



Work in Progress: Involving Teachers in International Community Engaged Learning Projects to Enhance Their Understanding of Engineering and Intercultural Awareness

Dr. Margaret Pinnell, University of Dayton

Dr. Margaret Pinnell is the Associate Dean for Faculty and Staff Development in the school of engineering and associate professor in the Department of Mechanical and Aerospace Engineering at the University of Dayton. She teaches undergraduate and graduate materials related courses including Introduction to Materials, Materials Laboratory, Engineering Innovation, Biomaterials and Engineering Design and Appropriate Technology (ETHOS). She was director of the (Engineers in Technical Humanitarian Opportunities of Service-Learning) for approximately ten years. She has incorporated service-learning projects into her classes and laboratories since she started teaching in 2000. Her research interests include community engaged learning and pedagogy, K-12 outreach, biomaterials and materials testing and analysis.

Dr. Kellie Schneider, University of Dayton

Kellie Schneider is an Assistant Professor in the Department of Engineering Management & Systems at the University of Dayton. Prior to joining the faculty at UD, she was an instructor in the Freshman Engineering Program at the University of Arkansas. She received her Ph.D., M.S. and B.S. all in industrial engineering from the University of Arkansas. She has a variety of research interests including quality & reliability, engineering education, and community-based OR. She is a member of ASEE and IIE.

Dr. Leanne Petry, Central State University

Dr. Leanne Petry is an Associate Professor in the College of Engineering, Science, Technology, and Agriculture at Central State University. Her expertise is in analytical and materials characterization techniques, including microscopy, spectroscopy, chromatography, and electrochemistry. Her research interests include oxidation-reduction reactions at the surface of electrodes for sensor applications, corrosion mechanisms of materials, as well as their electrochemical degradation. She has incorporated problem-based learning into her lectures, laboratories, and outreach activities to engage students and the community in the STEM education process.

Dr. M. Suzanne Franco, Wright State University

Professor of Statistics and Research, Program Director for EdD in Organizational Studies, in the Leadership Studies in Education and Organizations Department, College of Education and Human Services.

Dr. Malcolm W. Daniels, University of Dayton

Dr. Amy Anderson, University of Dayton

Amy Anderson is the Associate Provost for Global and Intercultural Affairs and Executive Director of the Center for International Programs (CIP) at the University of Dayton. The CIP provides coordination, strategic planning and administrative support for the internationalization of the campus, which includes the Education Abroad Office, Partnerships and Exchanges, International Student and Scholar Services, an Intensive English Program, faculty development programs, and cross-cultural learning living communities. Amy has been at the University of Dayton since 1998, and has over 30 years experience working in a variety of international education programs. Amy has also worked in the areas of international admission, international student advising and study abroad. She has taught at both the graduate and undergraduate levels in the U.S., Chile, Thailand and the British Virgin Islands, and speaks both French and Spanish.

Mrs. Marjorie Langston Langston, Hamilton Township High School

Megan Shepherd

Madeline Mock

Engagement in Practice: Involving Teachers in International Community Engaged Learning Projects to Enhance Their Understanding of Engineering and Intercultural Awareness

Abstract

The University of Dayton and Central State University are engaged in a new collaborative NSF Research Experience for Teachers project that has an emphasis on international engineering research focused on human-centered design and appropriate technology for developing countries. This three year project will engage 36 G6-12 in-service and pre-service teachers in a variety of engineering research opportunities through one the University of Dayton's Engineers in Technical Humanitarian Opportunities for Service-Learning (ETHOS) Center which focuses on engineering and community engaged learning. This paper will summarize the project, present observations from the spring participant sessions, and discuss the unique opportunities and challenges associated with involving teachers in international community engaged learning.

Introduction

It is well established that the United States (US) has a need for enhanced participation as well as increased racial and gender diversity in the Science, Technology, Engineering and Mathematics (STEM) fields, particularly engineering [1-4]. Farinde, Tempest and Merriweather (2014) report that careers that are perceived to help humanity with high levels of community engagement may be more attractive to African American, Latino/Latina, Native American and females [5]. Engineering Community Engaged Learning (CEL) is an excellent way to help those involved in these experiences to understand how engineering, as well as other STEM careers, can have a high level of community engagement, can be used to help humanity, require creativity and are personally rewarding careers. CEL provides the participants with a way to engage with the community through learning opportunities that address critical community-identified interests and needs, and sustaining reciprocal partnerships. This may be why CEL attracts females at a rate three times that of their male counterparts. A similar trend has been noted for other underrepresented populations in engineering, such as African Americans, Latino/Latinas, and Native American [5-11]. Furthermore, Zarske, et al found that project-based CEL design experiences have a significant positive impact on the identity and self-efficacy of all students, but a greater impact on women and minority students when compared to Caucasian males [7].

Teachers play a significant role in helping students develop an awareness of, and interest in different career opportunities [12]. They also help shape a students' self-efficacy and outcome expectations which can have a significant impact on the student's choice of careers [13]. Unfortunately, many teachers either have little knowledge of the field of engineering or have misconceptions about the field such as failing to identify engineering as a career that helps

humanity [14-15]. This is unfortunate since teachers can subconsciously pass on these misconceptions to their students and, as described above, careers that are perceived to help humanity with high levels of community engagement may be more attractive to females and underrepresented populations [5]. Therefore, in order for the US to achieve greater participation as well as increased racial and gender diversity in STEM, it is critical that teachers are provided with opportunities to engage in professional development that helps increase their understanding of engineering as a career field [16, 17]. Involving teachers in community based engineering activities is one way to help dispel their misconception that engineering is not a “helping career.”

In addition to developing a deeper understanding of engineering as an attractive career that helps humanity, teachers at all levels need enhanced intercultural competence. The changing demographics of the US require teachers to have this skill in order to effectively teach a more diverse student body. Furthermore, intercultural awareness, communication and competence have become critical professional skills in today’s global economy. Therefore, teachers need to have these skills if they are to guide their students to global competence [18-22]. Intercultural awareness and a commitment to build intercultural competence constitute prerequisite conditions. The US Department of Education has made broader global skills for students a priority [23]. It charges colleges, schools, and departments of education to provide new learning opportunities and course work to successfully develop these skills in teachers. Similarly, Walters, Garii and Walters (2009) argue for international travel as integral to teacher preparation, encouraging a sense of “otherness” and an appreciation for the role of human difference, addressing misconceptions and stereotypes, and challenging teachers’ understanding of their “professional self” [22].

The link to Community Engaged Learning (CEL) as an effective pedagogy for promoting intercultural competence development is well established. Dating back to the 1960s, researchers have explored the theoretical characterization of intercultural competence and the effectiveness of varying classroom practices [24]. More recently, various researchers have explored the efficacy of CEL and research immersion experiences. Research shows that teachers learn to navigate complex, intercultural encounters through challenging CEL experiences promoting, “reflective, critical and ethical practices” [25].

Since international engineering CEL has the potential benefit to both increase intercultural awareness, while also demonstrating engineering as a career that helps humanity, engaging teachers in this type of experience may prepare them to encourage and inspire their students, particularly females and other underrepresented minorities, to consider engineering as a possible career field. In an effort to provide international engineering CEL experiences to teachers, two regional universities that have significant experience in working with K-12 teachers, and with engaging in international CEL are collaborating on a National Science Foundation Research Experience for Teachers (NSF RET) project called Collaborative NSF RET Global STEM –

Appropriate Technology for Developing Communities (Global STEM). This three-year project started in 2019, and will include three cohorts of 12 teachers each through 2022.

The Global STEM participant experience has been modeled after the University of Dayton's ETHOS Center's CEL internship program which has placed nearly a 1,000 students in short (~two weeks) and long term (~10 weeks) engineering immersions in the United States and in developing countries for nearly 20 years. The ETHOS Center engages in work that contributes to the ongoing mission of the community partner and that supports the advancement of sustainable, effective and appropriate solutions to community identified technical challenges, while also providing transformative educational experiences that help the participants gain a better understanding of the global interaction of technology and society. ETHOS center activities have been developed and facilitated to adhere to a set of core values which include: (1) Appropriate Technology – do more with less, make use of local resources without exploitation, co-create design solutions with the community; (2) Cultural Sensitivity – respect the inherent values of the culture; (3) Partnership – develop relationships, work with the community, spread hope and empowerment; (4) Cultural Immersion – act in solidarity through service, learn with and from the community; and (5) Personal Transformation – let the world change you. The CEL internship program is connected to a course that includes a project-based introduction to appropriate technology and human centered design, selected readings and discussions on appropriate technology development and cultural immersion, cultural, travel safety and health preparation, project work through their CEL internship, project reporting and guided reflection [26].

Program Description

The three year Global STEM project which started in 2019 has been designed to provide a total of 36 pre-service and in-service teachers with a transformative international research experience thematically centered on human-centered design and appropriate technology for developing countries. A goal of this project is to help the teacher participants transfer their international, engineering research experience to their classrooms, and develop and disseminate new curricula via the TeachEngineering Platform. Additionally, a goal of this project is to help teachers attain new knowledge of engineering disciplines and careers, gain a deeper understanding of how engineering can be used to serve the local and global community, and gain a new appreciation for the value of diverse team-based learning environments. A final goal of this project is to help the participants develop greater intercultural self-awareness and an understanding of how cultural norms affect teaching and pedagogy, engineering design, and the adoption of engineering innovations.

The Global STEM program has been designed so that the participants will engage in a 300-hour experience over the course of a year. The program has five distinct components: (1) Intercultural competence and travel preparation; (2) Appropriate technology related research and/or human-centered design that supports the work of an international community partner under the

mentorship of a faculty member at one of two regional universities; (3) On-site work at the international community partner's facility; (4) Two-week intensive curriculum development with the participant cohort under the guidance of a curriculum coach; and (5) Follow-on programming that includes continued research with a faculty member, piloting, revising, and final submission of curriculum to TeachEngineering.

Through both the ETHOS Center's experience, and research presented in the literature, participant preparation that includes cultural orientation, health, safety and travel information, technical preparation, and that embodies the concepts of fair trade learning has been identified as a key factor for successful immersions that achieve reciprocal positive outcomes for both the participant and the international partner [27-28]. Therefore, the Global STEM program was designed to include significant preparation of the teacher participants through monthly, day-long orientation meetings January through April prior to their travel in June or July. During these orientation sessions, the participants are introduced to their international placements and partners, the intercultural aspects of engineering research and design, and the ethics of working with community partners in developing countries.

In addition to the cultural preparation, the Global STEM participants are prepared technically for their immersion through a variety of activities. Prior to travel, the participants are introduced to concepts of human-centered design and appropriate technology through assigned readings from *The Field Guide to Human Centered Design* (2015) and through facilitated discussions and activities during the orientation sessions [29]. The participants also interact with ETHOS Center international community partners in focused discussions about social justice challenges, sustainable development and Engineering Grand Challenges [30]. Additionally, the participants tour regional organizations engaged in community development that have served as domestic engineering CEL placement sites for students through the ETHOS Center.

A critical component of the technical preparation is the appropriate technology and/or human centered design research activities that the participants engage in with their faculty mentors prior to travelling to their placement. These pre-departure research activities align with the work that each of the Global STEM participants will be doing with their community partner during their international immersions. The participants engage in this research with their faculty member on a part-time basis (~2-5 hours per week) until their school year is over, and on a half-time basis after the school year is over and prior to departing for their immersions.

In late June or early July, the Global STEM participants travel internationally to their assigned community partner site (~1-2 participants per site) where they join previously placed undergraduate and graduate students (~1-2 students per site) to work on an engineering project. The participants are placed at their partner site for two to four weeks, based on the availability of the participants and as negotiated with the ETHOS director, international partner and faculty

mentor. The ETHOS Center coordinates the travel and accommodation planning, provides safety and security oversight of the RET immersion, and coordinates in country research support. Upon return from their international immersion experience, the participants continue to work on their project with their international partners using institutional research facilities and online communication technology.

To help the teachers bring their experience back into the classroom, the participants engage in an intensive, two-week curriculum development workshop under the guidance of a curriculum coach. This workshop is held in late July, after all of the teachers have returned from their international placement. During this workshop, the participants work in teams and use their research experience and international immersion to develop STEM curriculum using the TeachEngineering format. During the school year, the in-service teachers pilot their curriculum in their classroom and then revise, edit and submit their curriculum for publication to TeachEngineering. The year-long program concludes with a half-day symposium celebration where the participants present their project work and curriculum to guests from program school districts, and the two regional universities.

The Global STEM project is being assessed using a convergent parallel mixed method design. Among the tools being used in this evaluation include surveys, and pre and post assessments such as the Intercultural Development Inventory (IDI), and the Intercultural Effectiveness Scale (IES), and Science/Math Teacher Efficacy & Beliefs Instrument (STEBI/MTEBI) [31-33].

Placements for the Summer of 2020

The project team recruited its first cohort of seven in-service and five pre-service teacher participants. The teachers have tentatively been assigned to their placements at one of seven different international partners. Among these partners include Change and Be Changed, Inc. located in Malawi. The current focus of project work at this site is stabilization and improvement of the hospital access road to mitigate rainy-season erosion. Also located in Malawi is Determined to Develop (D2D). In recent years, ETHOS students surveyed the land donated by the local community to create a master plan for building a new high school, and then later worked alongside local tradesmen to help build the first classroom facilities for new high school. The current project focus at this site involves two projects: (1) Implementation of the campus master plan including site development, building design and construction, and (2) Utility level water provision using a pumping station and land line to the campus from lake Malawi. Another placement will occur at the DI Lab at the Pontifical University of Chile in Santiago. Current project work at this site is the design and clinical assessment of a single-finger prosthesis integrated with printed elastomer materials. Leveraging a long-term partnership with ETHOS Center, teachers placed at Grupo Fenix in Nicaragua will work on a sustainability assessment of eco-latrines and human waste composting. In Peru, teachers placed at Grupo - Pontifica Universidad Católica del Perú will engage in projects related to the design and construction of a

geodesic drying dome for agricultural produce processing. Located in close proximity to each other in Bangalore, India are the final two placements: Solar Electric Light Foundation (SELCO) and Technology Informatics Design Endeavour (TIDE). At SELCO, the teachers will work on a solar related projects such as solar-powered aeroponics systems, security systems to protect rural farmlands from elephant predation, screen-printing processes and electronic braille machines. At TIDE, the teachers will work on biomass cook stove products.

Summary

The Global STEM RET is a collaborative effort between two regional universities with an emphasis on international engineering research that focuses on human-centered design and appropriate technology for developing countries. This three year project engages 36 G6-12 in-service and pre-service teachers in a variety of engineering research opportunities through the ETHOS Center. In the fall of each year, 12 teachers are recruited into the year-long research program which includes research at one of the two campuses and with an international community partner, and additional programming throughout the year. From January to April, teachers participate in a series of orientation activities designed to prepare them technically, and culturally for their international immersion. Throughout June and July, the teachers conduct campus-based research as well as engage in a related project with an international partner in a two to four week international placement. The ETHOS Center, which has provided CEL experiences through technical immersions for nearly 20 years, coordinates the participant travel. Upon their return, the teachers continue to engage with their project and their international partners using institutional research facilities and virtual communication technology. Teachers also participate in an intensive, team-based curriculum development program for two weeks, where they develop lessons using the TeachEngineering format under the guidance of a curriculum coach. The follow-up program includes lesson piloting and publishing, continued research, reflection, and closing presentation and celebration. Lessons are piloted, edited and published during the fall and winter.

It is hypothesized that the Global STEM program will expose participants to the integrative nature of engineering with other disciplines (social science, geography, language arts, visual arts) and the social impact of engineering in the world, giving them a better understanding of the engineering profession, while also increasing their intercultural awareness. This understanding as well as the curriculum developed through this program will empower the teachers to encourage their students, particularly females and minorities to pursue engineering careers.

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