One size does not fit all: Understanding how faculty implement evidence-based instructional practices in their engineering courses

Amy L. Brooks
School of Civil and Construction Engineering
Oregon State University
Corvallis, OR
brookamy@oregonstate.edu

Shane A. Brown
School of Civil and Construction Engineering
Oregon State University
Corvallis, OR
shane.brown@oregonstate.edu

Prateek Shekhar
School of Applied Engineering & Technology
New Jersey Inst. of Technology
University Heights, NJ
pshekhar@njit.edu

Kevin Heath
School of Civil and Construction Engineering
Oregon State University
Corvallis, OR
kevin.heath@oregonstate.edu

Heydi Dominguez
School of Applied Engineering & Technology
New Jersey Inst. of Technology
University Heights, NJ
hld6@njit.edu

Jeffrey Knowles
School of Civil and Construction Engineering
Oregon State University
Corvallis, OR
jeffrey.knowles@oregonstate.edu

***Abstract*—This Work-In-Progress paper summarizes insights from early research activities related to a National Science Foundation (NSF) Improving Undergraduate STEM Education (IUSE) project investigating faculty adoption of evidence-based instructional practices (EBIPs) in engineering classrooms. We are investigating EBIPs in engineering classrooms because, although instructors are interested and willing to adopt them, uptake by engineering faculty is lagging. To understand what is driving limited incorporation of EBIPs, our research objectives are anchored in our overlying goal of examining the lived experience of engineering faculty as they seek out and try innovative teaching practices (i.e., EBIPs) in their courses. This paper reports insights from early exploratory interviews with engineering faculty around their experiences with trying EBIPs. We report on general patterns observed during the early stages of our analysis of the interview transcripts with three engineering faculty (*n* = 3). We discuss how our analysis informs the next steps of our overarching investigation and briefly discuss the broader significance related to the context of faculty approaches for implementing EBIPs into their engineering courses.**

Keywords—faculty development, evidence-based practice, instructional change, qualitative analysis, interviews

I. INTRODUCTION

This NSF IUSE project seeks to advance understanding of faculty adoption of evidence-based instructional practices (EBIPs) into engineering classrooms. Research suggests that faculty are both interested and willing to adopt EBIPs [1], yet historically, their interest has not transitioned into successful incorporation of them into their courses [2, 3]. Barriers to EBIP adoption include lack of familiarity among faculty members and limited time available to them for developing their classroom practices [4]. In facing these obstacles, faculty would benefit from content-specific resources around how to implement EBIPs in their classrooms. Further, adoption of new teaching practices is often influenced by context [5-7], suggesting that providing resources that work within local and individual conditions are key to successful adoption of EBIPs. As such, faculty implementation of EBIPs need to be facilitated by increasing the availability of usable materials that scaffold faculty in their course development process. However, there is lacking research addressing what the specific contextual needs of faculty are, as well as the processes by which faculty attempt to implement EBIPs within their local conditions.

To address this gap in knowledge, we aim to understand the contextual and individual challenges, and successes, faculty encounter when developing their engineering courses to implement EBIPs. To meet this objective, we are collecting data about contextual barriers, affordances, and decision-making processes faculty experience when incorporating EBIPs into courses from a nationwide sample of engineering faculty members. Ultimately, we will use this contextual knowledge to develop strategic and collaborative scaffolding to assist a group of engineering faculty members, which will include both hard and soft scaffolding strategies. Hard scaffolding will aim to mitigate known challenges to adopting EBIPs such as lack of familiarity with EBIPs [8] or student resistance [9-11]. To meet the contextual needs of individual faculty, we will incorporate soft scaffolding which aims to support modifications of instructional innovations to meet local needs, which has been shown to greatly influence the fidelity of implementation of EBIPs [12].

As part of our early research activities, our primary objective with this study was to survey and interview participating faculty to investigate context-specific barriers, affordances, and decision processes faculty experience as they seek out and attempt to modify their courses to inform future activities for meeting our overarching research goals. To investigate these experiences, this study was guided by Situated Learning Theory (SLT), which was originally introduced by Lave and Wenger [13] and aims to acknowledge the role of social interactions in learning as it relates to the local context. Unlike traditional approaches in which learning occurs from the abstract, non-contextual experiences (e.g., books, lectures, etc.), SLT posits that learning occurs through interactions with other individuals and connections with a learner's own contextual experiences [14]. In the context of the study presented here, the SLT perspective suggests that efforts to promote innovative teaching practices among engineering faculty should move beyond simply conveying generic information about teaching practices to purposefully situating the instructors as active participants within their own authentic teaching experiences and contexts. If our understanding of current faculty's contextual barriers, affordances and decision-making processes related to course development for EBIPs remains unclear, the ability to holistically facilitate the adoption of EBIPs will continue to stagnate. As part of a broader research project, we aim to fill this knowledge gap by generating empirically informed resources for engineering faculty as they navigate incorporating EBIPs in their course(s) in their unique local contexts.

II. Summary of Data Collection & Analysis

A. Participants

Engineering instructors were identified through the authors' professional networks and were contacted directly to invite them to participate in the study. In this Work-in-Progress (WIP) paper, we present early findings of data collected from three professors (n = 3) who had varied roles, institutions, and teaching experiences. All participants were tenured or tenure-track faculty members. Two of the participants were based in a civil engineering department at a large, research-focused institution, and one participant was based in an engineering department at a small teaching-focused university. All three participants had 10-15 years of teaching experience. To protect confidentiality of participants, all direct and indirect identifiers were anonymized, and participants were assigned pseudonyms by the authors (Table I).

B. Data collection

We used semi-structured interviews for collecting data from the three participants. These interviews have centered on probing faculty experiences with trying new instructional practices in their courses by asking open-ended questions. While the semi-structured approach encouraged open discourse with our participants, the interview protocol was structured to elicit information regarding participants' teaching background, process(es) for trying different teaching approaches, and experience(s) with revising their courses. Sample prompts from the protocol included the following:

1) Tell me about your teaching experience in engineering.

2) How do you typically choose course/classroom activities?

3) Tell me about a time you revised your instructional practices for your course(s).

4) What made changing your approach challenging/easy?

5) What resources have you used in the past to inform your course design?

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TABLE I. Summary of Participants' Positions, Institutions, and Teaching Experience

Pseudonym	Current position	Institution type
Brandt	Associate professor	Research-intensive
Nick	Professor	Research-intensive
Steven	Professor	Teaching-focused

With the exploratory nature of these interviews, we also concluded them by asking directly if there was anything about their instructional approaches and course revision process that they wish they had been asked. Prior to data analysis, the three interviews were machine transcribed and checked for accuracy against the audio recordings by the lead author.

C. Data analysis

Given that decisions about instructional innovations and course revisions hinge on local contexts, the three interview transcripts were qualitatively analyzed as individual cases. Data analysis was performed primarily by the first author, with collaborative review by co-authors. The first stage of analysis established general trends within the individual interview transcripts while also familiarizing the author with the interview content and language used by the participating faculty members. Initial trends were presented and reviewed by the co-authors. Multiple passes were made through the transcripts and inductive coding was used to identify salient codes and themes within each individual interview. First cycle coding methods comprised of an exploratory, flexible, and iterative combination of initial, process, emotion, in vivo, and versus coding methods [15]. Examples of first cycle codes generated in this study are shown in the table below (Table II).

After exploratory first cycle coding, we transitioned to dramaturgical coding, which is useful for exploring participant experiences and actions in case studies [15]. This method was used to identify super-objectives (i.e., primary instructional goal), objectives, obstacles, strategies, attitudes, emotions, and subtext within each of the interviews. Examples of dramaturgical codes are provided in Table III. Finally, focused coding was used to establish the salient trends within each interview [16]. We present the results for each participant to highlight their particular experiences and concerns holistically, similar to a case-based approach. This structure facilitates broader reader understanding of these individuals' contexts and overall approach to adoption of new instructional practices.

TABLE II. Examples of Exploratory Codes

Coding method	Example codes
Initial	NUMBER OF STUDENTS PROBLEM SOLVING
Process	ENGAGING STUDENTS RECEIVING FEEDBACK
Emotion	FRUSTRATED EXCITED
In vivo	"WINGING IT" "IN THE TRENCHES"
Versus	QUANTITATIVE vs. QUALITATIVE INSTRUCTION SUCCES vs. FAILURE

TABLE III. EXAMPLES OF DRAMATURGICAL CODES

Coding method	Example codes
Super-objective	GET AND KEEP STUDENTS ENGAGED HUMANIZE ENGINEERING
Objectives	BE PREPARED AND DELIBERATE IDENTIFY THE “CRUCIAL” TOPIC
Obstacles	“RIGHT” METHOD UNEXPECTED RESPONSIBILITIES
Strategies	REUSING COURSE MATERIALS COLLABORATING WITH COLLEAGUES
Attitudes	IT’S HARDER TO “WING IT” ONLINE IT WAS A “WILD RIDE”
Emotions	OVERWHELMED PROUD
Subtexts	REMINISCING DOUBTING ABILITIES

III. PRELIMINARY FINDINGS

Across the three participants, a total of 126 minutes of audio recorded interview data were collected. Our participants from research-intensive institutions, Brandt and Nick, tended to focus on their experiences with mechanics of teaching such as course logistics, incorporating relevant and current technologies into their classes, and interactions with specific innovative teaching strategies. While these topics were similarly discussed during the interview with Steven, who was based at a teaching-focused institution, they served primarily as a foundation on which Steven experienced abstract connections between teaching and the components of his role as a faculty member such as his identity, beliefs, educational aspirations, and role in the greater culture of both education and engineering. Below, trends observed within the individual participant interviews are discussed.

A. Case #1: Brandt

Throughout Brandt’s interview, both his decision-making processes and reflections on past attempts to change his approach were centered around the ultimate objective of getting and keeping his students engaged. Brandt situated his experience of trying something new in his course(s) around his efforts to adapt his instructional approaches to meet changing classroom modalities and resulting demands due to COVID-19. In discussing trying something new in his courses, he described incremental changes he has made in recent years that ranged from simply using more online technology such as Zoom polls and online quizzes to purposefully be more deliberate and specific with his class preparation to ultimately address difficulty in engaging students online. While many of his decisions were driven by feedback from the students, which was particularly lacking in virtual classes, his interview responses suggested a feeling of isolation in knowing what to do and if what he was doing was ‘right’.

While Brandt indicated difficulty in reading students’ reactions to his teaching strategies in online modalities, he noted that there are lessons to be learned from the course adaptations made for COVID-19. Brandt seemed to feel that technology could serve as both a tool for advancing his teaching techniques as well as an impediment to efficiency and engaging students equitably. He expressed concern that students can have varying degrees of access to technology in in-person class environments, but this inconsistency is dampened in online modalities because if they are logged in, he knows that they are ‘ready to go’ on the computer. To address his uncertainty about what to do in his courses, he described discussing tactics with colleagues, exploring institutional resources like the Center for Teaching and Learning (CTL), and spending time reading and researching activities to implement. In discussing his experience with seeking out resources (e.g., seminars, course templates, etc.) from his institution’s CTL, he expressed a dulled interest due to lacking transferability to his engineering courses. Despite these efforts, he frequently suggested that they were too generic and not applicable to the specific needs he has in his engineering classes and even lamented feeling bored in instructional training. *“...some of the times when I...attend, ...I'm completely bored because, yes, I've heard of this story, but it doesn't apply to me. It's so generic that it's not so useful.”* Given our SLT positioning that acknowledges the importance of local context, Brandt’s concerns about transferability of CTL resources to the needs of his engineering classes makes sense. To address this challenge with boredom, easily modifiable materials that actively engage faculty in their own local environment as suggested by Henderson and Dancy [4] may help overcome barriers related to interest, familiarity, and time that might otherwise dissuade faculty members from adopting of innovating teaching strategies.

B. Case #2: Nick

During Nick’s interview, motivations to try new teaching approaches in his courses were often framed as a reaction to external influences such as advancements in industry and relevant technology, student feedback, unexpected changes in institutional needs, and collaborating with colleagues. Nick’s willingness to adapt new instructional strategies was often exhibited through his efforts to incorporate the most current software and technology into his course, so that students “*kind of see what the state of the practice is”* and *“go out and be comfortable that they have enough theory of [how] people are doing it now, but also how are people gonna be doing it five, 10 years from now?”* While Nick suggested that incorporating technology into his classes has been well received, he also explained that he found it difficult to evaluate teaching strategies to know that they are accomplishing the learning outcomes he has been aiming for beyond just anecdotal feedback from students. Even with some familiarity with literature on instructional innovation, his lack of expertise and different demands on time meant that there has been little opportunity to conduct what he viewed as reliable, rigorous evaluation of his efforts. This uncertainty around what works may have led to feelings of isolation, overwhelm, and ultimately less confidence around trying new things: *“...I'd say that's, that's the part that I struggle with is, how to like, formally, really verify that and have confidence that, ‘Yes, this did make it’ aside from anecdotal, you know, the conversations with students.”*

Adapting to departmental changes was more complex, but Nick described ways he had successfully navigated and adapted to these demands. In discussing an experience with an unexpected increase in class size near the start of a semester, he explained described it as a ‘wild ride’ that essentially forced him to adapt. Notably, challenges with reacting to these external changes were mitigated by support from others including teaching assistants, co-teaching, and group collaboration on instructional methods. He described ways that he and his co-instructors have adapted the course since their first attempt at teaching it such as adjusting the timing for introducing different activities throughout the term, how they assess student understanding with quizzes and exams, and how they tie laboratory exercises with the course material. Similarly, for another course, Nick worked closely with other engineering faculty to co-develop resources for their students. He highlighted the utility of his colleagues' varied perspectives. In describing a co-teaching experience, he explained, *"That's one thing I think that's really helped, is having a lot of different people kind of looking at the content and making sure things are understandable as, as we kind of update some of those things."*

C. *Case #3: Steven*

As mentioned previously, Steven's interview tended to have a more abstract focus on experiences related to his decision-making and processes used to innovate in his classes. Steven's overarching goal for his instructional approach was to humanize engineering courses, and many of his attempts to try new teaching strategies were driven by this sentiment. Underlying his goal was a deep connection between Steven's teaching and identity as an engineering faculty. In discussing his knowledge of educational research that relies on experimental trials, he contrasted, *"With teaching, it's me. So, I think the big evidence that I always know about is, 'Am I connected to this?'.* For Steven, purposefully feeling connected to his teaching approaches gave him more confidence, which was particularly useful in what appeared to be resistance to the status quo in traditional teaching methods: "*I…saw that I was just sort of perpetuating the system in my classes by 'Concept. Concept. Apply the concept. Rinse. Repeat.' There wasn't really anything that was sort of this great service to the world."*

Beyond the connection that Steven drew between his teaching approach and identity, he also discussed more concrete barriers and affordances to his decisions to innovate. For example, he felt demotivated to innovate when he suspected that an activity or topic might require more grading, but notably positioned this discouragement as a desire to balance home life: *"…innovation comes at a cost. I am provided the same amount of release, whether I teach the course with no innovation versus whether I'm generating. So any time—I think of all things as a time commitment."* Because of this conflict with committing his time to teaching versus his own wellbeing, Steven sometimes chose teaching practices based on efficiency and pragmatism. In a similar manner, Steven suggested conflict between wanting to innovate while also feeling trepidation around how students would react. While he felt confident in his course content, he expressed worry that if students are unsatisfied with his teaching practices, then his teaching evaluations might suffer. Because teaching evaluations influence promotion, the high stakes perception of them may drive faculty members to select practices that reward what students like. Students show resistance when they experience instructional innovations that do not meet their expectations of what they expect to be a mode of instruction in engineering courses [17]. Conceptually, Steven seemed to convey a high risk, low reward situation wherein spending time developing innovative instructional approaches could potentially penalize his career if they were not well-received by students, and only be rewarded with a 'pat on the back' at best. This hesitation to transform teaching practices is driven by a complex culture within engineering and academia that is outside the scope of the present WIP study, but regardless may stifle instructional innovation and will be explored in future research activities that are part of the larger project goals

IV. Next Steps & Broader Significance

This preliminary phase of our project has elicited early findings regarding faculty processes and experiences with trying new instructional practices and revising their courses. While we focused on individual cases, we find some early themes across our participants. First, despite similarities across the participants, their differing local conditions, personal preferences, and course topics lend to a complex process of decision-making when it comes to trying new teaching approaches in the classroom. Second, it is evident that our participants have a desire to know and apply innovative teaching strategies, but they often felt uncertainty around knowing what the 'right' method is for their context, and if it is working in their classes. Borrego, et al. [2] have shown quantitatively that familiarity of EBIPs is one of the key barriers to their adoption. Before innovating in their courses, faculty members need to know not just what methods are established and work, but also how to implement and operationalize them in their own courses. Third, past research has shown that engineering faculty see scaffolding techniques as necessary for their students in order to encourage autonomy [18]. However, it is evident that engineering faculty members themselves could benefit from scaffolding in order to support, improve, and adapt their instructional methods in ways that are appropriate for their contexts. Our participants all independently supported the idea of external assistance and/or evaluation. This need for guidance and feedback on their teaching practices could be met not just through a community of teaching innovation but also as Steven put it, 'building community around the messiness of teaching'.

Notably, our participants in the present study share some demographic and professional characteristics, however, the broader objectives of our project specifically aim to amplify a diverse range of voices and representation across institution types. All the participants were relatively experienced with teaching engineering courses which may have led to greater confidence in adapting their course approaches. Further, all three participants obtained tenure by the time of their interview, which can lead to the feeling more freedom and increased access to resources and time to explore and take risks in their courses [19]. To further examine contextual influences on teaching practices, future data collection related to this project will involve purposeful sampling from a broad range of participants both in terms of demographic backgrounds as well as experience teaching, institutional types, academic rank, etc. Given the complex revelations that emerged from our interviews with participants who had similar teaching experiences, we anticipate unpacking a wide variety of narratives around making sense of what it means to innovate in the classroom as we interact with more participants as part of the broader research project. Our early findings demonstrate the range of contextual variation that engineering faculty members face that undeniably inform their decision-making processes around what to try in their classrooms and confidently knowing that it works.

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