How and Why Mathematics Faculty Use Evidence-Based Instructional Practices: A Revised Model of Instructional Decision-Making in Undergraduate Mathematics Education

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Evidence-based instructional practices (EBIPs) are widely recognized as effective, yet their use in undergraduate mathematics remains sparse. While prior work has explained why faculty adopt EBIPs, less attention has been given to what happens after that decision – namely, how instructors implement these practices, why they use some approaches over others, and what shapes their persistence. In this theoretical report, I review literature on individual and contextual factors influencing EBIP use and identify limitations in existing models of instructional decision-making. I then propose a revised model that integrates Lattuca and Pollard's (2016) framework with Schoenfeld's (2010) resources-orientations-goals (ROG) theory. The model emphasizes the context-dependent nature of mathematics faculty's EBIP use and centers implementation as the site where persistence is shaped. Using data from one case study, I illustrate how the model can trace the full cycle of EBIP engagement from adoption, to enactment, to the experiences that influence continued use.

Keywords: Evidence-Based Instructional Practices, Active Learning, Undergraduate Mathematics Education, Faculty Decision-Making, Instructional Persistence

In undergraduate mathematics, traditional lecturing remains dominant across national and linguistic boundaries (Artemeva & Fox, 2011; Johnson et al., 2018; Stains et al., 2018), despite decades of research supporting evidence-based instructional practices (EBIPs), such as active learning. EBIPs promote student-centered instruction, foster higher-order thinking, and often involve collaboration, with evidence showing improved exam performance and reduced failure rates even in large classes (Freeman et al., 2014; Theobald et al., 2020). However, EBIPs encompasses a wide range of strategies, from minimal techniques like incorporating clicker questions to fully restructured formats such as inquiry-based mathematics education (Laursen & Rasmussen, 2019). This variation highlights that EBIP adoption is not a simple binary and that mathematics faculty may implement these practices in diverse ways (Johnson et al., 2018; Knowles et al., 2023).

Existing models of faculty instructional decision-making (e.g., Lattuca & Pollard, 2016; Sturtevant & Wheeler, 2019) explain why instructors might choose EBIPs but say little about what happens after that decision, such as how and why instructors implement these practices differently, and how these experiences shape their persistence using them. In this theoretical report, I highlight the need for research from this perspective and propose a substantial revision to an existing model of faculty decision making – one that better accounts for the iterative and context-dependent nature of EBIP engagement in undergraduate mathematics. This work aims to inform change initiatives that seek to expand EBIP use in undergraduate mathematics education.

Literature Review

This literature review has two parts. I first discuss the current body of literature on why mathematics faculty use EBIPs in their instruction. I then discuss limitations in what is known about why faculty use the specific EBIPs they do and how their implementation experiences are connected with their persistence using these practices, underscoring the need for models that account for this.

The Use of EBIPs in Undergraduate Mathematics Education

The uptake of EBIPs among mathematics faculty appears to be sparse (Johnson et al., 2018), reflecting a broader trend in collegiate STEM education (Froyd et al., 2013; Henderson et al., 2012; Larsen et al., 2019; Stains et al., 2018). Consequently, much of the research on why faculty use EBIPs comes from STEM education more broadly. This body of research has identified two main categories of factors that influence faculty decisions to engage in EBIPs: individual factors and contextual factors.

Contextual factors influencing EBIP use. Contextual factors refer to external, institutional, and departmental influences (Sturtevant & Wheeler, 2019). These include physical resources such as class size and classroom space (e.g., Apkarian et al., 2021; Henderson et al., 2012); teaching evaluations and student buy-in (e.g., Deslauriers et al., 2019; Shadle et al., 2017); time constraints (e.g., Johnson et al., 2018, 2019; Turpen et al., 2016); and the level of support and incentives provided by institutions and departments (e.g., Lund & Stains, 2015; Sturtevant & Wheeler, 2019).

Large classes and fixed seating can limit the student collaboration many EBIPs require, while flexible learning spaces are associated with greater uptake (Foote et al., 2014; Knaub et al., 2016). Faculty concerns about student resistance, often tied to increased cognitive effort or unfamiliarity, may discourage adoption, especially when negative teaching evaluations are feared (Apkarian et al., 2021; Deslauriers et al., 2019; Owen et al., 2020). Time constraints are also a common barrier: faculty cite insufficient time to prepare EBIPs, learn them effectively, or cover content, with concerns in mathematics often linked to preparing students for later courses (Johnson et al., 2018, 2019; Woods & Weber, 2020). Without adequate institutional or departmental support, these challenges can be exacerbated, particularly in environments that prioritize research over teaching; conversely, departments with student-centered norms tend to foster EBIP adoption through professional development, mentoring, and ongoing teaching-focused dialogue (Andrews & Lemon, 2015; Lund & Stains, 2015; Shadle et al., 2017).

Altogether, this literature suggests that multiple contextual factors, such as physical space, student buy-in, time constraints, and institutional culture, shape faculty's use of EBIPs. These factors can discourage adoption by creating logistical or motivational barriers, particularly when institutions do not actively support or incentivize teaching innovation.

Individual factors influencing EBIP use. Unlike contextual factors, which depend on specific settings (e.g., a specific institution or class), individual factors refer to personal influences such as orientations (e.g., beliefs, values, dispositions) and goals (Schoenfeld, 2010), identity, and prior experiences (Sturtevant & Wheeler, 2019). These factors shape instructional practice and can, in some cases, outweigh contextual influences in determining whether faculty adopt EBIPs (Andrews & Lemons, 2015; Johnson et al., 2019). The most salient of these factors are faculty's prior experiences, particularly those shaping their satisfaction with EBIPs, and their orientations and goals.

Experiences and satisfaction. Faculty experiences – as both students and teachers – play a critical role in shaping instructional choices. In mathematics, most instructors experienced lecture-dominated classrooms as students, and many replicate these methods, particularly if they were personally successful in them (Lortie, 1975; Woods & Weber, 2020). Conversely, dissatisfaction with lecturing – such as perceiving it as less engaging or less effective – can prompt faculty to explore EBIPs (Andrews & Lemons, 2015; Johnson et al., 2019). Positive experiences implementing EBIPs tend to encourage continued use (Andrews & Lemons, 2015; Sturtevant & Wheeler, 2019), whereas negative experiences – such as challenges in implementation, lack of preparation time, or unexpected student resistance – can lead to discontinuance (Hayward et al., 2016; Sturtevant & Wheeler, 2019). These findings suggest that satisfaction, whether with lecturing or with EBIPs themselves, is a pivotal motivator for instructional change.

Orientations and goals. Faculty orientations and goals – such as beliefs about student potential, views on where learning should occur, and perceptions of professional responsibilities – strongly influence teaching choices (Johnson et al., 2018, 2019; Shultz, 2022; Vishnubhotla et al., 2022). Instructors who believe all students can learn mathematics and value in-class engagement are more likely to adopt EBIPs, while those with lower expectations for student potential or a belief that learning occurs primarily outside of class (e.g., while studying) are more likely to lecture extensively (Johnson et al., 2019; Woods & Weber, 2020). Additionally, instructors who prioritize covering content with precision often view lecturing as the most efficient way to meet their goals (Woods & Weber, 2020; Shultz, 2022), whereas those who emphasize student sense making may view EBIPs as better aligned with their objectives (Dawkins et al., 2019; Johnson et al., 2013). Beliefs about student engagement also matter: some faculty see frequent questioning during lectures as sufficient active learning (Woods & Weber, 2020), in contrast to how active learning is usually conceptualized in the literature through higher-order thinking involving discussion, problem-solving, and collaboration (Chi et al., 1989, 1994; Hattie & Timperley, 2007; Banes et al., 2018, 2020; Callahan et al., 2021).

In short, faculty adoption and persistence with EBIPs is shaped by a combination of experiences, satisfaction, and deeply held orientations and goals. These individual factors can motivate faculty to innovate or reinforce their preference for traditional lecturing, and interact with contextual factors that either support or constrain their choice to use EBIPs.

The Need to Conceptualize How and Why EBIPs are Used by Mathematics Faculty

Active learning encompasses a wide range of instructional strategies that vary in intensity and impact. Some strategies, such as partial notes, clicker questions, think-pair-share, or small group problem solving, can be flexibly integrated into traditional lectures (Alcock, 2018; Braun et al., 2017; Dawkins & Weber, 2023), while others require substantial restructuring of the course, such as flipped classrooms (Milman, 2012), inquiry-based mathematics education (Laursen & Rasmussen, 2019), or the Extreme Apprenticeship method (Rämö et al., 2015). Research has shown that mathematics faculty use a variety of such EBIPs (e.g., Johnson et al., 2018). However, much of the literature examining these strategies in mathematics education is interventionist in nature, often situated within professional development programs or targeted course reforms (e.g., Hayward et al., 2016; Johnson et al., 2013; Laursen & Rasmussen, 2019). While these studies have been valuable for demonstrating the benefits of active learning, some research suggests that such intervention contexts (e.g., professional development) may influence the learning gains observed (Andrews et al., 2011) and the kinds of instructor experiences that shape persistence with EBIPs (Andrews & Lemons, 2015; Sturtevant & Wheeler, 2019).

Given this variation and the potential influence of intervention contexts, this highlights the need for theoretical perspectives that can account for both how mathematics faculty adopt and implement EBIPs in a range of settings, including the different ways they enact active learning in their classrooms. While many EBIPs have distinct names and program structures, they often share core practices such as facilitating student collaboration, eliciting student thinking, and structuring opportunities for sensemaking (Freeman et al., 2014; Theobald et al., 2020). Hence, conceptualizing how mathematicians use these practices – including how contextual and individual factors influence which practices they choose and how their experiences shape their persistence – can complement intervention-based research and provide insight into the mechanisms that make active learning effective and sustainable. In total, this underscores the value of theory that can account for both how and why mathematics faculty use EBIPs.

A Model of Faculty's Use of EBIPs in Mathematics Education

In this theoretical report, I propose a model of faculty's use of EBIPs to investigate how and why mathematics faculty use these practices in undergraduate mathematics. I build on Lattuca and Pollard's (2016) model of faculty decision-making, as modified by Sturtevant and Wheeler (2019), and integrate Schoenfeld's (2010) resources–orientations–goals (ROG) theory. The ROG framework complements the decision-making model's structure and terminology while offering a lens for understanding how faculty decisions manifest in classroom practice and influence their experiences using EBIPs. I also incorporate refinements from my literature review.

Conceptualization of EBIPs

Implementing EBIPs with fidelity requires skills and knowledge that take time and effort to develop (Andrews-Larson et al., 2019; Archie et al., 2022; Fukawa-Connelly, 2016; Hayward et al., 2016; Johnson & Larsen, 2012). Some scholars therefore conceptualize EBIP use along a continuum rather than as a strict binary (Braun et al., 2017). Rather than urging all mathematics instructors to immediately abandon lecture, others emphasize ways to adapt lecture to be more student-centered and equitable (Alcock, 2018; Dawkins & Weber, 2023; Rasmussen & Johnson, 2023). Moreover, evidence of EBIP effectiveness (e.g., Freeman et al., 2014) often reflects a range of implementation levels, including courses with minimal active learning (Rasmussen & Johnson, 2023). I therefore define EBIPs broadly as instructional practices that actively engage students in learning mathematics, spanning both flexible and transformative strategies, from partial integration of active learning techniques to fully inquiry-based approaches.

An Existing Model of Faculty Decision-Making

Lattuca and Pollard's (2016) model of curricular change, as adapted by Sturtevant and Wheeler (2019) to focus on EBIPs, describes how extra-institutional, external, and internal influences shape faculty motivation to change instructional practices. Extra-institutional influences situate decisions within broader socio-cultural contexts, such as the COVID-19 pandemic or national calls to improve STEM education (Conference Board of the Mathematical Sciences, 2016; Saxe & Braddy, 2015). External influences include institutional and departmental culture, professional norms, and disciplinary orientations, while internal influences include beliefs, knowledge, professional identity, and prior experiences. These categories align closely with the individual and contextual factors described in my literature review.

The model posits that influences interact to shape motivation, which in turn drives adoption or rejection of EBIPs. Motivation may stem from perceived utility, personal interest, value alignment, or perceived costs (Lattuca & Pollard, 2016). Sturtevant and Wheeler (2019) extended the model to include dissatisfaction with current practice as a key motivator for EBIP adoption, and dissatisfaction with EBIPs as a driver of their discontinuance, aligning with literature on EBIP persistence (Froyd, 2013; Henderson et al., 2012). Overall, this model conceptualizes EBIP use as a motivated decision, which is constrained or facilitated by salient influences, and the decision to quit or persist with these practices is influenced by one's dissatisfaction using them.

Revisions to the Model

In this theoretical report, I propose revisions to Lattuca and Pollard's model. First, since many individual and contextual factors from my literature review align with the influences in the model, I adjusted it to use this terminology. Specifically, I expanded internal influences to include all individual factors and external influences to include all contextual factors, renaming them individual factors and contextual factors, respectively. I also embedded the model within the socio-cultural context to capture extra-institutional influences.

Next, I incorporated Schoenfeld's (2010) ROG theory into the model. While Lattuca and Pollard's model offers a framework for understanding faculty's decisions to engage in EBIPs, Schoenfeld's ROG framework provides a finer-grained lens for understanding how those decisions manifest in the classroom. Resources include both physical and knowledge-based assets, with knowledge being central. Orientations refer to the beliefs, values, and preferences that guide instructional choices. Goals are the intended outcomes, from long-term aims such as fostering mathematical engagement to immediate objectives like covering a topic. In familiar situations, decision-making is often automatic, but in unfamiliar ones, instructors' choices align with their orientations and goals, narrowing which approaches they consider

To integrate ROGs, I added an implementation phase to the model to address a limitation Sturtevant and Wheeler's (2019) adaptation; namely, the pathway from the decision to engage in EBIPs to the outcome of persistence or discontinuation is underdeveloped, leaving unexamined the experiences that shape instructors' satisfaction or dissatisfaction. In practice, these outcomes emerge through the implementation of EBIPs, where instructors encounter a range of both challenges and positive experiences. Including an "Implementation of EBIPs" phase makes visible how individual and contextual factors continue to influence instructional choices after the decision to use EBIPs is made. As others have argued, implementation experiences can influence whether faculty continue using EBIPs (e.g., Andrews & Lemons, 2015), highlighting the need to understand not just decisions to adopt, but the lived enactment of these practices in context. Hence, this addition enables researchers to examine not only whether mathematics faculty choose to use EBIPs, but also how they come to use them in specific ways, shedding light on both the substantial variation seen in EBIP implementation and the role of implementation experiences in shaping persistence.

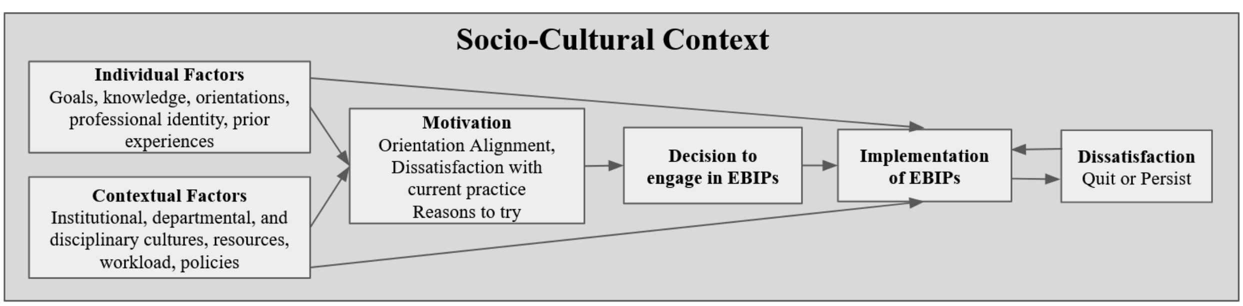

Figure 1. Visual Representation of the Revised Model. This revised framework models the influences that shape faculty engagement with EBIPs.

This model (Figure 1) provides a comprehensive cycle of EBIP use, not only looking at initial adoption but ongoing experiences. It distinguishes between individual and contextual factors, with contextual factors shaping individual ones. Individual factors include goals, knowledge, orientations, identity, and experiences. Contextual factors encompass institutional and departmental culture, resources (e.g., mentors, institutional support, classroom dynamics), policies, and workloads. These factors, situated within a broader socio-cultural context, influence faculty motivation to engage in EBIPs and ultimately their decision to do so. Experiences implementing EBIPs, which are also shaped by individual and contextual factors, then influence whether faculty persist with or discontinue these practices continually (as indicated by bidirectional arrows in Figure 1).

An Example of the Model in Action

I draw from data from my dissertation to illustrate this cycle of EBIP use. Noah (pseudonym) is a tenured associate professor at a private research university in the western United States. He has several years of active-learning experience (including six years of flipped calculus) and, in Fall 2024, taught Discrete Mathematics using group worksheets and interactive lectures.

Motivation to Use EBIPs: The Decision to Engage in EBIPs

Noah's path to using EBIPs illustrates the influence of individual factors like goals, orientations, and prior experiences and contextual factors like departmental support. As a teaching assistant in an honors calculus course, he watched students "invent all these things for themselves," expanding his sense of what types of teaching were possible. Departmental culture later enabled him to use EBIPs, as he felt "more free to design courses" once in a department supportive of "teaching in different ways." Noah's prior experiences as a student and teacher also generated dissatisfaction with lecturing. While he "learned fine" from lecture plus homework, he recognized many of his students were "still learning…how to tell whether what they've done is correct," so they needed in-class opportunities for feedback, highlighting the need to bring active learning into his classrooms.

Implementing EBIPs: The Choice to Use Lecture and Group Work

Noah's resources, orientations, and goals explain how he implemented EBIPs: several days of interactive lectures followed by a class session devoted to small group problem solving. In discrete mathematics, his goal was for students to "learn how to read and write proofs." Firstly, Noah believed students needed initial exposure to content (orientation): "learning is also how the material is presented… they have to be exposed before they can sort of do [math]." While he preferred active learning, Noah described lecturing out of necessity, having abandoned a plan to flip his class due to limited time to prepare videos (time constraint): "I ended up lecturing content in class, and that's almost not as effective really." Still, he used active learning because "It's kind of basically kind of like getting everybody to come to office hours and work on homework…If I'm there in class when they're working on it, I can see what they're doing…" He described using group work specifically because "the process of explaining this to someone else" helps one identify "what you are stuck on," making group work better aligned with his goals and orientations than other options, such as individual problem solving in class. Hence, Noah was drawn to lectures followed by group work sessions since this let him cover content, while also providing opportunities for students to work together and receive feedback from him, while being less time intensive than flipping his class.

Dissatisfaction with EBIPs: The Choice to Persist

Lastly, an episode during the semester highlighted how Noah persisted past dissatisfaction stemming from student resistance to group work. When early group work fell flat during an initial observation, with limited interaction between students, he saw the problem not as a flaw in group work itself but as a mismatch between his orientation toward collaboration and his current group work structure. In response, he moved from using unassigned groups to assigned pairs at shared whiteboards with a single marker to ensure collaboration. The next observation showed improved participation, including cross-interactions between pairs; Noah was "pretty happy with it" and reported using the structure again. This highlights Noah's adaptation as a persistence strategy: dissatisfaction during implementation triggered revision, not quitting, mediated by contextual factors and individual factors. In ROG terms, he mobilized resources (whiteboards), acted from orientations (collaboration) toward goals (improved proof writing).

Overall, Noah's case illustrates the revised model in action, highlighting how different factors influence one's initial motivation, EBIP implementation, and persistence. Moreover, this illustrates the potential affordances of research in undergraduate mathematics that conceptualizes the uptake and continued use of EBIPs in this way. Without this modification, the model would have had limited explanatory power beyond Noah's initial decision to engage with EBIPs. The modifications made it possible to analyze not only why Noah chose to use EBIPs, but also why he favors interactive lectures with small-group problem-solving (something the original model does not address), and how he persists despite dissatisfaction (with dissatisfaction accounted for in the original model but left vague). In particular, the model highlights how individual and contextual factors shaped both his use of EBIPs and his classroom experiences. These factors, in turn, gave rise to specific affordances and challenges, and revealed how Noah responded, both in the EBIPs he chose to adopt and in the ways he adapted them in order to persist.

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