Overcoming Pedagogical Inertia: Amplifying the Course Transformation Narratives of Engineering Educators.

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NSF CAREER: Overcoming Pedagogical Inertia: Amplifying the Course Transformation Narratives of Engineering Educators

1 Motivation and Background

The aim of this CAREER project is to learn from and with engineering educators who have successfully overcome the barriers that often impede change in other contexts. Research on the barriers that affect instructional change and curricular transformation are well-documented in the literature [1]–[8]. In response to those barriers, the engineering education community has pursued a multitude of approaches to innovating courses and curricula, including many that require significant resources (e.g., federal funding opportunities, development of new engineering programs, top-down change leadership). While these approaches have transformed engineering curricula in some places, these resources may not be accessible for many engineering departments and institutions. For example, since the program's inception, almost 40 institutions have received NSF Revolutionizing Engineering Departments (RED) grants, but there are over 600 institutions with ABET-accredited programs [9]. In this instance, there are simply more institutions than available funding. Nevertheless, some educators have overcome the most common barriers and positively impacted students' educational experiences, without solutions like large financial investments or new programs. To complement existing efforts like the RED grant program, this project seeks to examine the alternative approaches used by these educators to transform their courses and curricula.

Collaboration with and learning from faculty is critical to successful change efforts. A common approach for disseminating education innovations and promoting educational change is the diffusion of innovations paradigm, originally designed to support the diffusion of new technologies [10], [11]. Yet, this approach often overlooks the value of local solutions and expertise [12]. In practice, this overlooking occurs when we prompt the adoption of an evidence-based practice without understanding the barriers educators face in their local context, as compared with the context where the practices were originally developed [10], [13], [14]. This CAREER project, on the other hand, will leverage approaches that see faculty as partners and their knowledge of their local contexts as assets. In addition, we seek to incorporate the voices of faculty often overlooked in the literature (e.g., professional track faculty, educators at Minority-Serving Institutions, and those at non-research-extensive institutions). While research is beginning to place a greater focus on educators [15]–[18], this gap in the discourse on educational change motivates explorations of a broad range of faculty experiences, roles, and contexts.

This project adapts the positive deviance approach to amplify the voices of educators and to advance our understanding of curricular transformation in engineering education. The positive deviance approach has been used to identify behavioral and social change solutions to intractable and complex problems embedded in complex systems (e.g., child malnourishment [19] and healthcare quality [20]). The approach shifts discourse from a focus on root cause analysis or the integration of external solutions to new possibilities within the local context that are uncovered by local agency [12]. A core component of this approach is the partnership with community members to understand and learn from their peers, particularly those who have overcome the constraints that have impeded others and are effectively addressing the complex problem [12], [19]–[22]. For this CAREER project, we will identify, learn from, and amplify the stories of positive deviants, innovative engineering educators who have successfully transformed curricular design while

facing inertia that may have dampened or impeded other educators in similar contexts. We have structured the project to foster an environment in which peer community members (i.e., other engineering educators) engage in agentic activities (e.g., snowball recruitment, ideation of localized strategies) and partner with the research team to learn from the practices of the educators identified as positive deviants. The classification of positive deviants (PDs) will be used temporarily. A new descriptor will be developed in partnership with community members to more accurately capture what we are learning about the PDs. Over the course of the project, the community members will interact directly with the PDs, support the analysis of the PDs' change stories, and disseminate the results to their communities. By examining and amplifying the PDs within our community, we can develop visible examples of alternative approaches to curricular transformation.

2 Overview of the Project Plan

The project plan includes three phases: (1) *Define & Determine*, (2) *Discover*, and (3) *Design & Disseminate* (Figure 1). The goals of **Phase 1** are to (1) generate profiles of engineering educators according to their course transformation efforts and (2) identify PDs within the engineering education community. Phase 1 includes the following activities: literature review, secondary data analysis, survey development, survey dissemination, and cluster analysis of survey results. The findings from the literature review and secondary data activities laid the foundations for our survey development. We will conduct a cluster analysis of survey results to *define* course transformation efforts and to identify the PDs. To learn from these educators, **Phase 2** is designed as a multiple case study with PDs to *discover* the individual change stories of each of the educators. We will concurrently facilitate a collaborative inquiry with engineering faculty, the peer community members. The collaboration with engineering faculty is a central part of the PD approach, providing them with opportunities to engage with the data and analysis from the multiple case study and reflect on how it relates to their own context. **Phase 3** will focus on community-developed and led *dissemination* and propagation activities to amplify the stories of PDs and the overall results of the first two phases. Engineering faculty participants from Phase 2 will co-*design* and facilitate dissemination activities for their local communities (e.g., departments, fields). By making the change efforts visible and engaging in community-developed and led education activities, Phase 3 aims to empower current and future engineering educators.

This paper presents findings from Phase 1 *Define* activities: (1) a literature review exploring course and curricular transformation, (2) a qualitative analysis that connects literature with the narratives of educators who have transformed their courses, and (3) initial survey development. The paper concludes with a discussion of the project's future work.

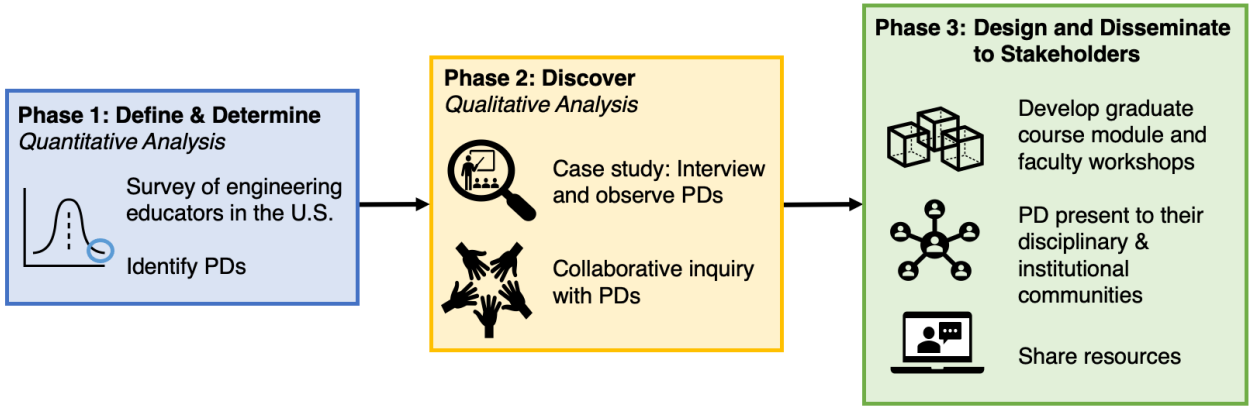

Figure 1: Project Overview

3.1 Literature Review: Curricular Transformation in Engineering Education

To establish the theoretical foundation for examining curricular transformation in engineering education, we conducted a literature review drawing on research from engineering education and broader higher education scholarship on instructional change, institutional context, and professional agency [23]–[25]. The aim of this review was not to catalogue specific pedagogical innovations, but to synthesize conceptual frameworks that explain how curricular transformation is constrained and enacted in higher education settings. Prior work in engineering education emphasizes that instructional change is embedded within organizational systems shaped by disciplinary norms, reward structures, and institutional cultures, which collectively influence the conditions under which faculty pursue change [13], [26]–[28]. In parallel, education research has theorized professional agency as a key mechanism through which individuals, such as faculty, interpret and act within these institutional conditions [29]–[32].

Across the engineering education literature, curricular and instructional change is often framed in terms of structural and institutional barriers, including entrenched disciplinary norms, misalignments between faculty teaching and learning beliefs and institutional priorities, and limited organizational support for experimentation and sustained reform [28], [32], [33]. Research on educational change further demonstrates that faculty engage in sensemaking processes, interpreting reform efforts through their local contexts, professional identities, and prior experiences, which shape how change initiatives are taken up or resisted [34], [35]. Empirical studies in engineering education show that educators involved in change efforts often experience tensions between their instructional values and the norms they perceive as dominant within their institutions, which in turn influence both the scope and sustainability of reform efforts [27], [28], [33], [36], [37]. These patterns suggest that understanding curricular transformation requires attention not only to institutional structures, but also to how beliefs and identities mediate educators' engagement with change.

Research on learning beliefs offers further insight into these dynamics by showing that misalignments are not limited to faculty–institution relationships but also occur between faculty and students [38], [39]. Studies in engineering education contexts reveal persistent differences in learning beliefs, particularly in self-regulation, constructivist conceptions of knowledge, and tolerance for uncertainty, that can complicate the implementation of non-traditional or student-centered curricula [34], [37]. Such belief misalignments indicate that curricular transformation

unfolds within complex sociocultural systems involving multiple stakeholders whose expectations and assumptions may not align [38], [39]. These findings help explain why instructional change often encounters resistance even when supported by strong empirical evidence.

Literature on professional agency provides a complementary theoretical perspective by centering educators as active agents who interpret, negotiate, and act within their sociocultural and institutional contexts [27]. Foundational scholarship conceptualizes professional agency as relational, context-dependent, and temporally embedded, emphasizing the dynamic interplay among individual intentions, professional identity, and structural conditions over time [27], [40], [41]. Building on this foundation, research in engineering education conceptualizes professional agency as a dynamic, cyclical process comprising awareness of contextual constraints, recognition of available resources, strategic "moves," and iterative action informed by feedback and perceived impact [42]. Related work using the PD approach highlights that meaningful educational change often emerges from locally situated actors who implement uncommon yet successful practices under shared constraints, and that these practices are inherently context dependent [43]. Together, these perspectives underscore the importance of examining how educators interpret their professional environments and exercise agency in enacting curricular transformation despite systemic resistance.

This literature review highlights the importance of closely examining how educators interpret their professional environments and exercise agency in implementing curricular change despite systemic resistance. By identifying gaps in how professional agency is emphasized in studies of instructional change, the review directly informed the project's focus on analyzing educators' narratives to understand curricular transformation from the perspective of those enacting it. This synthesis further underscores the relevance of connecting professional agency with a PD approach, which emphasizes locally situated change driven by individuals who succeed despite shared constraints [43]. Accordingly, we define PDs as active agents in engineering education who interpret, negotiate, and act within their sociocultural and institutional contexts to enact curricular transformation despite misalignments between their instructional values and institutional norms.

3.2 Secondary Data Analysis: Narratives of Transformational Educators

To further explore our conceptual definition of a PD for this project, we conducted a secondary qualitative analysis of interview narratives from engineering educators who pursued course transformation. This activity accomplished two objectives: (1) capturing the interplay between the agency of educators and their professional contexts as they pursued curricular changes and (2) exploring recurring patterns across the narratives. Published narratives from prior studies were selected as analysis data [44]. Analysis followed an iterative process of coding, categorizing, theme generation, and team discussions.

Across the narratives, we identified three patterns: 1) beliefs about supporting students and critical reflections on their teaching, 2) ingenuity that creates new possibilities, and 3) intentionality of change efforts. That is, course changes that misaligned with institutional norms were based on the intentional actions of educators to reflect their instructional values and were sustained through adaptation to locally situated dynamics.

First, the educators in this analysis were driven by strong beliefs about supporting students and critical reflections on their teaching and the system of engineering education. For some, this motivation appeared as a desire to rewrite racial and gender injustice [44, pp. 9–25, 81–90], while for others, it was about engaging in a continual improvement in their teaching and the experiences of their students [44, pp. 39–44, 69–90]. This theme contrasted paradigms that rely on passive adoption of evidence-based practices and demonstrated faculty members' agency toward transforming their courses to achieve their instructional goals. For instance, one educator sought to unveil gendered biases in the textbooks used in a core engineering course. This transformation successfully improved critical thinking skills of students as they "learn[ed] to push a little harder on some of other [assumptions within engineering education]" [44, p.16]. Even the instructional changes that could be viewed as "random" like teaching outdoors successfully created interactive moments for one educator and their class, as students "felt a whole lot more comfortable…ask[ing] questions" [44, p. 85].

Second, the ingenuity of transformative educators was a unifying driver of course changes across different professional contexts. As educators narrated their journeys, they attributed their achievements to the factors often overlooked in the diffusion paradigm. The most visible ingenuity was leveraging students' experience and knowledge, rather than teaching methods developed outside their classrooms [44, pp. 9–25, 39–44, 69–90]. Embracing flexible course structure and collaboration with students, educators effectively captured students' comprehension of the course materials [44, p.75]. Additionally, the ingenuity, coupled with the awareness of broader social context, enabled these educators to discover resources outside their professional context. For example, a liberal art college supported their efforts to teach students how to think about engineering from interdisciplinary perspectives [44, p.16] and the "accumulation of all [their non-academic] experience" was vital for designing effective project-based courses [44, pp.41–42].

Finally, the educators highlighted the intentionality of their change efforts. Educators who pursued course changes despite misalignment with institutional norms consistently described the changes as a means to address specific problems, rather than as changes for change's sake. These problems were often tied to structural or cultural limitations in engineering education that constrained student learning. Hence, transformation in this sense was framed as a strategic and intentional response to perceived challenges rather than an isolated adoption of new pedagogical techniques.

The significance of our narrative analysis is twofold. First, the three narrative patterns illustrate how curricular transformation emerges from the dynamic interdependence between instructional values of educators, interpretations of their professional contexts, and the structural conditions in which they operate and navigate. Second, the connection between our literature review findings and the lived experiences of engineering educators demonstrates the relevance of professional agency theory to our project on faculty capacity to pursue curricular transformation.

4 Survey Development

Building on the findings of the literature review and secondary data analysis, we developed a survey to be distributed nationally to engineering faculty. The primary goal of the survey is to help us identify faculty members who have engaged in meaningful course-level change efforts and to characterize the contexts in which these efforts have occurred. As such, the results will allow us

to characterize the unifying and distinguishing characteristics of educators pursuing these efforts and to identify the educators who will be recruited for the next phase of the project.

Our survey consists of four main sections. The first section explores the characteristics of one meaningful change the educator made during their career, including perceived barriers, motivations, and desired outcomes. Items developed for this section were primarily informed by the work of Palmer [45]. The second section captures the sociocultural context of the changes and the faculty's individual perceptions of that context. Items from the second section were informed by the *STEM Faculty Instructional Barriers and Identity Survey* [4]. The third section was designed to collect institutional and course-related information (e.g., course size, department type, instructional modality, and course level). Lastly, the fourth section asks for the faculty's professional and demographic information.

All survey items were developed following an iterative process involving generation or editing, individual review, group discussion, and modifications. The full survey was later reviewed, via a cognitive walkthrough, by three faculty project advisors whose feedback informed further refinement. To evaluate face and content validity, we further conducted cognitive interviews with two chemistry and one math faculty in different regions in the U.S. These interviews resulted in feedback on item clarity, interpretation of wording and response scales, and the cognitive effort required to complete the survey.

The refined survey was piloted to nationally with 57 non-engineering STEM educators contacted through professional organizations and university department chairs. Results from the pilot helped us improve the clarity of the items, structure the full survey, and remove confusing or redundant items. Three major revisions were implemented. First, we added initial screening questions to ensure we were receiving responses from faculty located in the U.S. who had taught engineering courses. Second, we added an open-ended question for faculty to share the influence of their personal background on engaging in change. Third, we removed items from the second section (i.e., sociocultural context). In particular, we removed the subsection covering perceptions of departmental beliefs about learning. We removed the subsection for two main reasons: 1) low reliability coefficient, and 2) wording that was redundant with items covered in other sections. The structure of the final survey can be seen in Appendix 1.

5 Survey Dissemination and Future Work

Our survey is being disseminated in Spring 2026. To reach a broad range of educators from diverse backgrounds, we curated a database of a) academic deans from engineering colleges, b) professional societies, c) NSF awardees from projects related to curricular change, and d) authors of articles on pedagogical change. We emailed each contact individually. Additionally, survey respondents had the opportunity to nominate other faculty to answer the survey. We will complete Phase 1 by conducting cluster analysis of survey results to generate profiles of engineering educators engaged in curricular and/or course transformation. Using the resulting profiles, we will identify 8-12 educators who embody the definition of a positive deviant in engineering education. In 2026-2027, we will move into Phase 2 where we will learn from and with these innovative educators.

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Appendix

Section	Subsections	Total Items
Screening		3
Detail about change	Focus of innovation	7
	Influence to innovate	7
	Barriers to innovation	13
	Outcomes of innovation	11
Sociocultural Context	Institutional beliefs about student engagement in learning	6
	Institutional beliefs about teaching and learning	7
	Personal beliefs about student engagement in learning	6
	Personal beliefs about teaching and learning	7
Course Information		10
Individual's background	Professional	8
	Demographic Information	4

Appendix 1: Structure and Content of Survey

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