A Qualitative Exploration of Resource-Related Barriers Associated with EBIP Implementation in STEM Courses

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1. Introduction:

Pedagogical research has demonstrated a growing awareness of Evidence Based Instructional Practices (EBIP) in engineering education. An EBIP is commonly defined as a novel educational tool which redirects instructor efforts towards strategies which result in a demonstrable increase in student apprehension of course learning outcomes. Adoption rates for these innovative methods have remained stagnant despite their known effectiveness [1], [2], [3]. Understanding the contextual barriers and affordances provides a framework for developing detailed instances of EBIP implementation. Instructors often cite factors such as time, lack of motivation, student resistance, and insufficient resources as reasons for their hesitation and or abandonment of alternative teaching methods. However, these barriers are often discussed at a surface level, making it a challenge to ascertain which departmental, institutional, and cultural changes must be made to form an effective catalyst towards EBIP adoption rates.

Due to the inherently complex nature of engineering-based classrooms, it becomes necessary to examine the experiences of instructors from various engineering departments over a broad range of disciplines to determine what resources they have available, as well as what resources are still needed for EBIP implementation. For example, engineering faculty often express the desire to utilize EBIPs in their courses but are uncertain on how to specifically tailor the EBIP to their class without further departmental support or a "pre-packaged" resource [4]. The purpose of this qualitative study is to gain a further understanding of the ways faculty utilize available resources when implementing EBIPs in their classes. We also aim to understand what type of additional course-specific resources and support are needed for faculty to effectively adopt EBIPs. Our specific research inquiries revolve around the following questions:

- What resource-related barriers exist in the context of EBIP implementation in engineering classrooms?
- What departmental, institutional, and cultural changes can be made to better align with instructor needs and expectations?

An in-depth understanding of faculty needs related to the foregoing questions will be potentially transformative to engineering faculty development efforts and departmental resource allocation.

2. Literature Review:

Previous qualitative studies have explored the issues surrounding EBIP awareness and adoption rates by examining the decision-making processes on an individual and institutional scale, and then developing models to combat perceived challenges. Borrego et al. [5] provided a statistical analysis of survey responses to determine what qualities department chairs are looking for when contemplating proposed educational innovations. The difficulties of implementing Problem-Based Learning (PBL) are highlighted in [4], in which they outline several common barriers and provide detailed strategies for fitting them into course projects and activities. A more general

systematic approach is presented in [6] which sets up a framework for addressing and resolving barriers to student learning outcomes and faculty-driven curricular modifications. A seven-step plan is prescribed which focuses on the goals, objects, mechanisms, and models for change, highlighting the importance of interactive faculty members, administrative support, administrative presence, and critical action research. Results suggested that holding adoption and resource-focused workshops will motivate departmental chairs to be more accepting of EBIPs. Similarly, Duhram and Aragon [7] showed that implementing a STEM faculty summer development workshop increased the implementation rate of EBIPs, as well as the variety of EBIPs used. In [8] a group workshop was performed to study perceived barriers among faculty in the social sciences, sparsely mixed with faculty from the fields of physics, biology, and chemistry. From this discussion, it was determined that barriers could be divided into three main categories: “Student Characteristics”, “Issues Impacting Faculty”, and “Pedagogical Issues”. Upon closer examination it was noted that several of these *perceived* barriers were not substantially supported by evidence. In [8], they propose that active learning will become more palatable to faculty if local development programs become more accessible, allowing instructors to be exposed to, and participate in various pedagogical practices.

The discrepancy between high EBIP-awareness rates and low EBIP-implementation rates can be attributed to perceived barriers from faculty [5]. Many perceived that barriers hinder the faculty’s decisions to implement EBIPs. These factors include student engagement [9], fear of negative student response [10], departmental culture and practices [11], and time constraints associated with class preparation [8]. In addition to perceived barriers, instructors are often introduced to EBIP concepts through general workshops that are often perceived as highly theoretical concepts void of practical application [12]. These workshops are typically conducted by a CTL located on a university campus. Therefore, understanding what potential changes could be made to these workshops, and what departmental resources should be provided, may facilitate a stronger affinity between engineering instructors and EBIP implementation.

3. Methodology:

This study presents qualitative results based on a subset of interviews and survey responses from 69 engineering faculty from 47 different institutions. Thirty-six of the institutions were doctoral/professional institutions and the other 11 were undergraduate/teaching focused institutions. We particularly focus on quotes given by two participants whose demographics are presented in Table 1. Participant P65 is an Assistant Teaching Professor in Chemical Engineering and participant P46 is an Assistant Professor in Biomedical Engineering. At the time of the interviews, both interviewees had been teaching for less than a year. The responses given by participants P65 and P46 were representative of the resource-related barriers discussed by several of the other participants. Therefore, to eliminate redundancies in reporting common themes, it was decided to provide a focused exposition of their experiences. Furthermore, this particular selection was made to give voice to less-seasoned instructors and individuals who are demographically underrepresented in the study. Discussions with participants revolved around their previous and current experience with EBIPs inside the classroom. A semi-structured interview protocol guided our conversation with participants, utilizing questions and prompts such as “What EBIPs do you currently use?”, “Walk me through the process of first

implementing EBIPs", "What resources were particularly helpful to you?", "Are there resources you wish existed to help with the implementation of certain EBIPs?".

This project is part of a larger study investigating barriers to EBIP implementation and aiming to create resources for instructors to facilitate greater adoption rates. Participants in this larger study were selected from a pool of 437 respondents after completing a nationwide survey inquiring about EBIP use and their level of interest in participating in the study. Incomplete survey responses were removed, resulting in 281 responses available for survey analysis and other research activities. After being contacted through email, 69 out of the 281 participants responded and agreed to take part in three separate interviews over the course of an academic year. Results are extracted from a subset of the first round of interviews, which were conducted at the start of the Fall Term/Semester of 2022.

Table 1: Participant Demographics

Participant Number	Gender	Race / Ethnicity	Institution Type
P65	Female	White	Doctoral / Professional
P46	Female	Black	Doctoral / Professional

Data for this study were obtained through content analysis of interview transcripts. Each interview was professionally transcribed and uploaded to a qualitative data management software (MAXQDA). After reading each interview multiple times, inductive coding was performed by 3 researchers. The coding process focused on the topics of resources used by faculty regarding EBIP implementation. Due to the high subjectivity inherent to the coding process, codes and interview content were discussed at length by the coding team to ensure inter-rater reliability [13].

4. Results & Discussion

4.1 Analysis of P65 interview

During the interviews, faculty participants expressed that they indeed do have access to CTL centers at their university campuses where they can seek guidance and assistance in implementing active-learning assessment techniques. However, when the expectations of the faculty do not align with services offered by the CTL consultants, the interaction can lead to confusion or a feeling of being overwhelmed with the amount of preparation they have to do on their own. These sentiments are highlighted in the quote by participant P65, in which they recollect an account of attempting concept tests in their classroom through an online platform. P65 states that, **"...at the beginning of the summer, I went to our learning center…they said, well, you can use whatever you want and here's 12 different options. And I'm like, well, that's not helpful cuz I have to sift through all 12 of those options and that's overwhelming and I don't have time to think about that"**. After choosing a platform, P65 expresses other frustrations with, **"...all the functionalities of all the different platforms and like why I would choose that one over this one, what's the cost to students versus cost to the department"**. Note that participant P65 gave this response after being prompted to discuss time-management barriers. This suggests that the instructor, at least in this instance, did not view the CTL as a resource, but instead as a barrier associated with superfluous amounts of preparation time

relative to their initial expectations. This anecdote reveals the current lack of communication between faculty instructors and CTL consultants, while at the same time highlighting the need for proper training with regards to educational software and online platforms. This specific faculty member was looking for a more thorough and personalized experience which would have realized a greater feeling of, **"…support or like, um, resources to help me learn it … I've spent a day looking at I-clicker and I can go through all those videos myself, but it would be a lot easier if I could just go to someone and ask like, hey…I can't figure this out. Help me. And we don't have that. Like I don't have that resource"**. P65 expresses that they would benefit more from a type of, **"…instantaneous support…"**, in which, **"…the university had … a single tool that they use and I knew that my students were going to use it in their chemistry class, in their physics class, in their other chem classes, I … wouldn't hesitate so much"**.

When asked similar questions about case-based teaching examples, participant P65 described their experience with resources available at their university. They stated that there are, **"...cases that are pre-written for individual courses and chemical engineering. And I really wanted to do it with my students…and I just couldn't figure out how to tie it to the content I was teaching…I was scared that the students would think it was just random… it needs to tie to a math concept or a unit operation…"**. This further suggests that faculty feel hesitant about using the resources provided to them because the available tools are not tailored to the course learning outcomes. This then creates a state of confusion for the students, resulting in more stress for the instructor and a decreased desire to further pursue implementation of the EBIP. When probing the interviewee for a solution to these issues, their response revealed once more that they felt as if they were not receiving adequate support, stating, **"...I'm kind of doing a lot of this in isolation. So, if I had someone [with experience]...and probably just having that conversation with someone [for] like a 15, 20 minute conversation where we could talk about [potential problems]..."**, that would generate a more positive experience.

The faculty participant specifically outlines what barriers they face with technology-related in-class activities, such as concept tests, and case-based teaching when seeking support from their CTL center. The challenges primarily consisted of:

- Confusion and feeling overwhelmed by the number of available tools
- Lack of one-on-one support
- Lack of uniformity within the university between administration, faculty, and students

It can be inferred from these statements, that P65 believes access to resources should be simplified and consistent across engineering majors, highlighting the need for departmental and institutional reform. A similar analysis and conclusion has been reached by [14] with regards to insufficient training being a primary barrier to EBIP implementation. Anderson et al. [1] also recognize the importance of institutional change within research universities. They emphasize the need for the redirection of funds towards education, noting that teachers are, "... often left to fend for themselves…", when attempting to utilize alternative modes of teaching or the technology that comes along with it.

4.2 Analysis of P46 interview

In the interview with participant P46, the issue of safety protocols is discussed in the context of developing interactive class demonstrations. The difficulty is tied to the resources needed to effectively illustrate the process of **"electro spin"** in a tissue engineering course without the proper instrumentation being available in the lecture room. The lecturer wanted to show a **"hands on activity"** to the class, however it was, **"...really challenging to do … a hands-on demo … because a lot of what I do involves a lot of … safety protocols and things that have to be done [in the] lab"**. Later going on to say that, **"...it's very complicated. It requires a lot of PPE and things like that. So I'm trying to find a way to like, take what I do in lab, but bring it into the classroom and feel like it's gonna be just as impactful to the students".** This excerpt from the conversation reveals that proper equipment and facilities are available at the interviewee's institution. However, the issue lies in the logistical details of supplying a class of approximately **"65 students"** with the proper personal protective equipment and making it an effective learning experience for everyone in attendance. While still discussing the electro-spin in-class activity, participant P46 started to ponder, **"...how could I do that in the course? But I just didn't have like the, the training or just like the, the mentorship, or just like the, someone to consult with on how to do it"**. To provide context, the situation Participant P46 is elaborating on, took place when they started their **"teaching journey"** as a graduate student. This passage of the conversation reveals the participant's expressed desire for a more personal approach when receiving guidance on creating an engaging classroom environment. This further demonstrates the crucial role of community when committing to pedagogical changes. In other words, a lack of solidarity has the tendency to create a stale culture which recycles antiquated notions of teaching. The sentiments illustrated by P46 suggest that EBIP-awareness should perhaps begin in graduate school, which would proactively normalize the use of alternative teaching innovations, as opposed to reactively finding a mentor after becoming an instructor. They further go on to state, **"...that was probably the first time where I really felt like I really had to build my own curriculum. I had to do all of the grading. I had to do the lecturing…and then, um, in, during my postdoc years, again, really didn't get the opportunity to teach, but I took a teaching course on how to teach … in the science field. And that's where I learned a lot more about, um, pedagogy and, and really building your curriculum based on your audience"**. The preceding passage further highlights how the academic and professional trajectories taken by P46 have led to a mindset which embraces flexibility and an evolving educational landscape. Participant P46 also discusses their teaching philosophy, stating that, **"...every time I present, I want to be interactive and I want to be engaging. I don't wanna just be sitting in front of the class…I wanna kind of, I want to appear to be a human, um, to them, to them instead of like this professor or at that time, this graduate student".** P46 is sincere in developing a comfortable active-learning environment in their classroom. It is arguable that harnessing this compassionate and humanistic disposition at the early stages of an educator's career can be further complemented by gaining exposure to EBIPs and guidance on how to specifically implement them. This momentum may then carry on and resonate with colleagues and other faculty members in the department. The foregoing statements related to the challenges of in-class demonstrations illustrate several factors related to resource availability and EBIP implementation which are bulleted below:

- Providing teaching opportunities for graduate students creates a path for individuals of a younger generation to try out alternative teaching methods and normalize EBIP implementation in engineering courses
- When developing an in-class activity for the first time, the need for a mentor is crucial to mustering support and confidence, especially for less experienced teachers
- The availability of teaching tools (i.e. pedagogy courses) is critical to developing a broader and more interactive classroom environment
- Organization of laboratory resources and logistics facilitates a means by which in-class demonstrations may become more realizable

5. Conclusion

Inquiry about the familiarity, usage and experiences with resource-related barriers provided valuable insights on ways to improve their reach and impact within their institution. General themes included: poor faculty sentiment about broadly themed teaching workshops, the need for more one-on-one assistance with course development and EBIP implementation, and the benefit of feedback and interaction within the teaching community about their experiences implementing EBIPs

Several context-specific barriers, along with possible solutions, were revealed through participant interviews. For instance, in terms of communication between faculty and CTL staff, it is recommended that a more personal and proactive approach be taken for guiding instructors on how to tailor their courses to support active learning. This may be facilitated by providing a more succinct list of standardized materials that may be easily modified to fit course content and learning outcomes. For example, furnishing "fill-in-the-blank" templates of case-based or problem-based learning activities may reduce the sentiments of anxiety associated with these EBIPs. There are two primary sources of uncertainty tied to these innovative pedagogical tools. One source of uncertainty comes from unfamiliarity, and not knowing exactly how to utilize the method in practice. The other uncertainty is related to whether the EBIP will work or not. Therefore, a one-on-one mentor approach seems most suitable when seeking assistance on EBIP-implementation.

In terms of technology based EBIP implementation, it may prove useful to streamline the process with an existing matrix of pros and cons associated with various platforms. P65 noted that they were overwhelmed by the number of choices and functionalities of all the available options. Having a one-on-one consultation appointment, in which a CTL advisor walks through a shortened list of alternatives could make the process more palatable to faculty.

Considering participant P46's experiences, another proposed avenue for combatting resource-related barriers to EBIP implementation is training at a graduate level. It is not uncommon in PhD or Master's programs for students to take on graduate teaching assistant positions. This experience is often considered as preparation for holding an academic position in higher education. Therefore, it is reasonable at this stage for graduate students to be exposed to EBIPs through some form of training. This type of coaching may prepare instructors on how to react if EBIPs do not have the initial desired effect. Thus, shifting away from the current paradigm of abandonment, and instead moving towards adaptation.

Results from this study provided an improved understanding of the resources needed to assist faculty in implementing EBIPs. Such knowledge could inform faculty development efforts and provide insights into existing teaching resources on how to better assist faculty in the EBIP implementation process. Ideally, the results from this work would be integrated into a conceptual model regarding a broader range of barriers (i.e. time constraints, cultural norms within the department, student resistance, etc.) which may be fine-tuned to specific engineering courses.

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