

Developing Critical Consciousness to Promote Engineering for Social Justice: A Pilot Program to Enhance STEM Outreach and Engineering Education through Service-Learning

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Abstract

There is a growing literature on the intersections between Engineering and social justice.¹⁻⁴ This paper describes the context and rationale for developing an *Engineering for Social Justice Scholars Program* in an effort to create new opportunities to enhance engineering education and support a growing K-12 engineering outreach program serving underrepresented minorities in the STEM fields. The pilot program features a two-semester service-learning course sequence. The first course, *Social Justice and STEM Education*, engages undergraduate students as mentors in a STEM education outreach program for middle school youth in Chicago Public Schools. In the second course, *Leadership in Engineering for Social Justice*, students apply their knowledge to manage local STEM education outreach programs and also work in teams to develop and implement projects that support engineering for social justice. Through complementary readings, activities, and reflection related to the experiential learning, the program is designed to help students develop a critical consciousness about gender and racial/ethnic disparities in STEM education and the integral role of social justice in engineering education and practice.

Keywords

Service-learning, social justice, K-12 outreach

Introduction

Community-university engagement may be an important strategy to address inequalities in STEM fields while also providing opportunities for high-impact learning experiences for undergraduate students.⁵ In particular, service-learning has gained increasing popularity in engineering education as an effective pedagogical strategy that has benefits for community partners.⁶⁻¹² However, some scholars have advocated for a more critical approach to traditional service-learning, one which explicitly attends to social justice issues, including attention to authentic relationships, an orientation toward social change, and work that supports the redistribution of resources.¹³⁻¹⁴ And, there has been an emerging literature in engineering education promoting increased critical reflection on the engineering profession and the development of educational innovations to train more socially just engineers.^{1,4,15}

An Opportunity to Enhance STEM Outreach and Engineering Education

In the 2015-2016 academic year, the College of Engineering at the University of Illinois successfully piloted a new program (ICANEXSEL) in partnership with Chicago Pre-College

Science and Engineering (Chi S&E), a non-profit organization with a mission to prepare students from inner-city Chicago Public Schools for college science and engineering programs. In collaboration with the College of Education's Office for Mathematics, Science, and Technology Education, ICANEXSEL partners launched a 6th and 7th grade program, focused on a pre-algebra and physics curriculum. The program included several instructional Saturday sessions per semester, a visit to the Fermi National Accelerator Laboratory, and fieldtrips for youth and their parents to participate in activities on the University campus. Plans were discussed to scale the partnership by adding a grade level each year to develop a K-12 pathway program. Each grade level would continue to focus on mathematics preparation in addition to a new engineering topic.

The 8th grade expansion planned for 2016-2017, with an emphasis on computer programming, presented an opportunity to enhance the outreach program with a service-learning course. A scaled program would require increasing numbers of University student facilitators. To keep the administrative load manageable, a way to mobilize a consistent flow of reliable student mentors was needed as well as processes to streamline program planning, coordination, and logistics. Because each Saturday session required a ten-hour commitment (including transportation to/from Chicago), it would prove challenging to identify enough students who were available and willing to commit to several program sessions per semester as a co-curricular activity. The creation of a service-learning course could institute requirements for students to participate consistently in all of the ICANEXSEL sessions. This increased contact time between University and middle school students offered potential for enhancing the quality of the learning and mentoring relationships.

Creating a service-learning course connected to service opportunities with the ICANEXSEL program could enhance the learning experiences of the undergraduate students as well as the youth. University students could receive training and preparation before entering the service setting, which could enhance their teaching skills and interactions on site. Also, creating opportunities for structured reflection would raise the University students' awareness and understanding of issues related to racial/ethnic inequities in STEM and the importance of enabling access to STEM curricula in under-resourced communities. It could help support students in articulating their learning and skill development from the service experiences and in making connections to their future goals. And, there was potential for students in the course to develop a sense of community and empowerment as a team, which could be leveraged to impact social climate in the College around diversity and social justice issues in engineering education.

In the first service-learning course, *Social Justice and STEM Education*, undergraduate students served in the ICANEXSEL program and mentored a group of predominantly African-American and Latino/a middle school students. Course content explored how economic and social inequality impacts STEM education. Through complementary readings, classroom activities, and discussion, the course was designed to help students develop a framework for understanding racial, ethnic, and gender disparities in STEM education and a critical consciousness related to social justice and engineering. Broadly, the goal was to facilitate development of students' knowledge, skills, attitudes, and agency to address social justice issues. Students learned about the relation between engineering mindsets and social justice, paradigms for civic engagement and critical service-learning, issues related to diversity, racial/ethnic identity development, stereotype threat, and systems of oppression; and the socio-ecological contexts of schooling in urban areas in the U.S. Assignments exposed students to research-based knowledge about racial and gender inequities in STEM education. And, structured reflection was used to build students'

confidence and comfort level in discussing race, ethnicity, gender, and structural oppression; improve students' ability to identify and dismantle assumptions and stereotypes, and encourage self-examination and engagement in authentic cross-cultural relationships.

In the second service-learning course, *Leadership in Engineering for Social Justice*, students will build on knowledge acquired in the first semester in order to manage local STEM education outreach programs. Strategic community partnerships have been established, which are aligned for mutual benefits and ample opportunity for student leadership development. The course will cover a broad range of topics related to social justice and engineering, human-centered design, humanitarian and development engineering, ethical responsibilities in the profession, and critical frameworks for understanding NAE Grand Challenges for Engineering. Students will also work in teams to develop and implement a variety of projects related to engineering for social justice.

Developing a Critical Consciousness in STEM Education

Researchers have found that creating opportunities to develop a critical consciousness for multicultural education and practice can be challenging.¹⁶⁻¹⁷ Engineering students typically have little experience with critical reflection in the curriculum and have relatively bounded understandings of knowledge gained in engineering (considered “core” to their education) versus liberal education domains (considered peripheral or additive to the role of engineers). Also, a culture of depoliticization in engineering, with the accompanied epistemological philosophies that value “objective” and linear knowledge, present barriers to incorporating reflective practice, a technique which values alternative ways of knowing, into engineering education.¹⁸

In the first semester of the program, students were encouraged to make connections and apply concepts to their service-learning fieldwork, personal experiences, and to the larger society. By enhancing students' knowledge and critical consciousness related to their participation in systems that impact STEM education, more opportunities are created for students to engage in constructive dialogue that re-focuses social justice in engineering education and practice. In the program, we attempt to problematize technocratic and meritocratic philosophies endemic to engineering education, and which work against goals for achieving equity for underrepresented students.¹⁹ In this way, the program aims to carve out “cultural space” to confront dominant ideologies of depoliticization and meritocracy²⁰ in order to foster students' empowerment to not only think more critically about the field of engineering, but to take action toward engineering for social justice. This action included the creation and execution of a public arts event, *STEMposium*, a collection of performances shining a spotlight on the intersections of STEM and issues of identity, power, education, ethics, engagement, and social justice. And, it will take the form of diverse team projects that will be developed in the second semester.

Connecting service-learning courses to STEM outreach programs may be a promising strategy for building students' knowledge, skills, attitudes, and agency about social justice issues in STEM education. This approach is intended as a launching off point to encourage students' further exploration and action related to social justice and engineering education and practice. Structuring effective reflection activities to promote critical consciousness, supporting differentiated student development and motivation, overcoming student resistance to change, confronting mindsets about community engagement and interdisciplinary learning, and curricular hurdles related to the de-valuing of social justice in engineering education are among the challenges to address in the planning and implementation stages of this pilot program.

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