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Beyond the Classroom: Experiential Learning with Engineers Without Borders in Guatemala

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Dr. Ayala received his BS in Mechanical Engineering with honors (Cum Laude) from Universidad de Oriente (Venezuela) in 1995, MS in 2001, and Ph.D. in 2005, both from the University of Delaware (USA). Dr. Ayala is currently serving as Associate Professor in the Engineering Technology Department at Old Dominion University. Prior to joining ODU in 2013, Dr. Ayala spent 3 years as a Postdoc at the University of Delaware where he expanded his knowledge on simulation of multiphase flows while acquiring skills in high-performance parallel computing and scientific computation. Before that, Dr. Ayala held a faculty position at Universidad de Oriente where he taught and developed courses for a number of subjects such as Fluid Mechanics, Heat Transfer, Thermodynamics, Multiphase Flows, Hydraulic Machinery, as well as different Laboratory courses. Additionally, Dr. Ayala has had the opportunity to work for a number of engineering consulting companies, which have given him an important perspective and exposure to the industry. He has been directly involved in at least 20 different engineering projects related to a wide range of industries. Dr. Ayala has provided service to professional organizations such as ASME, since 2008 he has been a member of the Committee of Spanish Translation of ASME Codes. Dr. Ayala has published over one hundred journal and peer-reviewed conference papers. His work has been presented in several international forums in Austria, the USA, Venezuela, Japan, France, Mexico, and Argentina. Dr. Ayala has a 42.80 average of citations per year of all his published work.

Beyond the Classroom: Experiential Learning with Engineers Without Borders in Guatemala

Abstract

Engineers Without Borders (EWB) is a non-profit organization that designs and implements sustainable engineering projects to improve the quality of life for disadvantaged communities. This study investigates the impact of student participation in an EWB project in a disadvantaged community in Guatemala aimed at improving access to clean water. Specifically, the study explores the skills gained, career aspirations, and understanding of global issues and sustainable development among the participating students. The project involved a collaboration between EWB students and community members to design and implement a sustainable water supply distribution system. A post-project questionnaire was administered to the student participants to assess the project's impact on their personal and professional development. The results indicate that the project positively impacted the students' skills and knowledge, equipping them with critical thinking, problem-solving, technical writing, and proficiency in engineering surveying, fluid mechanics, hydraulic engineering, and AutoCAD. The challenges highlighted the importance of flexibility, creativity, resilience, and effective project management in community-based initiatives. These findings can inform the design of effective experiential learning programs and highlight the significance of incorporating real-world projects into engineering education curricula. These findings can inform the design of effective experiential learning programs and highlight the significance of incorporating real-world projects into engineering education curricula. Future research can expand on the scope of this study by investigating the generalizability of the results to other regions and cultures and exploring potential ways to improve the program to support the development of future leaders in sustainable engineering.

Introduction

Engineering education has transformed in recent years, emphasizing experiential learning to develop students' competencies. One example of this trend is Engineers Without Borders (EWB), which provides students hands-on field experience through sustainable engineering projects. [1]. EWB's experiential learning program is based on the principle of direct experience and reflection, which effectively develops the skills necessary for engineering practice, including problem-solving, teamwork, and leadership [2]. According to the National Academy of Engineering, experiential learning opportunities in engineering education can also help students understand the societal impact of their work and become influential leaders and responsible citizens [3].

Participation in EWB's experiential learning program has significantly impacted students' personal and professional development, promoting improved teamwork abilities, enhanced communication skills, and a deeper understanding of global issues and sustainable development [4]. Moreover, it fosters a more significant commitment to utilizing their skills to assist disadvantaged communities and a better understanding of the role of engineers in addressing global challenges [5] [6]. However, there is a gap in the literature regarding the challenges EWB students face, the professional growth they experience due to their project participation, the knowledge, and skills they acquire, and their plans to continue this type of work in their future careers.

This study seeks to investigate the benefits and challenges of EWB's experiential learning program for engineering students and to examine the impact of participation in EWB projects on students' personal and professional development, including their skills, knowledge, and career aspirations. Specifically, the study seeks to answer two research questions: *What are the benefits and challenges of EWB's experiential learning program for engineering students, and how does participation in EWB projects impact students' personal and professional development, including their skills, knowledge, and career aspirations?* By answering these questions, this study will contribute to a deeper understanding of the benefits and challenges of experiential learning in engineering education and inform the development of strategies to support students' learning and growth.

One notable example of EWB's work is the Guatemala Project, which aimed to address water distribution and sanitation issues in the community of La Reforma. The residents of La Reforma faced significant challenges in distributing water from water tanks to their homes, which resulted in women and children spending most of their days carrying water and limited their ability to work or attend school. Additionally, the shared and frequently recycled water posed severe health risks to the community, as it was used for drinking, bathing, watering crops, and laundry (Figure 1). The student team implemented a sustainable solution by designing and installing a gravity-fed water distribution system that significantly improved access to clean water and reduced the burden of water collection on women and children. This project serves as a case study for this research, as student teams participated in the various phases of the project and gained valuable skills and knowledge. Table 1 summarizes the project's objectives, timeline, and outcomes.



Figure 1. Shared water was being used for drinking, bathing, watering crops, and laundry, posing severe health risks.

Community Location	La Reforma, Guatemala
Community Characteristics	The community is a small town with a low economic status and limited employment opportunities.
Community Population	Approximately 200 to 800 people are present in the community.
Problem	The community faces various challenges due to the lack of easy access to water, as they must travel a long distance to obtain it, and the quality of life is poor, with an inefficient water gathering process, difficulty in obtaining potable water, and the absence of running water and community infrastructure.
Consequence of the Problem	Women and children in the community are burdened with the task of gathering water, causing them to miss out on work or education, and young girls are unable to attend school due to the time and physical demands of carrying heavy containers of water.
Goal of the Project	The goal of the project was to provide a water supply distribution system that would facilitate the lives of the community, provide clean water that is easily accessible from each household, and ultimately improve the quality of life for the residents.

Table 1. Summary of the project.

The success of EWB projects depends on carefully planned and executed phases, including community selection, assessment trips, design, fundraising, implementation trips, and monitoring trips. The Guatemala Project is an example of how student teams participate in these phases to address the community's lack of access to clean water. The project's objective was to provide a water supply distribution system that would facilitate the lives of the community, provide clean water that is easily accessible from each household, and ultimately improve the quality of life for the residents. Throughout the project, the student team engaged in various tasks, such as surveying the land to create detailed maps using AutoCAD, measuring distances, and conducting water tests to detect contaminants (Figure 2). The team also worked closely with community members to design and implement a solution that was culturally sensitive and responsive to the community's unique context. The student team held weekly meetings throughout the project to plan and organize activities, maintaining regular communication with EWB USA and community representatives. Students also organized and participated in various fundraising activities, such as a "Smash Car" event and a Rubik's Cube competition, to support the project.



Figure 2. Students collected water samples, tested the water for contaminants, surveyed the land, and conducted community assessments.

Methodology

This study utilized a qualitative approach to gain an in-depth understanding of the impact of EWB's experiential learning program on students' personal and professional development. The sample consisted of eight students who volunteered to participate in the study after participating in the Guatemala Project.

An open-ended questionnaire was administered to the participants at the end of their project experience in Guatemala. The questionnaire included open-ended questions that allowed participants to provide detailed responses on their personal and professional development, challenges and successes, knowledge of global issues and sustainable development, and career goals and aspirations. The open-ended format allowed for individualized responses, capturing a broad range of perspectives and experiences.

The questionnaire responses were analyzed using content analysis to identify recurring themes in the participants' experiences. The analysis process involved identifying themes in the responses to identify patterns within the data.

The limitations of this study include the small sample size and the potential lack of generalizability of the findings to other experiential learning programs or regions outside of Guatemala. However, the insights gained from this study can inform the development of effective strategies to support students' learning and growth in engineering education and provide insights into the impact of community-driven projects in promoting sustainable engineering and global development.

Results

This section presents the findings of a content analysis of the open-ended questionnaire completed by the students (n=8) who participated in the EWB project in Guatemala. The questionnaires gathered information on the participants' motivations, experiences, skills, knowledge, and career development. As an open-ended questionnaire, some responses may have fallen under multiple themes; therefore, the total percentage of each question may not add up to 100%.

For question 1, the findings show that the student's motivations for getting involved with EWB were diverse. The most common reasons were personal goals for career development and philanthropy (33%), followed by a desire to help people and make a difference (28%). The data also indicated that initial attraction to the project (22%) and interest in water resources engineering (17%) played a role in students' decision to join EWB. These findings suggest that the students joined EWB for a variety of reasons, including professional and personal goals, as well as a desire to make a positive impact in the world. For example, one participant stated: *"I thought it would be a great opportunity to start helping people and get some experience in the field even before I graduated."*

Regarding question 2, the findings demonstrate that data collection, collaboration with community members and stakeholders, and community involvement were essential components of the team's approach to the problem (43% each). Topographic maps and surveys (29%) and resources from EWB-USA (14%) demonstrate the team's commitment to a multi-disciplinary approach. These

findings indicate that the project approach emphasized community involvement and multi-disciplinary collaboration, with data collection as a foundational component. This aligns with community-based participatory research (CBPR) principles, emphasizing the importance of involving the community in the research process and forming partnerships between community members and researchers [7].

Question 3 indicated that there were diverse, including fundraising (25%), documentation workload (25%), communication with leaders (25%), community and municipality involvement (25%), the design phase (17%), terrain elevation change (17%), distance and language barriers (17%), and the impact of the pandemic (17%). These findings highlight the multiple challenges encountered during the project, including financial, logistical, and communication challenges, as well as the impact of unforeseen events such as the pandemic. For example, one participant stated, *"Raising funds was a challenge due to the substantial amount required. To address this challenge, we reached out to leaders at ODU, who provided us with guidance and support."*

Question 4 indicated that the project had a significant impact on the personal and professional development of many individuals, enhancing their professional and interpersonal skills (37.5%), offering a more realistic expectation of their industry (12.5%), and exposure to engineers working as a team (12.5%). Understanding real-world problems was another critical aspect that impacted 12.5% of participants, and the fulfillment and satisfaction of making a difference in the world. Improved teamwork and perseverance were also noted by 12.5% of participants, while 6.25% of participants found direction in life because they participated in EWB. Additionally, understanding problem-solving in engineering was another outcome noted by 6.25% of participants.

The project significantly impacted the participants' perspectives on engineering and its role in addressing global issues, as revealed in Question 5. Half of the participants reported realizing the impact of engineering in addressing essential needs. An equal percentage reported a heightened awareness of engineering responsibility to society and its potential to impact the world positively. A smaller percentage of 17% reported a personal motivation to learn more about engineering, and 8% reported a shift in their perception of the field. These findings highlight the importance of initiatives such as this project in raising awareness and changing attitudes toward the role of engineering in addressing global issues.

In response to question 6, 33% of the students reported applying critical thinking and problem-solving skills to their projects. Technical writing was highlighted as necessary by 17% of the students, and an equal proportion emphasized the use of engineering surveying, fluid mechanics, and hydraulic engineering. AutoCAD was also deemed necessary by 17% of the students. The application of fundamentals, problem-solving, and systems design was reported by 17% of the respondents, and mathematics was used by 17% of the students in their projects. These results demonstrate the diverse range of skills and knowledge students bring to their projects and the real-world impact of their education.

According to the results of question 7, 37.5% of the students plan to continue working on similar projects by joining professional organizations. An equal number of respondents (37.5%) intend to use their skills and knowledge to help communities. Of the respondents, 12.5% plan to focus on personal development and improvement of their skills, while an equal number view these projects

as an opportunity for travel and cultural experience. These results highlight the diverse motivations and goals of individuals participating in similar projects and how they plan to continue contributing to such initiatives.

Discussion

The survey results demonstrate the significant impact that engaging with underprivileged communities on real-world projects can have on students' personal and professional development. Notably, students gained diverse skills, including leadership, problem-solving, project management, and cultural competence, and a deeper understanding of the social, cultural, and economic context of the communities they served, which is essential for developing sustainable projects that meet community needs [8].

It is important to note that the personal goals of students, such as career development and philanthropy, motivated 33% of students to join EWB. This highlights the importance of aligning projects to users' preferences and needs to maximize engagement and impact [8]. Similarly, students interested in service-learning programs like EWB sought personal and professional benefits, including leadership skills and the desire to positively impact their communities [9]. Moreover, 28% of students joined EWB to help people and make a difference, indicating a strong altruistic impulse among young adults who participate in volunteer work [10]. These findings emphasize the potential of community-based initiatives like EWB to engage and empower young adults to create positive change.

The challenges faced during the project were diverse and included technical and social aspects, such as fundraising, documentation workload, and communication with leaders, commonly encountered in similar projects. However, the COVID-19 pandemic added new challenges, emphasizing the need for innovation and adaptability in addressing these challenges. Effective project management strategies and contingency plans are crucial in overcoming such challenges and ensuring the success of similar projects in the future. The results highlight the importance of flexibility, creativity, and resilience in addressing the challenges faced during community-based initiatives, particularly in today's rapidly changing world, where new challenges constantly emerge. By learning from the experiences of previous projects, future initiatives like EWB can be better equipped to create positive change and make a lasting impact in the communities they serve.

This project serves as an excellent example of the intersection of contemporary issues and experiential learning in sustainable engineering and global development. By engaging students in hands-on, community-driven projects, the project equips future leaders with the skills and knowledge needed to address these challenges. Effective communication, collaboration, and problem-solving skills are also crucial in addressing contemporary challenges related to sustainability and global citizenship, as demonstrated in this project.

In conclusion, this study's findings highlight the importance of community-based initiatives like EWB in engaging and empowering young adults to create positive change. The challenges faced during the project highlight the need for effective project management strategies and contingency plans to ensure the success of community-based initiatives. Future projects can learn from the experiences of previous projects, emphasizing the importance of flexibility, creativity, and

resilience in addressing the challenges faced during community-based initiatives. To maximize engagement and impact, it is essential to align projects with user needs [8], as demonstrated by the personal goals that motivated many students to join EWB.

Conclusion

The Guatemala project led by EWB has significantly and positively impacted the La Reforma community by providing access to clean water and improving their quality of life. The project is an excellent example of the intersection of sustainable engineering and global development through community-driven initiatives.

This research paper highlights the importance of hands-on experiences in engineering education, as evidenced by the diverse skills and competencies gained by students through their participation in the project. The challenges faced during the project emphasize the importance of effective project management and contingency planning in community-based initiatives, providing valuable lessons for future projects.

The findings of this study shed light on the motivations and impact of service-learning initiatives on student participants and the communities they serve. Students are motivated by personal and career goals, philanthropy, and the desire to make a positive difference in the world. Service-learning initiatives significantly impact students' personal and professional development, including enhancing their professional and interpersonal skills, exposing them to real-world problems, and improving their teamwork and perseverance.

These findings have important implications for the development and promotion of service-learning initiatives, as well as the incorporation of real-world projects into engineering education curricula. Specifically, this study provides insights into the benefits of community-driven projects for future leaders in sustainable engineering and sheds light on the challenges and opportunities of engaging in sustainable engineering projects in disadvantaged communities. Future research could explore the role of service-learning initiatives in promoting equity and social justice in engineering education, particularly in relation to addressing issues of access and representation for underrepresented groups in engineering.

In conclusion, this study's findings highlight the significant impact of community-driven projects in sustainable engineering and global development. The potential of service-learning initiatives to positively impact student participants and the communities they serve is evident, emphasizing the importance of incorporating real-world projects into engineering education curricula. By doing so, future engineers can develop the necessary competencies and skills to address real-world challenges and contribute to creating a more sustainable and equitable world.

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