Bridging the Gap: Exploring Real-Life Experiences of Engineering Faculty in Implementing EBIPs

Stephanie Adams, Oregon State University

Stephanie Adams is currently enrolled as a doctoral student at Oregon State University, where she is working towards her PhD in Civil Engineering with a concentration in Engineering Education. Her current research focuses on the adoption of evidence-based instructional practices (EBIPs) among engineering faculty members. Additionally, she is investigating the identity development of engineering students in capstone courses.

Dr. Shane A. Brown P.E., Oregon State University

Shane Brown is an associate professor and Associate School Head in the School of Civil and Environmental Engineering at Oregon State University. His research interests include conceptual change and situated cognition. He received the NSF CAREER award in

Aturika Bhatnagar, New Jersey Institute of Technology

Aturika Bhatnagar is currently pursuing her doctoral studies in Industrial Engineering at the New Jersey Institute of Technology. She holds a Bachelor of Engineering degree in Electronics and Communication, as well as a Master of Engineering degree in Industrial Engineering and Management. Her research is in the area of engineering education and focuses on the development of instruments and advancements in entrepreneurial education.

Dr. Prateek Shekhar, New Jersey Institute of Technology

Prateek Shekhar is an Assistant Professor – Engineering Education in the School of Applied Engineering and Technology at the New Jersey Institute of Technology. He holds a PhD in Mechanical Engineering from the University of Texas - Austin, an MS in Electrical Engineering from the University of Southern California, and a BS in Electronics and Communication Engineering from India. Dr. Shekhar also holds a Graduate Certificate in Engineering Education from Virginia Tech. Prior to his current appointment, he worked as a Postdoctoral Researcher and Assistant Research Scientist at the University of Michigan. He is the recipient of the 2018 Outstanding Postdoctoral Researcher Award at the University of Michigan; and serves as a PI/Co-PI on multiple projects funded by the National Science Foundation. He currently serves in editorial capacity for the Journal of Women and Minorities in Science and Engineering, International Journal of Mechanical Engineering Education, and Journal of International Engineering Education.

Jeff Knowles, Oregon State University

Dr. Jeff Knowles is an engineering instructor at Oregon State University who began teaching courses in 2015. His current pedagogical research is related to barriers associated with implementing Evidence-Based Instructional Practices (EBIPs) in STEM-related courses and determining what affordances can be granted to overcome such contextual obstacles. Jeff's interests also include the numerical modeling of nonlinear wave phenomena.

WIP: Bridging the Gap: Exploring Real-Life Experiences of Engineering Faculty in Implementing EBIPs

Abstract

This Work-In-Progress paper presents early research findings from a project funded by the National Science Foundation (NSF), aimed at Improving Undergraduate STEM Education (IUSE). This study, part of the larger IUSE project, focuses on the integration of evidence-based instructional practices (EBIPs) among engineering faculty members. This investigation into EBIPs in engineering classrooms is motivated by the observed disparity between faculty interest and their actual adoption rates. The research objectives center on examining the real-life experiences of engineering faculty as they implement innovative teaching methods, such as EBIPs, in their courses, aiming to gain a better understanding of the limited integration of these practices. This paper shares initial insights derived from exploratory interviews with engineering faculty regarding their adoption of EBIPs. This report highlights three engineering faculty (n=3) who have generally experienced success in implementing EBIPs within their classrooms. These patterns emerged through initial thematic analysis of their interview transcripts. This analysis emphasizes the significance of instructors' openness to experimenting with customized EBIPs suited for their unique teaching environments. Faculty who observed increased student engagement utilized real-world applications facilitated by extensive experience and institutional support. This study's findings point to the importance of adaptable teaching methods, emphasizing the need for instructors to tailor EBIPs to their specific teaching contexts. These results underscore the importance of individualized strategies for effectively adopting EBIPs into educational settings.

Introduction

As a part of the NSF IUSE project, this paper seeks to explore the limitations and successes of engineering faculty implementing EBIPs. Although earlier research indicates a willingness and interest among faculty to incorporate new instructional practices into their courses [1], they also highlight a deficiency in the success of such adoption [2], [3]. Barriers to adopting EBIPs include inadequate preparation time, content coverage concerns, unsupportive colleagues or departmental culture, limited professional development opportunities, negative student reactions, and misalignment with instructor reward structures [4], [5]. Instructors commonly cite a lack of time, especially the initial commitment required to transition from traditional lecture-focused methods, as a key obstacle to instructional change [6], [7]. In order to turn daunting barriers into instructional successes, engineering faculty and teaching training centers need to be intentional in planning for EBIP implementation success. However, there is a lack of research and information addressing what specific strategies lead to success in EBIP adoption for specific teaching contexts, including both in-class activities and out-of-class preparation and motivation.

To address these challenges, our research investigated proactive measures engineering faculty and teaching training centers can employ which are aimed at enhancing the successful adoption of EBIPs. To achieve this goal, data were collected which fit under any of the following criteria: (i) hindrances experienced by engineering faculty in adopting EBIPs, (ii) support that was given or measures the faculty took that helped implement EBIPs, and (iii) what type(s) of EBIP the faculty member utilized. This data was collected from engineering faculty members from various American institutions. From this data, faculty success stories were examined and evaluated for commonalities and specific success strategies.

Summary of Data Collection and Analysis

Participants

As a part of the NSF IUSE project, interviews with 69 engineering faculty members representing 47 distinct institutions, including both research and teaching institutions, were conducted. For this work-in-progress paper, we present findings from data collected from three professors (n=3) who exemplified successful adoption of EBIP despite encountering barriers. These participants were selected after the completion of all initial interviews, based on their demonstrated ability to navigate obstacles and achieve successful EBIP adoption. Among them, two held non-tenured track teaching positions, while the third was a tenured professor. All three were affiliated with R1 institutions, albeit in different departments, and taught courses with varying enrollment. Pseudonyms were assigned by the authors to provide participant anonymity (viz. Table 1).

Table 1. Participants' Pseudonyms, Positions, and Department Affiliations

Pseudonym	Position	Department
Charles	Full Professor	Mechanical Engineering
Michael	Teaching Professor	Chemical and Biological Engineering
Victor	Instructor	Industrial Engineering

Data Collection

Data collection involved employing semi-structured interviews with participants [8]. Each participant engaged in a pilot interview, as well as one to two subsequent interviews. Each interview focused on exploring the participant's experiences with attempting and integrating new instructional practices into their courses, utilizing open-ended questions to encourage free-flowing discussion and researcher reflexivity. Despite the semi-structured nature of the interviews, the interviewer also followed an interview protocol to extract information on specific topics from the participants [9]. These topics encompass teaching experience, EBIP selection, the implementation processes, and plans for future course revisions. Sample question prompts from the pilot interview protocol are provided below:

1. What motivated you to try a new EBIP?
2. Can you describe the process you used to implement that EBIP?
3. In your view, how did this new instructional practice go for your students?
4. What helped you implement or keep using that EBIP?
5. What could have helped you not stop using that EBIP?

Follow-up interviews were conducted to gain a more comprehensive understanding of the factors influencing EBIP implementation, as well as to learn about the specific barriers and successes experienced by each participant. The initial subsequent interview with each participant took place three to four months after the pilot interview. This timing allowed the participant to integrate new EBIPs into their course(s), assess their effectiveness, and plan for future revisions. Victor and Michael completed one more subsequent interview, four and five months later than their initial subsequent interviews, respectively. These third interviews, like the second, focused on evaluating the challenges and successes they had encountered with EBIP adoption within their contexts since the previous interview. Additionally, these sessions allowed participants to elaborate on initial responses, ensuring a nuanced understanding, and enabling researchers to confirm the reliability of the data. Similar to the pilot interview, these interviews were semi-structured to allow for organic discourse but also utilized the use of an interview protocol for the researcher to ensure specific topics were touched on. Sample question prompts from the subsequent interview protocol are provided below:

1. Are there any interesting comments or stories you want to share about implementing EBIPs from this current term?
2. Can you think of any barriers you might be facing?
3. What was most challenging about implementing EBIPs?
4. What successes have you had with using EBIPs?

All the interviews were conducted virtually and then machine transcribed and checked for accuracy.

Data Analysis

The eight interview transcripts were analyzed by the primary author and then the analysis was reviewed by co-authors. The data analysis process involved multiple rounds of coding of the transcripts. In the initial explorative and flexible round, codes were generated to capture a broad range of themes and patterns emerging from the participants' responses [9]. Then, dramaturgical coding, a method of analyzing the participants' experiences, was employed in the second round, specifically focusing on these experiences, including successes and challenges, to illuminate the narrative aspects of their EBIP adoption. [10]. Additionally, thematic analysis was incorporated. The analysis aimed to discern trends for each participant across their various interviews, providing a comprehensive understanding of the evolving dynamics and experiences throughout their specific EBIP adoption process [11].

Preliminary Findings

Across the three participants, nine interviews were conducted, resulting in 353 minutes of audio-recorded data. Charles, Michael, and Victor, all faculty members at R1 universities, demonstrated diverse faculty experiences in implementing EBIPs. Each educator emphasized integrating real-life examples, occasional competitive elements, and engagement techniques to enhance student participation in their respective classes. However, they encountered unique challenges: Charles grappled with finding suitable examples for complex subjects, Michael faced difficulties in evaluating group work, and Victor navigated issues related to student engagement in the classroom as well as semester-long projects. Despite these challenges, all participants highlighted the significance of tailored strategies and a commitment to continuous pedagogical improvement.

They each touched on the need for external training in new teaching strategies and the need for motivation, both personal and departmental, in discovering and using new EBIPs. The trends observed with each participant are discussed below.

Case #1: Charles

Charles's adoption of EBIPs is characterized by a holistic approach that attempts to seamlessly integrate their extensive research background into their teaching philosophy. They prioritize equipping students with essential knowledge for research projects, employing a structured teaching methodology that includes organized lectures, independent problem-solving assignments, and engaging debates in classes like Energy Technology and Policy. Charles leverages their expertise in combustion and fluid mechanics to better engage his students through practical examples, fostering interdisciplinary education and critical thinking skills among students. His commitment extends beyond the classroom, with active participation in academic administration and a reflective perspective on their transformative journey from a theoretical student to a faculty member engaged in both research and teaching.

Despite these successes with EBIP implementation, Charles faced notable barriers when adopting new practices and activities. One significant challenge was finding appropriate examples for complex subjects, particularly in areas such as thermodynamics and fluid dynamics: *"The challenges… and barriers are more from a scientific point of view, it's coming up with the ideas."* He emphasizes the importance of practical demonstrations, like the dice rolling activity in a statistics and probability class, to make abstract ideas more tangible. However, the scarcity of quantitative and relatable examples for his thermodynamics and fluid dynamics classes posed a considerable obstacle. Charles suggested that learning from other educators or colleagues would prove helpful in improving EBIP adoption, but there is a lack of collaboration: *"A repository of good examples [would be useful] … Finding good examples that are not too complex… is hard.*" He shares that, from his perspective, there is a lack of instructors and institutions sharing their teaching practices, partially due to competition within academia. "*[Sharing ideas] would work only among friends. Unfortunately, we're not going to have one institution sharing teaching practices too much with others because that's our bread and butter, that's how we get paid.*" Additionally, the lack of adequate financial incentives from institutions to invest time and effort in refining teaching methods creates a motivation disparity between research and teaching priorities held by instructors. Charles' insights underscore the importance of recognizing and rewarding innovative teaching methods as a possible solution to the challenges posed by motivation disparity.

Amidst these challenges, Charles' implementation of EBIPs has witnessed notable successes. The incorporation of collaborative, open-ended problems in his teaching has enhanced his students' understanding of course materials, allowing them to dive deeper into the subject matter. His ability to seamlessly integrate engineering and policy perspectives in classes like Energy Technology and Policy fostered engaging debates among students, providing them with a comprehensive understanding of real-world challenges in an environment they can enjoy and engage with. *"[They started with] two-minute presentations. Then they asked questions and rebuttals to the other team… That was awesome. They all got excited!"* Charles shared his belief that letting students explore topics they find interesting and personally engaging increases their enthusiasm and participation in the course material. Additionally, the practical examples drawn from his combustion and fluid mechanics experience contribute to the accessibility of intricate concepts for students. Additionally, Charles vouches that success in implementing EBIPs lies in the teacher's motivation, the recognition of its transformative impact on students, and the creation of an environment that values and supports innovative teaching methods.

Case #2: Michael

Michael, an experienced educator with a background in chemical engineering and bioengineering, has devoted a decade to teaching and improving a variety of classes, employing a high-structure course design philosophy. His teaching methods include pre-class content acquisition, active learning, clicker questions, group work, and frequent formative assessments (such as quizzes). Michael places a strong emphasis on brief focused in-class activities and has undertaken extensive projects like the YouTube project. The YouTube project requires students to choose and watch a video and then devise a thermodynamic-related problem from the video's situation, aiming to engage students in real-world problem-solving scenarios.

Despite Michael's commitment to EBIPs, challenges arose in implementing them, particularly in the context of the YouTube video project. Difficulties included evaluating group work and providing comprehensive feedback, prompting Michael to seek support for seamlessly integrating teamwork and problem-solving skills into their teaching methodology. This challenge was compounded by resource limitations, specifically in terms of allocating additional teaching assistants or graders for project assessments. *"I just don't think I execute it well. And honestly, I don't enjoy it… Like having to grade 30 of these and give feedback, like I don't have fun doing that versus the in-class experience of the briefer types of active learning."* In the fall, Michael taught a class with about 140 students, approximately double the usual class size he taught, leading to grading challenges more extensive than in previous terms. His uncertainties about the educational value of the YouTube video project in the larger class context resulted in its exclusion for that semester.

Michael also highlighted the barriers of insufficient motivation and training which further hindered his desire and ability to find and adopt new and additional EBIPs into his classroom. *"I think that the motivation to initiate [EBIPs] is the hard part for me. If our teaching center had [collaborative guidance], I'd sign up and I'd probably be more likely to go to [the trainings]. I think that having a group of… external folks with different points of view would be even more exciting just because … I think [external viewpoints] could bring some uniqueness to the [class experience] for the students."* These insights suggest a significant gap in communication and responsiveness between instructors and the teaching center, as Michael's needs for collaborative guidance were not met. His decision to give up, realizing that the teaching center couldn't address his specific needs, implies a potential lack of awareness among instructors about alternative resources. It underscores the importance of the teaching center diversifying its resources and making them more easily accessible to serve a broader range of instructors' requirements. Michael's emphasis on the value of collaborative training, despite not having easy access to it, highlights the need for resources to be readily available and easily navigable for instructors seeking to enhance their teaching practices.

As mentioned before, in the fall Michael faced the unique challenge of teaching a significantly larger thermodynamics class with about 140 students. Despite initial concerns, the class proved to be Michael's most successful thermodynamics course up to that point, establishing a lively learning setting with exceptional attendance. The use of clickers for real-time assessments and group quizzes contributed to the positive outcomes, replacing a formal group project due to grading challenges. The students reacted to these real-time, interactive learning approaches positively. *"Just thinking of student evaluations… the vast majority of comments about the act of learning is positive. The students really do appreciate the interactive nature… it gives them a chance to see how they're doing."* Additionally, Michael's commitment to formative development time allowed students to actively collaborate in groups and develop problem-solving skills in class. This interactive approach highlighted the value students found in hands-on learning experiences. *"[The students] see the value. They're thinking on their own."* These successes, both in terms of the students' learning and enjoyment, underscored Michael's dedication to effective teaching practices and creating an engaging classroom.

Case #3: Victor

Victor has been actively guiding students through courses such as Probability and Statistics, Foundations of Engineering Lab, and a database class. His teaching philosophy for the lab class centers around project-based learning and collaborative efforts among students. To enhance engagement, Victor implements practical and engaging strategies into his classes such as Kahoot quizzes, interactive activities, and hands-on experiences with tools such as Arduino boards and sensors. Emphasizing conceptual questions in assessments, Victor leverages smart classrooms for collaborative learning and actively participates in peer observation programs for continuous improvement.

While implementing EBIPs, Victor encountered challenges specific to the Foundations of Engineering Lab. Communication issues among students engaged in semester-long projects, like constructing a robot, resulted in significant hurdles, including a lack of commitment, late submissions, and teams falling apart. *"We're focused on a project, and we have first-year students that have different skills… and commitments. Some students are more committed than others. I have senior students crying because they feel that the group is not responding as they want."* These student differences can lead to hard situations relating to time commitment and investment in the project. Simultaneously, the Probability and Statistics class, with an enrollment of nearly 140 students, faced time constraints that prevented the exploration of alternative teaching methods. This notably included the challenge of implementing an approach where students derive general formulas through their own thinking, with some faculty guidance during class, given the extensive nature of the course topics. To address these challenges, Victor implemented strategies such as creating smaller project groups and promoting teamwork in the lab class.

Victor, drawing insights from workshops and peer observations at the teaching center at his university, emphasized the necessity of tailored strategies for each class. Recognizing the complexities of time limitations and class material, he highlighted the importance of motivating students, particularly those resistant to change. In discussing a physical activity implemented in his Probability and Statistics class that involved a student push-up competition at the front of the room, Victor underlined the significance of motivating students through individual success: *"Maybe you're not the best in the class in academic terms, but you [may be] the best on this activity."* He used this rationale as a strategy for incorporating EBIPs and increasing student engagement in his classroom. This approach aimed to engage students by emphasizing personal achievement and capability beyond traditional academic measures.

Despite challenges, Victor experienced notable successes in adopting EBIPs. The integration of an iPad Pro for interactive engagement and group activities played a crucial role in encouraging collaboration since he was able to engage with students in various locations around the classroom during the problem-solving process. *"I bought an iPad Pro for my classes, and now instead of using the DocCam… I use the iPad… I'm walking in the classroom with the iPad, taking notes, and passing the microphone to students so they can participate more easily."* Also, Victor's introduction of real-life examples, occasional competitive elements, and engagement techniques significantly enhanced student participation during activities compared to regular lectures. One of the main successes Victor experienced was when he implemented a new engagement strategy by introducing color-coded indicators, allowing students to discreetly signal when they required assistance without interrupting their work. *"When a student had a question, they put a green [card] on their desk and the instructor knew that the student needed help or support… [The student] can focus on their problem and know that someone will see the color and will stop, rather than hand-raising when they cannot write."* Victor's proactive commitment to enhancing the learning experience and adopting new EBIPs is highlighted through his active involvement in conferences and workshops. By actively participating in these events, Victor indicated that he gained valuable insights into innovative teaching practices.

Broader Significance and Future Steps

The initial phase of this research project has provided valuable insights into faculty barriers and successes associated with adopting EBIPs and revising their courses. The findings of this study carry relevant implications within the field of engineering education. Common themes emerged, highlighting the complex nature involved when faculty members introduce new teaching approaches. All three participants expressed a desire for external support and training tailored to implement EBIPs in their courses, revealing a knowledge gap between theoretical awareness and practical application [12]. Additionally, needing both personal and institutional motivation for EBIP adoption, revealed a significant motivation disparity that influences instructional decisions [13]. Finally, each of the participants individually highlighted student-related barriers that impacted the adoption and continuation of EBIPs.

First, the identified knowledge gap between the academic research in engineering education and the integration of EBIPs into classrooms underscores the necessity of targeted professional development programs. Faculty members express a longing for training that focuses on innovative teaching methods, with positive feedback stemming from experiences in workshops and conferences dedicated to such practices [14]. To bridge this gap, there is a crucial need for training initiatives or mentorship programs that equip educators with the skills and support required to effectively implement innovative teaching approaches.

Addressing the motivation disparity among faculty and cultivating a supportive environment for change are key factors in promoting the widespread adoption of EBIPs, ultimately elevating the quality of engineering education. Recognizing and rewarding innovative teaching practices at the departmental level can serve as a powerful motivator for faculty members. All three participants underscored the importance of fostering a positive departmental culture to encourage the adoption and sustained use of EBIPs in the classroom.

Furthermore, participants identified implementation barriers related to students and the classroom. The logistical challenge of large class sizes was a common obstacle faced by all three participants in their efforts to integrate new EBIPs [15]. Additionally, Charles and Victor highlighted student resistance to new instructional practices as a significant barrier. Overcoming these challenges requires a comprehensive approach that addresses both faculty training and student engagement to successfully implement EBIPs in engineering education [16], [17].

Moving forward, sustaining, and expanding mentorship programs will be crucial in fostering a culture of continuous learning and support among faculty members. These programs can pair experienced educators proficient in EBIPs with those seeking guidance, creating opportunities for collaborative problem-solving and the sharing of effective teaching strategies [2]. Concurrently, professional development initiatives should persist, focusing on hands-on training that equips faculty members with practical skills to seamlessly integrate innovative teaching methods into their specific engineering courses. By providing ongoing support and fostering a community of practice, these programs can contribute to closing the identified knowledge gap between academic research and the practical implementation of EBIPs [18], [19].

Addressing the motivation disparity among faculty members remains paramount for the sustained adoption of EBIPs. Institutions should implement targeted strategies to boost faculty motivation, recognizing and rewarding innovative teaching practices at both the individual and departmental levels. This could include incentives, promotions, and acknowledgment of achievements in innovative pedagogy. Simultaneously, efforts should be directed towards creating more engaging classroom spaces. This could include establishing classroom environments with reduced sizes to help alleviate a logistical barrier identified in the study. Strategies to motivate students to engage with new instructional practices, such as active learning and collaborative projects, should also be explored. This involves integrating student feedback and designing courses that captivate and inspire, ultimately fostering a positive and dynamic learning environment that aligns with the goals of EBIPs. As these future steps unfold, a holistic approach encompassing faculty support, motivation strategies, and student engagement initiatives will contribute to the broader goal of enhancing the quality of engineering education through the effective integration of evidence-based practices.

Acknowledgement

The authors would like to express their gratitude to the participants who generously shared with us their time and insights and to the NSF for their funding that supports the IUSE project. This work is supported by the U.S. National Science Foundation through grant number 2111052. The opinions are those of the authors and do not necessarily represent the National Science Foundation.

References

[1] M. Borrego and C. Henderson, "Increasing the Use of Evidence-Based Teaching in STEM Higher Education: A Comparison of Eight Change Strategies," *J. Eng. Educ.*, vol. 103, no. 2, pp. 220–252, 2014, doi: 10.1002/jee.20040.

[2] M. Borrego, J. E. Froyd, and T. S. Hall, "Diffusion of Engineering Education Innovations: A Survey of Awareness and Adoption Rates in U.S. Engineering Departments," *J. Eng. Educ.*, vol. 99, no. 3, pp. 185–207, 2010, doi: 10.1002/j.2168-9830.2010.tb01056.x.

[3] C. Henderson and M. H. Dancy, "Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics," *Phys. Rev. Spec. Top. - Phys. Educ. Res.*, vol. 3, no. 2, p. 020102, Sep. 2007, doi: 10.1103/PhysRevSTPER.3.020102.

[4] M. Prince, M. Borrego, C. Henderson, S. Cutler, and J. Froyd, "Use of Research-Based Instructional Strategies in Core Chemical Engineering Courses," *Chem. Eng. Educ.*, vol. 47, no. 1, Art. no. 1, Jan. 2013.

[5] M. Andrews, M. Prince, C. Finelli, M. Graham, M. Borrego, and J. Husman, "Explanation and Facilitation Strategies Reduce Student Resistance to Active Learning," *Coll. Teach.*, vol. 70, no. 4, pp. 530–540, Oct. 2022, doi: 10.1080/87567555.2021.1987183.

[6] L. J. Carroll *et al.*, "Barriers instructors experience in adopting active learning: Instrument development," *J. Eng. Educ.*, vol. 112, no. 4, pp. 1079–1108, 2023, doi: 10.1002/jee.20557.

[7] H. Sturtevant and L. Wheeler, "The STEM Faculty Instructional Barriers and Identity Survey (FIBIS): development and exploratory results," *Int. J. STEM Educ.*, vol. 6, no. 1, p. 35, Oct. 2019, doi: 10.1186/s40594-019-0185-0.

[8] M. Miles, A. M. Huberman, and J. Saldaña, *Qualitative Data Analysis: A Methods Source*, 3rd Edition. SAGE Publication, 2014.

[9] J. Saldaña, *The Coding Manual for Qualitative Researchers*, Second Edition. Thousand Oaks, California: SAGE Publication, 2013.

[10] K. Charmaz, *Constructing Grounded Theory*, Second Edition. Thousand Oaks, California: SAGE Publication, 2014.

[11] C. Nancy, E. Douglas, and W. Hilson, "Qualitative Research Basics: A Guide for Engineering Educators." [Online]. Available: https://eer.engin.umich.edu/wp-content/uploads/sites/443/2019/08/Chism-Douglas-Hilson-Qualitative-Research-Basics-A-Guide-for-Engineering-Educators.pdf

[12] A. Brooks, K. Heath, S. Brown, H. Dominguez, P. Shekhar, and J. Knowles, "One Size Does Not Fit All: Understanding how Faculty Implement Evidence-Based Instructional Practices in Their Engineering Courses," presented at the IEEE Frontiers in Education (FIE), IEEE, 2022.

[13] A. Brooks, J. Knowles, E. Clement, S. Prateek, and S. Brown, "Are All 'EBIPs' Created Equal? An Exploration of Engineering Faculty Adoption of Nine Evidence-Based Instructional Practices," *ASEE Annu. Conf. Expo.*, 2023.

[14] J. Knowles, A. Brooks, E. Clement, P. Shekhar, S. Brown, and M. Aljabery, "A Qualitative Exploration of Resource-Related Barriers Associated with EBIP Implementation in STEM Courses," presented at the ASEE Annual Conference and Exposition, ASEE, 2023.
[15] E. Yerushalmi, C. Henderson, K. Heller, P. Heller, and V. Kuo, "Physics faculty beliefs and values about the teaching and learning of problem solving. I. Mapping the common core," *Phys. Rev. Spec. Top. - Phys. Educ. Res.*, vol. 3, no. 2, p. 020109, Dec. 2007, doi: 10.1103/PhysRevSTPER.3.020109.
[16] P. Shekhar and M. Borrego, "Implementing Project-Based Learning in a Civil Engineering Course: A Practitioner's Perspective," *Int. J. Eng. Educ.*, vol. 33, no. 4, pp. 1138–1148, 2017.
[17] L. G. Bullard and R. M. Felder, "A Learner-Centered Approach to Teaching Material and Energy Balances," *Chem. Eng. Educ.*, vol. 41, no. 2, p. 93, 2007.
[18] K. Friedrich, S. Sellers, and J. Burstyn, "Thawing the Chilly Climate: Inclusive Teaching Resources for Science, Technology, Engineering, and Math," *Improve Acad. J. Educ. Dev.*, vol. 26, 2008, doi: http://dx.doi.org/10.3998/tia.17063888.0026.013.
[19] N. Sabelli and C. Dede, "Empowering Design-Based Implementation Research: The Need for Infrastructure," *Teach. Coll. Rec.*, vol. 115, no. 4, pp. 464–480, 2013.