needed for the Malawi project, such as AutoCAD and QGIS, reflecting the benefits of student ownership and accountability [4]. Two alumni Malawi PMs also responded to the survey and highlighted skills that carried over from EWB-UD to their careers, including interpersonal communication, technical writing, and flexibility. These are examples of durable skills, which apply across a broad range of industries and job titles and will last through a student's lifelong career [23]. A unique skill taught to EWB-UD PMs is financial management, as students balance an annual project budget, coordinate international financial transfers, and track in-country payments to translators, contractors, and drivers. These financial skills, outside the scope of a typical engineering curriculum, have diverse applications in students' personal and professional lives.

In addition to the durable skills they gained, students who traveled to Malawi reported an additional impact of EWB-UD on their career plans. Both current and previous students described their involvement as a catalyst for interest in service-oriented careers, with alumni of the program pursuing the Peace Corps, global engineering graduate programs, and employment related to water access.

Recommendations

The literature and survey results support the finding that student project ownership, an effective leadership structure, and international travel contribute to meaningful student learning. In addition, there are elements of the project that have created unique experiences for engineering students. EWB-UD members consider the sustainability of their projects, build international partnerships, and develop a technical understanding of a project outside the scope of their undergraduate degree programs. Student feedback shows that international travel, cross-cultural exposure, and communication skills are valued outcomes of involvement with the Malawi project. Elements of EWB-UD's ten-year engagement with Malawian communities that are supported by the literature as important to sustaining a healthy student organization for the long term include intrinsically motivated members, effective onboarding, and strong NGO

partnerships. Student turnover every four years remains a challenge, but a strong institutional knowledge-sharing system lowers the barrier for incoming members to learn new skills and preserves lessons learned by previous classes. Through the application of proven project-based learning principles, EWB-UD and similar international service-learning organizations can provide meaningful benefits for both engineering students and community partners.

Acknowledgements
The author thanks Professor Jennie Saxe for her advice in conceptualizing and executing this paper. Special thanks are also extended to Villages in Partnership for their support of EWB-UD, without which the chapter's work would not be possible.

References
[1] K. Trenshaw, R. Revelo, K. Earl, G. Herman, "Using self determination theory principles to promote engineering students' intrinsic motivation to learn," *International Journal of Engineering Education,* vol. 32, no. 3(A), pp. 1194-1207, 2016.

[2] A. Schüler-Meyer, M. Hendrickx, C. Verhoosel, "The intended and unintended impacts on student ownership when realizing CBL in mechanical engineering," *European Journal of Engineering Education,* vol. 48, pp. 340-357, 2023.

[3] D. Dounas-Frazer, L. Ríos, H. J. Lewandowski, "Preliminary model for student ownership of projects" in *Proceedings of the Physics Education Research Conference (PERC), Provo, Utah, USA, July 24-25, 2019,* Y. Cao, S. Wolf, M. Bennett, pp. 141-146, 2020.

[4] A. H. Jamal, M. Essawi, T. Oleg, "Accountability for project-based collaborative learning," *International Journal of Higher Education,* vol. 3, no. 1, pp. 127-135, 2014.

[5] T. Bauer, B. Erdogan, "Organizational socialization: The effective onboarding of new employees," *APA Handbook of I/O Psychology,* vol. III, pp. 51-64, 2011.

[6] J. Ugoani, "Effective delegation and its impact on employee performance," *International Journal of Economics and Business Administration,* vol. 6, no. 3, pp. 78-87, 2020.

[7] E. G. Williamson, B. J. Borrenson, R. Irvine, "Learning habits of charitable giving through the extracurriculum," *Educational and Psychological Measurement,* vol. 11, no. 1, pp. 103-120, 1951.

[8] S. M. Michels, "Organizational continuity: A succession plan for a nonprofit organization," Masters dissertation in Management, The College of St. Scholastica, Duluth, MN, 2011.

[9] N. Kamdar, T. Lewis, “Deriving long-term benefits from short-term study-abroad programs,” *Journal of Management and Engineering Integration,* vol. 7, no. 2, pp. 1-10, 2015.

[10] G. Earnest, “Study abroad: A powerful new approach for developing leadership capacities,” *Journal of Leadership Education,* vol. 2, no. 2, pp. 46-56, 2003.

[11] D. Pusca, R. J. Bowers, D. O. Northwood, “Hands-on experiences in engineering classes: the need, the implementation and the results,” *World Transactions on Engineering and Technology Education,* vol. 15, no. 1, pp. 12-18, 2017.

[12] J. Kaminsky, C. Casias, C. Leslie, A. Javernick-Will, “Expected Outcomes of a Construction Career: Gender Identity and Engineers Without Borders-USA,” *Construction Research Congress,* pp. 2071-2080, 2012.

[13] P. A. Harvey, “Borehole Sustainability in Rural Africa: An analysis of routine field data” in *30th WEDC International Conference, Vientiane, Lao PDR,* 2004.

[14] M. Wood, “A handpump for Africa: The Afridev experience,” *Waterlines,* vol. 11, no. 4, pp. 29-31, 1993.

[15] D. Gilbert, M. Lehman Held, J. L. Ellzey, W. T. Bailey, L. B. Young, “Teaching ‘community engagement’ in engineering education for international development: Integration of an interdisciplinary social work curriculum,” *European Journal of Engineering Education*, vol. 40, no. 3, pp. 256-266, 2015.

[16] “Guideline to Remote Work for International Projects,” *Volunteer Village,* 2024. Available: https://volunteer.ewb-usa.org/s/article/Guideline-to-Remote-Work-for-International-Projects

[17] D. Leege, D. McMillan, “Building More Robust NGO–University Partnerships in Development: Lessons Learned from Catholic Relief Services,” *Journal of Poverty Alleviation and International Development,* vol. 7, no. 2, 2016.

[18] W. Oakes, J. Duffy, T. Jacobius, P. Linos, S. Lord, W.W. Schultz, A. Smith, “Service-learning in Engineering” in *32nd Annual Frontiers in Education, Boston, MA, USA, November 6-9, 2002,* 2003.

[19] T. Larson, Z. Dulanya, E. Mwathunga, “Borehole siting and construction in rural Malawi: A sociotechnical process?,” *Geophysics,* vol. 87, no. 1, pp. 39-47, 2022.

[20] J. Truslove, A. Coulson, E. Mbalame, R. Kalin, “Behaviors and Trends toward Routine Maintenance and Major Repairs of Afridev Handpumps in Rural Malawi,” *Water,* vol. 13, no. 12, 2021.

[21] J. Volger, P. Thompson, D. Davis, B. Mayfield, P. Finley, D. Yasseri, “The hard work of soft skills: augmenting the project-based learning experience with interdisciplinary teamwork,” *Instructional Science,* vol. 46, pp. 457-488, 2018.

[22] B. Bilgin, A. Felder, H. Darabi, R. Nazempour, S. Reckinger, R. Revelo, D. Ozevin, “Looking Ahead: Structure of an Industry Mentorship Program for Undergraduate Engineering Students,” *Advances in Engineering Education,* vol. 10, no. 3, pp. 9-18, 2022.

[23] T. Taylor, “What are Durable Skills, and Why Do Our Students Need Them?,” *Project Lead the Way,* 2022. Available: https://www.pltw.org/blog/durable-skills.