Collaborative Research: Getting Engineers to Talk Across Disciplines
[EEC 1129447]

How do engineers come to know and understand the knowledge that is essential for their field? To answer this critical question and advance engineering education, we must investigate students' engineering epistemologies. Research has shown that advanced engineering students, even graduating students, possess significant misunderstandings about key engineering concepts. To repair these misunderstandings, we must develop a deeper and more practical understanding of the ways that students develop, or fail to develop, knowledge about key engineering concepts.

National leaders have called for the identification of student preconceptions and misconceptions within STEM disciplines, and substantial progress has been made through the development of many discipline-specific concept inventories and creative application of these concept inventories in the classroom. Despite these advances, there is still significant work to do before conceptual understanding research yields broad practical classroom implications. Because of this research-to-practice gap, there is a **critical need** to develop cross-disciplinary theories or frameworks that broadly characterize patterns in conceptual understandings. These theories will help researchers and instructors interpret and apply conceptual understanding research to the creation of effective teaching practices and assessment tools.

We propose to fill this research-to-practice gap. Our ***objective*** is to initiate the process of building theory that informs practice by developing cross-disciplinary models or ways of thinking about the structure of knowledge. To accomplish this objective, we have four specific research aims: 1) conduct inductive analysis of qualitative data to determine the structure of conceptual understandings across disciplines, 2) evaluate the applicability and validity of existing conceptual change frameworks to existing data sets, 3) investigate motivational factors that influence conceptual change, 4) create deliverables that inform both educators and researchers.

This project will yield at least four specific, measureable outcomes: 1) **characterizations of engineering learning** that will inform instruction and the construction of appropriate assessment, 2) **a proposed theoretical framework of conceptual change in engineering education** with particular attention to the characterization of misconceptions, the granularity and relatedness of concepts, and the context dependence of students' understandings, 3) **proposed next steps in conceptual change research** in engineering education, which includes the identification of the next set of critical research questions (with a particular focus on the motivational factors that influence conceptual change) and novel research methodologies for investigating these questions, 4) **a shareable database** of (a) qualitative interview data on students' understanding of diverse engineering topics that can be used to develop "concept questions" and descriptions of motivational factors, and (b) building blocks for teaching and assessment tools that address misconceptions in the classroom.

The **intellectual merit** of this work is the development of cross-disciplinary theories of conceptual understanding in engineering education. Existing theories of conceptual change are insufficient to explain the observations and conclusions researchers have drawn through extensive data collection and analysis. This proposed project will explicitly test existing theory with cross-disciplinary data to ultimately build and test more appropriate, data-driven theories for engineering fields. These theories will be ground-breaking, because they will include new knowledge of how engineering students' conceptual understandings are influenced by cognitive, motivational, and epistemic factors.

The **broader impacts** of this research include the potential to impact teaching and learning in all engineering fields by creating increased opportunity for developing pedagogical practices for remediating misconceptions and making integrated engineering curricula that facilitate students' conceptual development. Moreover, this project directly results in an explicit plan to propel research in engineering epistemologies forward.