A Work in Progress

Integrating Cultural Sensitivity and Indigenous Knowledge in Engineering Education: Adaptive Approaches to Problem-Solving and Growth Mindset

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Abstract
Cultural sensitivity and the incorporation of indigenous knowledge systems play a significant role in the initial stages of the engineering design process, particularly in problem identification, which sets the foundation for all subsequent problem-solving efforts. Despite a large body of literature on engineering problem-solving methodologies, there appears to be a research gap in how cultural contexts and indigenous perspectives influence the early stages of problem identification [1, 2, 3], underscoring the need for studies into such aspects of problem identification. This study explores how first-year engineering students develop problem-identification skills through the lens of indigenizing engineering education, aiming to weave indigenous knowledge and cultural perspectives seamlessly into the curriculum. By fostering a culturally inclusive mindset, our objective is to enable students with the capacity to recognize and creatively address complex environmental, sustainability, and social challenges that disproportionately impact indigenous communities. Model-eliciting activities (MEAs) [4, 5, 6] related to water issues will be integrated into first-year engineering courses, fostering real-world problem-identification and problemsolution skills using actual data to promote a growth mindset. Our research objectives are a) Examine how exposure to indigenous-specific environmental, sustainability and social issues impacts first-year engineering students' problem-identification, design, and problem-solving abilities. b) Identify the relationship between early exposure in a first-year engineering course and indigenous-contexts problem identification skill development. Cultural mindset development and Indigenous pedagogical principles will guide our study. We will adopt indigenous pedagogical principles [18] for a culturally responsive learning environment respecting Indigenous perspectives and values. Quantitative and qualitative data will be collected through pre- and postsurveys and student focus groups. Anticipated outcomes include substantial improvements in problem identification, design, and problem-solving abilities, fostering a culturally responsive and holistic approach among students.

Introduction and Context

In engineering education and practice, problem identification is fundamental. It requires not only the recognition of complex challenges but also an understanding of diverse cultural perspectives and indigenous knowledge to inspire innovative solutions.

Problem identification is the initial step in the engineering design process and plays a pivotal role in shaping the course of subsequent problem-solving efforts [10]. While a substantial body of literature focuses on engineering problem-solving skills, research on problem identification remains relatively underexplored [1, 2, 3, 7]. Many existing assessment tools and educational approaches emphasize problem-solving rather than the critical phase of problem identification [1]. Furthermore, the impact of cultural and contextual factors on problem identification skills represents a largely unexplored area, especially within the context of indigenizing engineering education [8, 9]. This research gap underscores the need for more comprehensive studies into the multifaceted aspects of problem identification, including its cultural and interdisciplinary dimensions, to enhance engineering education and practice. To address this gap, this research-inprogress aims to examine the development of problem-identification skills within the context of a newly implemented Engineering+ (ENGR+) program.

Background

The College of Engineering's Engineering+ program was crafted to enhance its engineering undergraduates' retention and graduation rates, targeting an increase in first-year retention from 84% to 90% and a boost in the six-year graduation rate from 63% to 70% [16]. At the heart of the ENGR+ program lies a trio of courses (ENGR 100, 102, and 103) structured around a lecture/studio format, each serving a distinct purpose: ENGR 100 introduces students to the engineering field, ENGR 102 focuses on design and problem-solving, and ENGR 103 covers engineering computation [16, 17]. This curriculum sequence aims to equip students with essential engineering skills and foster a sense of belonging and community by encouraging interdisciplinary learning and identity formation as engineers. Over 40 faculty members have collectively crafted the program's curriculum, adopting cutting-edge teaching strategies that include small-group sessions facilitated by trained leaders, tackling large-scale societal issues via the aid of virtual lab tools, addressing complex, real-world problems to enhance critical thinking, undertaking projects that resonate with students' passions to strengthen their engagement with the course content, and incorporating matters of sociotechnical issues to support intercultural competence and communication. Integrating sociotechnical issues within the ENGR+ program emphasizes the essential role of problem identification in engineering education through the lens of cultural mindset development and Indigenous pedagogical practices. This approach fosters a teaching and learning environment that champions academic success and nurtures a culturally responsive and socially conscious engineering mindset, underscoring the program's commitment to addressing complex societal challenges. Engaging over 2000 students yearly, this study leverages cultural mindset development principles and Indigenous pedagogical practices to examine the critical role of problem identification in engineering education, advocating for a teaching and learning environment that supports academic success and cultivates a culturally responsive and socially conscious engineering mindset.

The approach to this work in progress involves integrating Indigenous knowledge systems and promoting cultural sensitivity while addressing societal-scale issues affecting indigenous populations and lands. Students engage in real-world problem-identification and problem-solution design, using real-world data to facilitate learning and a growth mindset. Model-eliciting activities (MEAs) related to water issues are developed and implemented in an ENGR+ course. The MEAs address cultural mindset development, where students learn to identify problems and design solutions for sociotechnical issues affecting indigenous populations and lands. Specifically, the MEAs seek to understand the factors that influence the development of a mindset geared toward identifying problems related to indigenous populations and their lands while incorporating Indigenous perspectives into engineering education.

MEAs are authentic learning activities requiring students to identify problems and design solutions [4, 5, 6]. MEAs, first used in elementary school classrooms [4, 5], were later adapted for first-year college engineering courses, showcasing their potential for STEM education. Six design principles guide the design of MEAs [4, 5, 6]. These design principles require that all MEAs include: (1) model construction – a mathematical model of a procedure/product, (2) realistic context – an authentic STEM-related problem, (3) self-assessment – an opportunity for student teams to selfassess the usefulness of the model, (4) model documentation – a procedure/product description, (5) model shareability and reusability – shareability and reusability for similar purposes, and (6) a useful learning prototype – a globally generalizable or modifiable procedure/prototype. These principles, developed by mathematics education researchers for elementary school classrooms [4, 5, 6], were adapted for first-year college engineering courses.

Framing

We utilize a combination of cultural mindset development [11] and Indigenous pedagogical principles [12, 13, 14, 15] to examine the development of problem-identification skills in first-year engineering students. By combining these frameworks, we aim to explore how early exposure in a first-year engineering education course influences the development of problem-identification skills in an Indigenous context and contributes to enhancing engineering education and practice. Simultaneously, we will adopt Indigenous pedagogical principles to create a culturally responsive learning environment that respects Indigenous perspectives and values.

Research Objectives

The research objectives are to a) examine how exposure to indigenous-specific sociotechnical issues impacts problem-identification, design, and problem-solving abilities in first-year engineering students and b) identify the relationship between early exposure in a first-year engineering course and indigenous contexts problem identification skill development.

Methodology

We adopt a Design-Based Research (DBR) methodology to systematically explore and develop innovative educational strategies, such as indigenous model-eliciting activities (MEAs). This ongoing study involves first-year engineering students from two engineering courses, ENGR 100 and ENGR 102, across Fall and Winter terms, encompassing approximately 360 participants. Our data collection methods include pre-and post-surveys, student focus groups, and analyses of MEA solutions. The surveys blend domain-specific existing self-efficacy and growth mindset measures with tailored questions reflecting specific challenges, issues, or difficulties indigenous communities face. Focus groups examine students' subjective experiences and viewpoints, complemented by analyses of MEA solutions, which scrutinize their approach to problem-solving. Together, these methods provide a rich, multifaceted understanding of student learning outcomes.

Anticipated Results

The anticipated results of this work in progress will be two field-tested Indigenous MEAs that can be implemented in ENGR+ courses to foster problem identification skill development, cultural mindset development, and Indigenous pedagogical principles. Other expected results include substantial improvements in problem identification, design, and problem-solving abilities, fostering a culturally responsive and holistic approach among ENGR+ students.

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