Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #45554

Cycles of Implementation and Improvement: How Reflection and Feedback Drive EBIP Use

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.

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

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.

Dr. Prateek Shekhar, New Jersey Institute of Technology

Dr. 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, National Institutes of Health, and Kern Family Foundation. He has served 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.

Dr. Maya Menon, New Jersey Institute of Technology

Maya Menon is a postdoctoral researcher at New Jersey Institute of Technology. She completed her doctoral degree in Engineering Education from Virginia Tech. She has an undergraduate degree in Computer Science from Arizona State University and graduate degree in Robotics and Automation from Amrita University. Her research explores how education can empower young engineers to address the world's toughest problems and work toward a sustainable future, with particular interests in interdisciplinary learning, real-world skill development, and faculty decision-making.

Cycles of Implementation and Improvement: How Reflection and Feedback Drive EBIP Use

Abstract

This conference research paper highlights that even though Evidence-Based Instructional Practices (EBIPs) are proven to enhance student learning in engineering education, many faculty struggle with their long-term integration. Reflective practices and feedback, though crucial for refining teaching strategies, have been underexplored in the context of sustained EBIP implementation. Addressing this gap can improve the ongoing success of EBIP adoption. This study examines how reflection and feedback between mentors and mentees contribute to the continued refinement and successful integration of EBIPs in engineering education. Using a grounded theory (GT) approach, this research analyzed data from faculty mentees and mentors involved in a mentorship program focused on EBIP adoption. The study explores how reflective practices and feedback loops create cycles of implementation, adjustment, and improvement. Regular feedback from mentors enabled mentees to address challenges and refine their EBIP strategies. The study found that EBIP implementation is not a straightforward process but involves cycles of reflection and adaptation, contributing to more sustainable practices. Reflection, guided by mentor feedback, also increased mentees' confidence and adaptive expertise, allowing them to modify EBIPs to suit their teaching contexts, helping to ensure long-term integration. Mentorship programs should include structured opportunities for reflection and feedback to support the ongoing success of EBIP integration. Institutions could also foster more sustainable EBIP adoption by providing resources for faculty to engage in reflective practices, allowing for personalized and context-sensitive implementation strategies. This conference paper's findings emphasize the critical role of mentorship in fostering sustainable EBIP adoption through structured reflection and feedback loops.

1. Introduction

Engineering education is at a pivotal moment where evidence-based instructional practices (EBIPs) have the potential to significantly improve student learning and engagement. Despite strong research showing that EBIPs lead to better student outcomes, increased motivation, and more effective learning experiences, widespread adoption remains difficult. Common barriers to adoption include time constraints, limited professional development opportunities, and institutional cultures that prioritize research over teaching innovation.

EBIPs represent a systematic approach to teaching, utilizing research-validated techniques such as active learning, collaborative problem-solving, inquiry-based instruction, and metacognitive strategies [1], [2]. These methods contrast with traditional lecture-based instruction, actively engaging students in the learning process, promoting deeper understanding, and developing critical thinking skills necessary for engineering practice.

The gap between educational research and classroom practice is a significant issue in engineering education. Studies such as Freeman et al. [3] and Passow and Passow [4] show the benefits of EBIPs, yet faculty often struggle to implement these strategies. Resistance to change is compounded by institutional inertia and a lack of support from both colleagues and administration.

Mentorship offers a promising solution by providing structured, supportive environments for EBIP adoption. A conceptual model developed in related research outlines the role of mentorship in overcoming these barriers. This study builds upon that model, exploring a long-term mentorship program designed to help engineering faculty adopt EBIPs effectively. This program paired experienced educators with faculty, with a focus on collaboration, reflection, and ongoing improvement.

Over 10–15 weeks, the mentorship program included weekly collaborative sessions that facilitated dialogue, resource sharing, and problem-solving. A 1:1 or 2:1 mentor-to-mentee ratio helped provide a personalized guidance, and faculty teaching core engineering courses such as Mechanics of Materials and Circuits were specifically targeted, recognizing the discipline-specific nature of pedagogical challenges in these subjects. Participants were recruited from diverse institutions, including research-intensive universities and teaching-focused colleges, fostering a collaborative learning environment and exchanging perspectives across various teaching contexts.

The program also included faculty at different stages of their careers, with mentors selected for their pedagogical expertise and technical knowledge. This helped mentees receive guidance that was tailored to their specific context, rather than relying solely on general teaching recommendations. The mentorship structure emphasized iterative growth and sustained improvement over the long term. This study focuses on participants' experiences and outcomes within the established mentorship program, rather than its initial design and development.

This paper presents an in-depth analysis of the discipline-specific mentorship program, offering critical insights into how mentorship can bridge the gap between research and practice in engineering education. It highlights key factors that support successful EBIP adoption, the importance of community in professional growth, and the role of mentorship in driving positive change in teaching practices. This research contributes to the growing body of work on faculty development in engineering education, offering a detailed framework for understanding the iterative EBIP adoption process and how structured mentorship can help faculty overcome challenges, adapt EBIPs to specific teaching contexts, and achieve lasting improvements in their pedagogical approaches.

2. Literature Review

2.1 EBIPs in Engineering Education

EBIPs are transforming engineering education by moving beyond traditional lecture-based methods to focus on active learning, student engagement, and critical thinking. Prince [1] demonstrated that active learning significantly improves student performance, highlighting EBIPs' potential to address persistent challenges in engineering education. EBIPs include strategies like collaborative learning, problem-based instruction, inquiry-driven approaches, and metacognitive techniques. Freeman et al. [3] found that EBIPs improved STEM student performance by an average of 0.47 standard deviations. Approaches such as cooperative learning and context-rich problem-solving are particularly effective in engineering [2]. Despite their proven success, implementing EBIPs in engineering education remains challenging. Borrego et al. [5] identified barriers such as institutional inertia, limited faculty training, and reliance on traditional teaching methods. Brownell and Tanner [6] further noted that successful EBIP adoption requires not only new techniques but also a fundamental shift in pedagogical approaches, institutional support, and faculty development. This complex process highlights the need for targeted strategies to support faculty through the implementation and sustained use of EBIPs.

2.2 Barriers to EBIP Adoption

The adoption of EBIPs in engineering education faces significant institutional and individual barriers. Research-driven academic cultures often prioritize productivity over teaching excellence, creating systemic disincentives for pedagogical innovation [7]. Faculty face challenges balancing their research responsibilities, administrative duties, and the effort required to redesign courses and implement new instructional strategies [8]. Individual barriers, including fear of failure and lack of self-efficacy, further complicate the adoption of EBIPs [6]. Many engineering faculty members lack formal training in pedagogy, relying on their own past learning experiences to guide their teaching methods [9]. Furthermore, the technical nature of engineering disciplines, with their emphasis on content depth, and departmental cultures resistant to change create additional challenges. There are concerns that more interactive methods could compromise technical rigor or fail to meet accreditation standards [4]. The absence of discipline-specific support structures and professional development opportunities further complicates the adoption of EBIPs, making institutional change particularly difficult.

2.3 Mentorship in Faculty Development

Mentorship is a critical element in faculty development, promoting professional growth through social learning and collaborative knowledge building. McMillan and Chavis [10] highlighted how professional relationships foster a sense of community, belonging, and identity development, essential in complex fields like higher education. Various mentorship models, including hierarchical, peer, and group mentoring, serve different developmental needs, such as offering guidance, creating professional networks, and supporting faculty through transitions [11]. Effective mentorship goes beyond information sharing, fostering individual growth and confidence [12]. In disciplines with rapidly evolving pedagogy, mentorship helps faculty navigate career stages, from early development to leadership roles [13]. In engineering education, mentorship supports the adoption of EBIPs, bridging the gap between pedagogical research and classroom application [14]. This is especially valuable in engineering, where many faculty lack formal pedagogical training and face challenges in instructional development.

2.4 Models of Instructional Change

Traditional models of pedagogical change view innovation as a linear process. Guskey's Model of Teacher Change [15] suggests that professional development leads to changes in teaching practices, which in turn improve student outcomes. Similarly, Clarke and Hollingsworth's interconnected model [16] emphasizes a structured pathway for professional development, progressing through stages of implementation in a more predictable manner.

The Adaptive Expertise Framework, developed by Hatano and Inagaki [17], complements these models by stressing the importance of flexible learning and problem-solving strategies. This framework views professional development as an ongoing process where educators advance from routine teaching methods to more adaptive, sophisticated approaches to complex instructional challenges.

While these traditional models provide valuable insights into the process of pedagogical transformation, they tend to assume a more normalized and planned approach to educational change. They often overlook the complex, context-dependent factors that influence teaching practices. Contemporary research increasingly challenges these linear models, suggesting that educational transformation is a more dynamic and iterative process influenced by individual agency, institutional structures, and broader contextual constraints.

2.5 Intersection of Mentorship and Instructional Practices

Reflection is a key mechanism in pedagogical development, particularly in STEM higher education. Research shows that critical reflection enables instructors to analyze teaching experiences, challenge existing beliefs, and foster professional growth [18]. However, Machost et al. [19] note that while many instructors engage in reflection, its depth often remains superficial, limiting meaningful change.

Social Learning Theory offers valuable insights into pedagogical transformation. Bandura's [20] framework suggests that learning occurs through observation, imitation, and modeling of social behaviors, explaining how educational innovations spread within professional communities. This aligns with collaborative teaching innovation approaches, where Nolan and Hutchinson [21] emphasize partnerships with students and colleagues to develop new educational strategies.

Mentorship also plays a vital role in knowledge sharing. Asampong et al. [22] demonstrates how mentorship relationships facilitate knowledge implementation through strategies like blended approaches, case studies, and virtual meetings. Hudson [23] further highlights the importance of social discourse, collaborative problem-solving, and sharing teaching philosophies while pursuing instructional growth.

2.6 Literature Review Conclusion

EBIPs have the potential to transform engineering education by improving student engagement and learning outcomes. Research by Prince [1], Freeman et al. [3], and Felder and Brent [2] highlights the effectiveness of active and collaborative pedagogies, but barriers to adoption remain. Institutional challenges, such as research-focused cultures, time constraints, and limited professional development [7]-[8], as well as individual resistance to change [6], hinder progress. Discipline-specific concerns, like fears of compromising technical depth and accreditation requirements, add complexity [4].

Mentorship can address these barriers by fostering professional growth, knowledge sharing, and social learning [11], [12]. It helps build confidence, bridges the gap between theory and practice, and promotes critical reflection and collaborative problem-solving [14], [18], [19]. Future research should focus on designing mentorship models that provide discipline-specific support and foster long-term instructional change.

3. Summary of Data Collection and Analysis

3.1 Methods

This study used a constructivist grounded theory (GT) approach to explore how an Evidence-Based Instructional Practices (EBIP) mentorship program influenced faculty adoption of EBIPs. Constructivist GT, as outlined by Charmaz [24], emphasizes the co-construction of meaning between participants and researchers, making it ideal for understanding the complex, context-dependent social processes in faculty development. The aim was to construct a conceptual model of effective mentorship mechanisms based on participants' lived experiences.

3.2 Study Participants

Participants included 26 mentees (denoted by P##) and 8 mentors (denoted by M##) from the EBIP mentorship program. Mentees were engineering faculty with diverse teaching experiences, tenure statuses, and institutional types, while mentors were experienced faculty offering expertise in mentees' course areas (viz. Table 1). Mentors were selected based on their connections to the program, such as being research project PIs, research faculty, professional contacts, or former mentees identified as effective future mentors, rather than solely on years of teaching experience. This sample represented a range of perspectives from both research-intensive and teaching-focused institutions. Theoretical sampling, a core principle of GT, guided the inclusion of all available participants, ensuring saturation and the capture of a wide variety of experiences related to EBIP adoption [25]. The design and implementation of the mentorship program is outside the scope of this paper.

3.3 Data Collection

Semi-structured interviews with mentees and mentors provided in-depth insights into their experiences. Interviews, lasting 45 to 60 minutes, were conducted virtually, recorded with consent, and transcribed verbatim. Mentee interviews explored motivations, mentor interactions, challenges, and reflections on the program's impact on their teaching practices. Mentor interviews addressed their strategies, perceptions of program effectiveness, and reflections on mentoring relationships. This dual perspective offered a holistic understanding of the mentorship program.

The semi-structured format allowed consistency while remaining flexible to explore emergent themes. Open-ended questions invited participants to share their experiences in-detail, and follow-up questions helped promote clarity and depth. The iterative nature of data collection supported theoretical sampling, enabling the researcher to adjust questions as new themes emerged [24].

Table 1. Participants' Information

Participant Number	Gender	Race/Ethnicity	Institution Type	Tenure Status	Years of Teaching Experience
P01	Female	White	R1	No	9
P02	Male	White	Teaching-focused	Yes	5
P03	Female	Asian	Teaching-focused	No	4
P04	Female	White	R1	No	13
P05	Female	White	R1	No	1
P06	Male	Asian	R3	Yes	9
P07	Male	Middle Eastern	R1	Yes	21
P08	Male	Asian	R3	On Tenure Track	5
P09	Female	Black or African American	R1	On Tenure Track	4
P10	Male	White	R1	Yes	11
P11	Male	Middle Eastern	R2	Yes	9
P12	Male	White	R2	No	8
P13	Female	White	Teaching-focused	Yes	10
P14	Male	White	Teaching-focused	No	9
P15	Male	Asian	Teaching-focused	Yes	6
P16	Male	Asian	R3	Yes	9
P17	Male	Middle Eastern	R1	No	12
P18	Female	White	R1	On Tenure Track	4
P19	Male	Asian	R3	Yes	10
P20	Male	White	R1	No	9
P21	Female	Black or African American	R1	No	7
P22	Female	White	Teaching-focused	No	2
P23	Female	Black or African American	R1	Yes	15
P24	Male	Asian	R1	On Tenure Track	1
P25	Male	White	R1	No	2
P26	Male	White	R1	No	4
M01	Male	White	R1	Yes	19
M02	Male	White	R1	No	9
M03	Male	Asian	R1	Yes	5
M04	Female	White	R1	No	10
M05	Female	White	R1	No	14
M06	Male	White	Teaching-focused	Yes	16
M07	Male	Asian	Teaching-focused	Yes	14
M08	Male	Asian	R3	Yes	10

3.5 Grounded Theory in Practice

The constructivist GT approach supported the development of findings that were grounded in participants' experiences and attentive to the broader social and institutional contexts [26]. The iterative process of data collection and analysis allowed for the continual refinement of themes and categories, ensuring the emerging theory reflected the complexity of mentorship in supporting EBIP adoption. Theoretical saturation was achieved when no new themes or insights emerged from the data.

Rigor and trustworthiness were supported through reflexive memo-writing, peer debriefing, and the use of constant comparative analysis to enhance credibility [25]. Team members who were familiar with the project but not involved in the interviews or analysis reviewed the findings to provide an addition check on accuracy and validity [27]. Ethical considerations included obtaining informed consent, protecting participant confidentiality, and ensuring secure data storage [28]. These measures upheld ethical integrity and strengthened the dependability of the study.

By employing constructivist GT, this study provided a nuanced understanding of mentorship's role in fostering EBIP adoption. The findings offer valuable insights into the mechanisms that support faculty development and the adoption of evidence-based teaching practices in engineering education.

4. Findings

4.1 Conceptual Model from Previous Research

The conceptual model, detailed in prior research currently under review, describes the dynamic and iterative process of EBIP adoption as it occurred within a mentorship program. This model captures the experiences of mentees and mentors as they navigated the complexities of integrating EBIPs into engineering classrooms. The process began with *intrinsic buy-in*, where mentees recognized the value of EBIPs and committed to their implementation. This foundational step reflected mentees' motivation and openness, which were essential for engaging fully in the mentorship program. The next phase, *EBIP negotiation*, involved collaboration between mentors and mentees to identify and select EBIPs suited to mentees' specific teaching contexts and goals. During this stage, mentees weighed various factors, such as the alignment of an EBIP with their course and students, while mentors provided guidance to help mentees choose an approach that was both feasible and effective within their instructional settings.

As mentees moved into the preparation phase, *preparation challenges* often surfaced, including time constraints, resource limitations, or uncertainty about how to implement the selected EBIP. To navigate these obstacles, mentors and mentees collaboratively developed *strategies to overcome preparation challenges*, such as resource planning, managing competing demands, and tailoring pedagogical approaches to specific needs. These efforts equipped mentees to attempt their first EBIP implementation.

The initial implementation could result in either a *challenging* or *successful attempt*, with outcomes defined by how mentees interpreted success and challenges within their unique instructional environments. When *implementation challenges* arose—such as difficulties with student engagement or logistical issues—mentors frequently offered support to help mentees reflect on and refine their strategies, tailored to their specific teaching contexts. This *challenging adoption reflection* phase enabled mentees to critically analyze their experiences, adapt their methods, and, in some cases, switch to a different EBIP if the original choice did not suit their teaching context.

To address recurring implementation challenges, mentors and mentees worked together to develop *strategies to overcome implementation challenges*, which supported iterative improvements in mentees' teaching practices. This process often involved revisiting earlier phases—such as preparation, implementation, and reflection—demonstrating the model's inherently cyclical nature.

Ultimately, the model captured the trajectory toward *successful implementation*, where mentees effectively integrated EBIPs into their classrooms, improving student engagement and outcomes. The process concluded with *successful adoption reflection*, during which mentees and mentors consolidated their learning, reflected on their growth, and considered future opportunities for EBIP use and pedagogical development.

The cyclical nature of the model highlights how mentees continually refined their practices over time, with the mentorship program serving as a critical support system throughout this iterative journey. This descriptive model underscores the program's capacity to navigate the challenges of EBIP adoption and foster meaningful, sustained pedagogical growth.

4.2 The Iterative Nature of Implementation and Improvement

The adoption of EBIPs emerged as an inherently cyclical process characterized by structured iterations of implementation, reflection, and refinement, supported by systematic mentor guidance. Both mentors and mentees engaged in regular, structured meetings that facilitated this iterative development. As P14 explained, meetings involved "going back over what we touched on the time before, what were our action items" and "reviewing what we had talked about and what we had agreed we would try before we met again." This systematic approach to reflection and planning created a foundation for continuous improvement in teaching practice.

Mentors developed systematic strategies to support this cyclical process, creating structured approaches to anticipate and address challenges throughout implementation. M02 described developing an "EBIP implementation plan" that incorporated "what barriers to anticipate and sometimes some solutions on how to get over them." This proactive planning aligned with mentees' preference for gradual implementation, as articulated by P15: "I think the first try, not only for this thing, but if I want to change anything, I would like to do that gradually." The alignment between mentor support and mentee needs facilitated a more effective adoption process.

The data revealed recognition of contextual challenges that necessitated multiple implementation cycles. M04 highlighted specific barriers including "department dynamic" and the challenge of simultaneous content learning: "If your first round is just trying to learn the content, it's hard to teach yourself the content and then come up with an EBIP thing." To address these challenges, mentors provided multi-faceted support through literature snippets, classroom assessment technique handbooks, normalizing conversations, and material resources. This multifaceted support system often enabled mentees to address the complexities of pedagogical change, supporting progress across multiple implementation cycles.

Participants' motivation and engagement in this cyclical process fluctuated over time. P12 described this pattern: "at the beginning of the semester, I was very motivated and I got three things done right out of the gate. And so it kind of waned over time because I was running out of time." Mentors demonstrated awareness that EBIP adoption often extends beyond initial implementation attempts, with M08 noting that some strategies might only be applicable for their mentees in subsequent iterations: "[My mentee] is planning to use [the strategies] in the following year... the strategies that you've suggested may only be useful to her in the next round." This recognition of the long-term nature of EBIP adoption helped set realistic expectations and maintain engagement despite temporary setbacks.

The collaborative nature of the development cycle was emphasized by both mentors and mentees. P20 noted the value of shared learning: "We all seemed to be on the same page and wanting to improve our classroom teaching... just having one more person that's like, 'Okay, we can do this and here's some things we can try and here's some successes that we can share.'" The cross-institutional nature of the mentorship program further enriched this collaborative learning by exposing participants to diverse teaching contexts and institutional cultures.

For example, mentees often noted that mentors from other institutions offered fresh perspectives that challenged their assumptions and expanded their approach to EBIP implementation. P26 shared that their mentor introduced them to a software tool designed to support collaborative learning, which led to a shift in their teaching. Rather than relying solely on instructor-led discussion, P26 began encouraging students to answer each other's questions, fostering peer learning and positioning well-prepared students as discussion leaders. The teaching strategy from their mentor, which came from outside P26's existing academic environment, led them to adopt a more student-driven, interactive classroom dynamic. As McMillan and Chavis [10] suggest, diverse professional communities foster innovation through shared perspectives. While within-institution mentoring can provide familiarity and alignment with local policies, the external voices in this program encouraged mentees to adapt EBIPs creatively to their unique settings.

This collaborative approach was enriched by mentors' efforts to understand the deeper aspects of implementation. As M02 explained: "I wanted to understand not just the methods they used, but what was actually going on in terms of the thought processes and decision-making processes... what made them adopt certain EBIPs or what made them give up on certain EBIPs." This depth of engagement facilitated more meaningful and sustainable changes in teaching practice.

The value of ongoing observation and engagement emerged as a key theme throughout the mentorship process. M02 emphasized the dynamic nature of this support: "During these sessions... you get to see how a story evolves instead of just being one thing... I'm seeing it evolve right in front of me and we're working through it together." This approach allowed mentors to provide progressive support, with M03 noting the importance of building on existing knowledge: "They were people who already knew something about it... now let's look into, let's just apply it... Let's get away with theory. Let's just apply it into your classroom." The evolution from theoretical understanding to practical application represented a crucial aspect of the adoption cycle.

Participants demonstrated a strong commitment to continuous improvement beyond the formal mentorship structure. P21 suggested mechanisms for ongoing development such as "an advanced mentee group that meets biweekly or monthly" and a discussion board for sharing experiences where instructors could post "Hey, I tried this week and it went really well" and receive feedback like "I tried that before. It didn't work for me either. Try this." This collaborative learning was supported by structured resources, with P14 highlighting the value of having practices "consolidated in this concise packet of information and your mentors, defining each of them for you and relating them directly to your specific content." These ongoing support tools helped sustain the momentum of pedagogical improvement beyond the initial implementation phase.

The results revealed that successful EBIP adoption was not about perfect initial implementation, but rather about creating a supportive environment that allowed for multiple cycles of trial, reflection, and improvement. The mentorship program provided structured support for this iterative process while acknowledging the complex, multi-cycle nature of pedagogical innovation and the importance of sustained, collaborative engagement in supporting instructional development. The combination of systematic mentor support, collaborative learning opportunities, and recognition of the long-term nature of pedagogical change created an environment conducive to meaningful and sustainable instructional improvement.

5. Discussion

The findings from this study reveal the fundamentally cyclical nature of EBIP adoption and teaching improvement, challenging traditional linear models [15], [16] of pedagogical change. Understanding implementation as an iterative process, rather than a one-time event, has important implications for both personal faculty development and mentorship programs. When educators recognize that initial challenges are part of a larger cycle of improvement, rather than indicators of failure, they may be more willing to persist through difficulties and view setbacks as opportunities for learning and refinement. This perspective shift can help reduce hesitancy around EBIP adoption and encourage more instructors to experiment with evidence-based practices.

The cyclical model also has significant implications for how we structure faculty support systems. Mentorship programs should be designed to accommodate multiple iterations of implementation and reflection, rather than assuming a straightforward progression from training to successful adoption. This might involve extending program timelines, building in structured reflection points, and creating opportunities for mentees to revisit and refine their approaches over multiple semesters. The data suggests that such iterative approaches allow faculty to develop deeper understanding of EBIPs and more effectively adapt them to their specific teaching contexts. The success of the mentorship program studied here suggests that similar models could be effective across other STEM disciplines, particularly when adapted to address discipline-specific challenges.

While individual mentorship drove successful EBIP adoption in this context, institutional support is vital for sustaining iterative improvement in many situations. By offering resources such as professional development funding and policies that recognize teaching innovation and instructional growth (e.g., tenure recognition), institutions can help address barriers like time constraints, which were often mentioned by participants (e.g., P12's comment about 'running out of time'). Allocating protected time for mentorship and fostering collaborative networks beyond formal programs could further enable faculty to refine their teaching. Such systemic support can enhance the impact of mentorship by reducing logistical and cultural hurdles [6], [8], helping faculty manage the time-intensive cycles of EBIP implementation and growth.

From a broader perspective, this research contributes to our understanding of how meaningful pedagogical change occurs in higher education. The findings suggest that effective teaching improvement is not about perfecting individual techniques, but rather about developing adaptive expertise through repeated cycles of implementation, reflection, and refinement. This understanding challenges the notion that teaching improvement is a linear progression toward mastery, instead framing it as an ongoing process of adaptation and growth. Faculty who embrace this cyclical view may be better equipped to handle the challenges and uncertainties inherent in adopting new teaching practices.

Moving forward, these insights could inform the design of more effective professional development programs in engineering education and beyond. By recognizing the iterative nature of teaching improvement and providing appropriate support structures, institutions can better facilitate the adoption of evidence-based practices and promote sustained pedagogical growth among faculty members. The success of structured mentorship in supporting these improvement cycles suggests that similar approaches could be valuable across various institutional contexts. Future research might explore how different types of support mechanisms can be integrated to better sustain faculty through multiple cycles of implementation and improvement, and how these cycles might vary across different institutional contexts and teaching environments. Understanding these variations could help institutions develop more targeted and effective support strategies for faculty at different stages of their teaching development.

6. Future Work

While this study provides valuable insights into the cyclical nature of EBIP adoption through mentorship, several promising areas for future research emerge. Longitudinal studies could track faculty members' teaching development beyond the formal mentorship period to better understand how these improvement cycles evolve over time and what factors influence long-term sustainability of EBIP use. Additionally, research could examine how different types of mentorship structures - such as peer mentoring, group mentoring, or hybrid models - might support these improvement cycles in different ways. This could help identify the most effective mentorship approaches for faculty at different career stages or in different institutional contexts.

Future research could also enhance understanding of how improvement cycles unfold across different educational contexts. Comparative studies across different STEM disciplines could help identify discipline-specific patterns in how these cycles unfold and what unique challenges emerge in different content areas. Additionally, investigating the relationship between faculty motivation and cycle progression could provide insights into how to better support instructors through challenging periods. Research examining the role of student feedback and outcomes in shaping these improvement cycles could also yield valuable insights for structuring future mentorship programs and faculty development initiatives. Such studies would contribute to developing more targeted and effective support strategies for faculty across various fields and institutional types.

7. 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 numbers 2111052 and 2111087. The opinions are those of the authors and do not necessarily represent the National Science Foundation.

References

[1] M. Prince, "Does Active Learning Work? A Review of the Research," *J. Eng. Educ.*, vol. 93, no. 3, pp. 223–231, 2004, doi: 10.1002/j.2168-9830.2004.tb00809.x.

[2] R. M. Felder and R. Brent, *Teaching and learning in STEM: a practical guide*. San Francisco, CA: Jossey-Bass, 2016.

[3] S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," *Proc. Natl. Acad. Sci. U. S. A.*, vol. 111, no. 23, pp. 8410–8415, Jun. 2014, doi: 10.1073/pnas.1319030111.

[4] H. J. Passow and C. H. Passow, "What Competencies Should Undergraduate Engineering Programs Emphasize? A Systematic Review," *J. Eng. Educ.*, vol. 106, no. 3, pp. 475–526, 2017, doi: 10.1002/jee.20171.

[5] M. Borrego, M. J. Foster, and J. E. Froyd, "Systematic Literature Reviews in Engineering Education and Other Developing Interdisciplinary Fields," *J. Eng. Educ.*, vol. 103, no. 1, pp. 45–76, 2014, doi: 10.1002/jee.20038.

[6] S. E. Brownell and K. D. Tanner, "Barriers to Faculty Pedagogical Change: Lack of Training, Time, Incentives, and…Tensions with Professional Identity?," *CBE—Life Sci. Educ.*, vol. 11, no. 4, pp. 339–346, Dec. 2012, doi: 10.1187/cbe.12-09-0163.

[7] A. E. Austin, "Promoting evidence-based change in undergraduate science education. A Paper Commissioned by the National Academies National Research Council," 2011, [Online]. Available: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=aeeaa99153a873884833eca5a67aa53a3039b32c

[8] 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.

[9] C. Henderson, A. Beach, and N. Finkelstein, "Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature," *J. Res. Sci. Teach.*, vol. 48, no. 8, pp. 952–984, 2011, doi: 10.1002/tea.20439.

[10] D. W. McMillan and D. M. Chavis, "Sense of community: A definition and theory," *J. Community Psychol.*, vol. 14, no. 1, pp. 6–23, Jan. 1986, doi: 10.1002/1520-6629(198601)14:1<6::aid-jcop2290140103>3.0.co;2-i.

[11] G. Crisp and I. Cruz, "Mentoring College Students: A Critical Review of the Literature Between 1990 and 2007," *Res. High. Educ.*, vol. 50, no. 6, pp. 525–545, Sep. 2009, doi: 10.1007/s11162-009-9130-2.

[12] R. M. Felder and R. Brent, "The National Effective Teaching Institute: Assessment of Impact and Implications for Faculty Development," *J. Eng. Educ.*, vol. 99, no. 2, pp. 121–134, 2010, doi: 10.1002/j.2168-9830.2010.tb01049.x.

[13] W. B. Johnson and C. R. Ridley, *The elements of mentoring*, 1st ed. New York: Palgrave Macmillan, 2004.

[14] S. Ma, G. L. Herman, J. H. Tomkin, J. P. Mestre, and M. West, “Spreading Teaching Innovations in Social Networks: the Bridging Role of Mentors,” *J. STEM Educ. Res.*, vol. 1, no. 1–2, pp. 60–84, Dec. 2018, doi: 10.1007/s41979-018-0002-6.

[15] T. R. Guskey, “Professional Development and Teacher Change,” *Teach. Teach.*, vol. 8, no. 3, pp. 381–391, Aug. 2002, doi: 10.1080/135406002100000512.

[16] D. Clarke and H. Hollingsworth, “Elaborating a model of teacher professional growth,” *Teach. Teach. Educ.*, vol. 18, no. 8, pp. 947–967, Nov. 2002, doi: 10.1016/S0742-051X(02)00053-7.

[17] G. Hatano and K. Inagaki, “TWO COURSES OF EXPERTISE”.

[18] S. Mattucci and J. Vale, “Instructor Reflections from a Graduate-level Course on STEM Education Research and Practice,” *Proc. Can. Eng. Educ. Assoc. CEEA*, 2023, doi: 10.24908/pceea.2023.17078.

[19] H. Machost, E. A. Kable, J. K. Mitchell-Jones, B. J. Yik, and M. Stains, “Characterization of physics and astronomy assistant professors’ reflections on their teaching: can they promote engagement in instructional change?,” *Discip. Interdiscip. Sci. Educ. Res.*, vol. 6, no. 1, p. 14, Apr. 2024, doi: 10.1186/s43031-024-00105-9.

[20] A. Bandura, “Social Foundations of Thought and Action,” in *The Health Psychology Reader*, 1 Oliver’s Yard, 55 City Road, London EC1Y 1SP United Kingdom: SAGE Publications Ltd, 2002, pp. 94–106. doi: 10.4135/9781446221129.n6.

[21] S. Nolan and S. Hutchinson, *Leading Innovation and Creativity in University Teaching: Implementing Change at the Programme Level*, 1st ed. London: Routledge, 2022. doi: 10.4324/9781003190745.

[22] E. Asampong *et al.*, “Capacity building through comprehensive implementation research training and mentorship: an approach for translating knowledge into practice,” *Glob. Health*, vol. 19, no. 1, p. 35, May 2023, doi: 10.1186/s12992-023-00935-8.

[23] P. Hudson, “Strategies for mentoring pedagogical knowledge,” *Teach. Teach.*, vol. 19, no. 4, pp. 363–381, Aug. 2013, doi: 10.1080/13540602.2013.770226.

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

[25] K. Charmaz and R. Thornberg, “The pursuit of quality in grounded theory,” *Qual. Res. Psychol.*, vol. 18, no. 3, pp. 305–327, Jul. 2021, doi: 10.1080/14780887.2020.1780357.

[26] H. A. Qureshi and Z. Ünlü, “Beyond the Paradigm Conflicts: A Four-Step Coding Instrument for Grounded Theory,” *Int. J. Qual. Methods*, vol. 19, p. 1609406920928188, Jan. 2020, doi: 10.1177/1609406920928188.

[27] Y. S. Lincoln, E. G. Guba, and J. J. Pilotta, “Naturalistic inquiry,” *Int. J. Intercult. Relat.*, vol. 9, no. 4, pp. 438–439, Jan. 1985, doi: 10.1016/0147-1767(85)90062-8.

[28] J. Creswell and C. Poth, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*, 5th Edition. 2024.