# Evolution of Chemical Engineering Faculty Beliefs and Barriers Toward Active Learning Incorporation

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## Abstract

This research paper investigates the impacts of incorporating inquiry-based laboratory experiences into core undergraduate chemical engineering courses on chemical engineering faculty instructors at a research-intensive university in the Northeast United States. While the benefits of active learning in STEM are well-documented, its adoption among chemical engineering faculty remains slow. Our institution is transforming its curriculum to include hands-on labs and engage faculty as change agents. We present results from a concurrent mixed-methods study that used surveys and interviews with four faculty before and after implementation. Findings reveal the most salient barriers—resources, preparation time, and class time—and how they manifest in context. Future work will track changes in faculty attitudes through longitudinal surveys and interviews. By understanding our faculty's current enthusiasm for active learning, we can better plan and inform our own change efforts, as well as those in other disciplines and institutions. The author team would prefer to present this paper as a talk.


## Introduction

Over the past two decades, major engineering and STEM organizations have called for widespread improvements in undergraduate education [1]. Toward this end, previous studies have built a substantial knowledge base of research-based instructional strategies (RBIS) toward improved STEM education, including inquiry-based learning, problem-based learning, think-pair-shares, and other forms of active learning [2]. A large body of empirical work now links active learning to improved student performance and reduced achievement gaps for underrepresented students [3], making it a central lever for both efficacy and equity in STEM education. Although the benefits of active learning have been well documented [1], [4], STEM faculty have low adoption rates due to perceived practical barriers to implementation. For example, chemical engineering faculty adopt active learning in their classrooms less than 50% of the time [5]. Previous studies highlight faculty decisions to adopt active learning are strongly shaped by practical concerns about content coverage, workload, student reactions, colleague norms, and structural course constraints [2], [6].

Building on this literature, our study examines faculty perceptions as we integrate active-learning laboratories into core chemical engineering courses. While other engineering disciplines have successful models of change, like biomedical engineering, which is a more recently emergent discipline [7], [8], chemical engineering has unique historic norms of a high-consensus discipline where the curriculum is virtually the same across the United States and even internationally [9]. These norms pose unique challenges for fostering change among faculty who have all been trained in a canonical educational progression and who have not been trained in the most effective practices to teach chemical engineering [10]. As such, while the ideas in this effort are not new, the context of the discipline creates novel opportunity for investigating how faculty development occurs.

## Conceptual Framework

We leverage the Concerns Based Adoption Model framework, in which educational change is modeled as a process that instructors undergo as they consider adopting a new educational strategy rather than an all-at-once decision [11] to examine faculty attitudes and experiences. In this process, instructors progress through five steps, described here in the context of our inquiry-based lab implementation: (1) gaining awareness of the broader department goal of implementing lab experiments in core courses, (2) seeking information on how this goal can be accomplished in their course, (3) reflection on the pros and cons of implementing labs in their course, (4) adoption of the lab and analysis of its efficacy, and (5) deciding to continue incorporating inquiry-based labs in their future courses. In our specific context, we are mostly interested in our faculty's progression through Steps 3 and 5; the authors help faculty progress through Steps 1, 2, and 4 before the course begins and as the course progresses. This framework outlines six barriers to adopting new educational strategies [2]. Although these barriers are not an exhaustive list of potential hindrances to active learning adoption, they represent a common set of concerns that faculty consider when weighing the costs and benefits of adopting a potential strategy. These barriers relate to both Steps 3 and 5 as potential challenges to implementing lab experiments effectively and reasons to adopt the lab experiments next year or not.

***Active Learning Initiative***

Traditional chemical engineering curricula often feature instructor-centered, lecture-based courses to introduce the theory behind real-world processes and reserve application of this theoretical knowledge for the canonical upper-level Unit Operations (UO) laboratory course [12]. However, existing literature and our prior work suggest that redesigning the chemical engineering curriculum to enable students to learn theory and immediately apply it to real-world equipment through hands-on laboratory exercises benefits student motivation and knowledge retention [13]-[17]. Toward this end, we are currently deconstructing the existing UO Lab course into self-contained experimental "inquiry labs" and integrating these inquiry-based labs into the Sophomore and Junior years of the curriculum. We have so far implemented ten inquiry labs in six core, required courses (listed in the Methods section). We aligned each inquiry lab with Kolb's experiential learning model [18], [19], in which students engage in concrete experience, reflective observation, abstract conceptualization, and active experimentation.

***Study Focus and Research Questions***

We analyzed faculty perceptions through the lens of six recurring barriers faculty raise that must be made visible (and ultimately addressed) to enable sustainable change: (1) resources and support infrastructure, including effective use of available tools and TA support; (2) anticipated student response, including worries about how the broader class will receive instructional changes; (3) preparation time demands, especially the perceived difficulty of designing and organizing in-class activities; (4) in-class time constraints; (5) department value, including how the university department values the integration of active learning into the curriculum; and (6) evidence of efficacy, looking at whether active learning efforts have been successful in enhancing student understanding [2]. By understanding our faculty's perceptions of these barriers as they relate to their courses, we can propose and evaluate concrete, department-level strategies to reduce them and support broader, more consistent implementation of active learning in STEM fields. In this study, we answer the following research questions:

**RQ1**: What barriers to implementing inquiry-based laboratories are most salient to our faculty?
**RQ2**: How did the most salient barriers manifest for our faculty in their courses? What strategies were most effective in overcoming these barriers?

## Methods

This work is part of a larger study investigating how incorporating active learning through hands-on, inquiry-based laboratories in core chemical engineering courses impacts engineering faculty and students. We focus on barriers to incorporation, since their salience is contextual, and highlighting the most prevalent barriers for our faculty would support future course implementations. Due to the small sample size of our faculty, we chose to present aggregated results of our faculty survey and anonymized quotes from our pre- and post-course interviews.

We employed a concurrent mixed methods study to identify and understand our faculty's most salient barriers to incorporating active learning into their classes (IRB0148897). We administered surveys at the beginning of the Fall semester in both 2024 and 2025, measuring the strength of various barriers to adopting research-based instructional strategies, among other constructs [2]. We then conducted semi-structured interviews with four chemical engineering faculty members before and after their course. These faculty were selected for interviews due to being the instructors for the courses at the beginning of the required core sequence, and thus being the first faculty to adopt inquiry-based labs in their classes. The pre-course interviews focused on the participants' teaching philosophy, perspectives on the efficacy of active learning, and anticipated challenges for the semester, among other topics. The post-course interviews focused on the same aspects, along with the participants' opinions on the success of our lab efforts, the biggest challenges they perceived, and steps to mitigate these challenges in the next iteration. These data were collected simultaneously across the semester and integrated in data analysis to answer RQ1 and RQ2.

### *Institutional Context and Participants*

The faculty participants in this study are members of the School of Chemical and Biomolecular Engineering at a large, research-intensive university in the Northeast. Of the total faculty employed in the department ($N$ = 32), 17 submitted at least one survey response. The six courses that had laboratory experiments added are core, required courses in the Sophomore and Junior Years of the curriculum: Chemical Process Design and Analysis (Fall 2024), Fluid Mechanics (Spring 2025), Physical Chemistry II for Engineers (Spring 2025), Chemical Engineering Thermodynamics (Fall 2025), and Heat and Mass Transfer (Fall 2025). All of these courses were taught by tenured/tenure-track faculty. This work followed a cohort of students ($N$ = 71) through the curriculum as changes were implemented. The instructional support for each class ranged from 4-6 undergraduate teaching assistants and 0-1 graduate teaching assistant.

### *Inquiry-Based Laboratory Implementation*

Prior to each semester, we met with each faculty member to discuss their priorities for implementing hands-on learning in their upcoming class. Collectively, we outlined the most important learning objectives to reinforce with a laboratory component, possible additional experiments and projects given our current equipment and purchasing power, and the different responsibilities for lab design, implementation, and assessment among the teaching team. Each faculty member had varying levels of familiarity with and adoption of active learning techniques, but none had previously incorporated hands-on learning in the form of inquiry-based labs in their classes.

***Data Collection and Analysis***

Over the two instances of administering the survey, we received a total of 24 responses ($n$ = 10 in Fall 2024, $n$ = 14 in Fall 2025). We analyzed the participants' responses to the survey questions shown below in Table 1.

**Table 1.** Survey items for faculty active learning willingness and barriers.

| Question | Item | Code |
|---|---|---|
| How willing are you to… [20] | …incorporate new active learning labs in your class, given the constraints of your curriculum? | Incorporate |
| | …give up time for course content in exchange for active learning labs? | Give_Up_Time |
| What barriers to incorporating new active learning labs are you most concerned about? [21] | Not enough resources available | Resources |
| | Department does not value active learning | Department_Value |
| | Negative student responses | Student_Feedback |
| | Not enough evidence that active learning is effective | Evidence |
| | Too much prep time required | Too_Much_Prep_Time |
| | Too much class time required | Too_Much_Class_Time |

Participants responded to these items on a 1-7 anchored numeric scale, with 1 being the lowest value (willingness: "Not at all," barriers: "Not at all concerned") and 7 being the highest value (willingness: "Extremely," barriers: "Very concerned"). To identify if any barriers were particularly salient for our faculty, we used a nonparametric statistical test (Kruskal-Wallis) for significance and calculated an effect size of these differences (ordinal epsilon-squared, ${\varepsilon^2}_R$) [22]. Moderate, relatively strong, and strong effect size thresholds are generally considered to be 0.04, 0.16, and 0.36, respectively [23]. Once we determined a significant difference in barriers among our faculty, we identified which specific barriers were most salient with Dunn's post hoc test, a nonparametric comparison test between each pair of barriers in question. We calculated the effect size of the differences between each barrier pair using a point-biserial correlation ($r$) [22]. Small, medium, and large effect size thresholds are generally considered to be 0.1, 0.3, and 0.5, respectively [22].

Simultaneously, we conducted semi-structured interviews with four faculty members before and after their courses incorporated active learning laboratories. Pre-course interviews were conducted during the planning meeting before each semester began, and post-course interviews were conducted before the end of the semester or before the start of the next semester, depending on scheduling constraints. One faculty member taught two of the five courses we worked with; since we were interested in their overall change in attitudes toward barriers to active learning, we conducted the post-interview only after their second course. Among other questions, we asked each faculty member, in their pre-interview, about their previous experience with active learning in general, hands-on laboratory exercises, their willingness to incorporate these labs, and potential barriers to the success of our efforts. Similarly, we asked each faculty member in their post-interview the same questions, with additional questions regarding their perspectives on the benefits of our efforts for the students, the challenges and barriers they experienced over the semester implementing the lab(s), and potential measures to alleviate these barriers for the next iteration of the course.

We transcribed the interviews verbatim, and at least one research team member checked each transcript for accuracy before analysis. We coded the interviews with a two-cycle approach. We used Values Coding for the first pass, identifying relevant quotes from each faculty member regarding the lab component of their course and assigning a value, attitude, or belief to each [24]. We chose Values Coding because we are interested in understanding how their perceptions and priorities regarding teaching and learning evolved through engagement with pedagogical innovation that semester. For the second pass, we deductively grouped Values Codes into categories and themes for each of the barriers discussed in literature [2] using thematic analysis. We then mixed the quantitative and qualitative data streams by comparing the salience of barriers to lab incorporation in each stream to understand how the most salient barriers manifest for each faculty member to answer both research questions. This method allows us to corroborate and expand upon the general trends we observe in the quantitative data and elucidate the most important steps to alleviate perceived barriers in future iterations of the course.

***Author Positionality***

Author 1 holds undergraduate and Ph.D. degrees in chemical and biomolecular engineering. He worked directly with faculty on implementing labs, conducted interviews, and administered surveys, ensuring consistency by asking the same questions regardless of prior knowledge. He presented findings at faculty meetings and consulted with co-authors throughout, as this was his first experience with lab implementation and engineering education research. Authors 2 and 3 are third-year chemical engineering undergraduates. Although enrolled in the courses studied, they did not collect data. They analyzed anonymized interview transcripts in two passes, meeting with Author 1 to ensure consensus. This was their first experience with engineering education research. Author 4 has a Ph.D. in engineering education and an undergraduate degree in chemical engineering. She mentored Author 1 on lab design and implementation and regularly uses RBIS in her own teaching. As a department faculty member, she engaged with study participants but refrained from data analysis due to these relationships. These positions may have affected our data quality, as Author 1's dual role as lab support and researcher may have limited participants' candor in interviews to preserve professional relationships. However, we believe that our domain-specific knowledge and direct involvement in lab implementation gave us richer data interpretation power to overcome this limitation.

## Results

We observed an overall willingness among faculty who responded to our survey to both incorporate and give up course time for active learning lab exercises (Figure 1). The median values for willingness to incorporate ($M$ = 7; where $M$ is the median) and give up time for course content ($M$ = 6) were not significantly different from a Mann-Whitney U test. The high values on a scale of 1-7 indicate a general enthusiasm for pedagogical innovation in the department. The outlier low scores of 2 for each item were given by the same faculty member, who was not one of the participants involved with the course implementations. We would have liked to disaggregate the results by time and demographics, including gender, tenure status, and race/ethnicity, but the sample sizes were not large enough to maintain anonymity of the participants.

We observed that our faculty perceive a lack of resources, too much prep time, and too much class time required as the most salient barriers to incorporating active learning labs (Figure 2). The median values of our faculty's concern towards the six barriers varied widely. Our faculty were least concerned about evidence that active learning is effective ($M = 1$), our department values active learning ($M = 1$), and student responses to active learning ($M = 2$). The most concerning barriers to active learning lab incorporation were available resources ($M = 5$), required class time ($M = 3$), and required prep time ($M = 4$). The difference among the means of these barriers was statistically significant ($H(df = 5) = 44.3$, $p < 0.0001$) with medium effect size (${\varepsilon^2}_R = 0.35$). We conducted a post hoc comparison test to determine if the three highest barriers were significantly different from each other and from the three lowest barriers (Table 2).

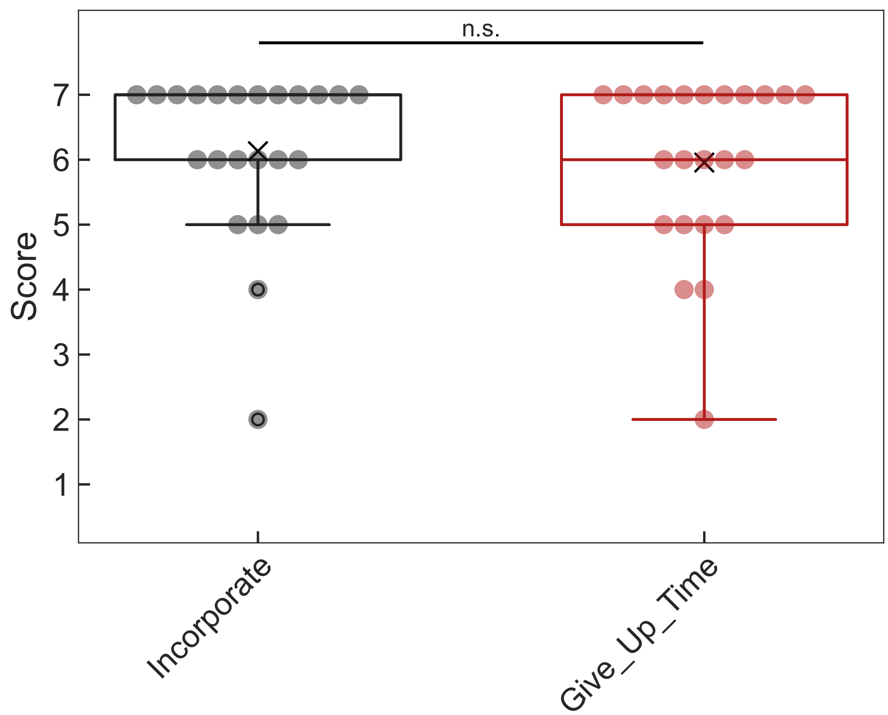


**Figure 1.** Quantitative survey results of faculty's willingness to incorporate and give up course time for active learning lab exercises. Individual survey responses are represented as circles. Boxes represent the upper quartile, median, and lower quartile of responses for each item and outliers are represented as open circles. Response count $n = 23$ for both items. Mean values are plotted as "x" markers over their respective boxes. n.s., $p > 0.05$.

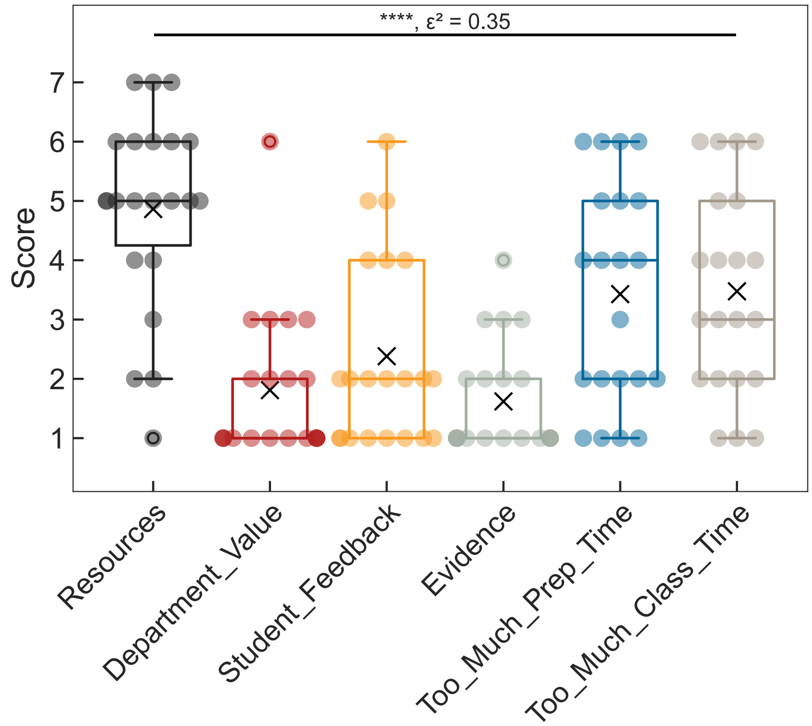


**Figure 2.** Quantitative survey results of faculty's most concerning barriers to incorporating active learning lab exercises. Individual survey responses are represented as circles. Boxes represent the upper quartile, median, and lower quartile of responses for each item and outliers are represented as open circles. Response count $n = 21$ for all items. Mean values are plotted as "x" markers over their respective boxes. ****, $p < 0.0001$.

**Table 2.** Dunn's post hoc test and $r$ effect size results of active learning barriers.

| | Resources | Department Value | Student Feedback | Evidence | Too Much Prep Time |
|---|---|---|---|---|---|
| Department Value | **** $r = 0.68$ | - | | | |
| Student Feedback | *** $r = 0.54$ | n.s. | - | | |
| Evidence | **** $r = 0.74$ | n.s. | n.s. | - | |
| Too Much Prep Time | n.s. | * $r = 0.39$ | n.s. | ** $r = 0.44$ | - |
| Too Much Class Time | n.s. | ** $r = 0.41$ | n.s. | ** $r = 0.46$ | n.s. |

n.s., $p > 0.05$; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$; ****, $p < 0.0001$

We observed significant differences, with large effect sizes, between Department Value and the three highest barriers, confirming that it is not a major concern for our faculty and that our department values active learning. Evidence showed a similar relationship, supporting our department's belief that active learning is effective. We observed no significant differences among the three highest barriers in Resources, Too Much Prep Time, and Too Much Class Time, affirming their status as the most salient barriers. Student Feedback showed only a significant difference for Resources, with a large effect size, and no significant differences for Too Much Class Time and Too Much Prep Time. This result suggests that it is a barrier of concern, falling between the least and most concerning barriers. However, we observe a bimodal distribution of responses to the Student Feedback barrier, with 15 responses at 2 or below on the 1-7 scale and 6 responses at 4 and above. As a result, we consider Student Feedback a low barrier, as its mean is driven higher by a small portion of the department (28.5% of responses).

Overall, our quantitative results suggest that although our faculty are generally willing to engage with active learning in their classes, resources, prep time, and class time remain significant concerns. This finding contrasts with previous literature findings that chemical engineering faculty perceive Evidence and Student Feedback as additional strong barriers to inquiry-based lab incorporation, along with Too Much Prep Time and Too Much Class Time [2]. Additionally, Resources was among the lowest-ranked selected barriers in that study, whereas it was the strongest barrier to our faculty. This discrepancy is likely due to differences in institutional context between our faculty and the population in that study; our results are specific to our department and university, whereas the previous study was conducted with faculty from many different institutions. Our results highlight the importance of considering institutional context when implementing inquiry-based laboratory experiments, as the resources available at each institution and the degree to which faculty are aware of and/or believe the evidence around the benefits of active learning vary greatly.

In pre-course interviews, faculty generally displayed a high degree of enthusiasm for the upcoming semester, which corroborates the quantitative data:

> Oh, I'm really excited about adding in a hands-on experiment, because to me, that's active, that is having fun. I feel like I've actually always taught using very, you know, a whole bunch of active learning techniques. – Faculty 3
>
> I wish I could, like, blow up everything and make it all hands-on, you know, and computationally included in that base. – Faculty 4

In post-course interviews, faculty expressed that both they and the students viewed the lab experiences positively:

> I loved it. Because one thing that–I loved it because they could see the concept in a, in a practice, and I think they liked it too. It worked well…it was clear to those that participated, it was useful. – Faculty 2

Despite this enthusiasm, faculty expressed several hesitations about the barriers to implementing labs in their courses and offered suggestions for overcoming those barriers and strategies for other faculty considering a similar course implementation to navigate them effectively.

***Resources: Laboratory Space and Equipment***

Surprisingly, although resources were identified as the largest barrier in the quantitative results, few faculty highlighted resources as a concern for their course in the interviews. The main way resources manifested as a barrier for our faculty was in physical space and equipment limitations:

> I really don't like the idea of having 8 to 12 people standing around a small heat exchanger, doing nothing. It sort of isn't active learning, though. – Faculty 3

Given the class size of 71 students, this quote emphasizes a concern around the logistical considerations of scheduling enough lab time for a large amount of students while maintaining small enough group sizes (4-6) to avoid detracting from the learning experience [25], [26]. Implicit in this concern is time, which appeared as the main barrier among our faculty in all interviews. One faculty member summarized the view of time as a resource in terms of lab scheduling:

> So, I wish we had either more time with like, a block like that, or, like, ideally, in my world, it would be every junior would register for an experiment time. Because if I had that time, I would also- like, I actually published a J. Chem. Ed. paper on a diffusion experiment, and, like, I would have run that with them in the next two weeks, but I couldn't get the lab time for the times I needed it. – Faculty 3

This faculty member showed a strong excitement for incorporating labs into their course, even beyond the equipment readily available in the Unit Operations lab. However, since the lab is a shared space and requires careful scheduling to abide by capacity limitations for safety, scheduling restrictions proved too great a barrier to overcome in that semester's iteration of the course. Although laboratory setups and use frequencies vary greatly among engineering departments, investments in more equipment, larger lab space, and trained staff members could help alleviate the resource barrier for lab implementation.

***Too Much Preparation Time for Hands-on Labs***

Faculty interpreted preparation time in two ways: effort on their end to design and organize effective lab instruction and student time for preparing to engage with a lab. Several faculty expressed a lack of time in their busy schedules to devote to lab design and implementation:

> And I see the light in that sense, but I'm not–it doesn't come as easily to me…Let me put it this way, it's more difficult than I think it should be. Like, looking at others do this, it's so easy, and then you want to adopt it, and you find out it's not, not trivial. – Faculty 4

> If I would have time, I–I can basically build anything. – Faculty 1

Department promotion structures typically place a larger emphasis on faculty research output than teaching, incentivizing faculty to devote more time to research and less time to teaching [27]. Coupled with a sense that their prior experiences and formal training are not sufficient to feel prepared to engage with pedagogical innovation in this way, this imbalance in systemic incentives appears to be a strong barrier for our faculty. Faculty acknowledge that successful active learning implementation requires effort, so departmental and university structures for how faculty allocate their time should be adjusted accordingly to align with the stated priorities of increased active learning in the classroom.

Faculty were also conscious of student time investment as a barrier to successful lab implementation; if students don't feel they have the time or will to engage with lab material outside of class, their efforts won't be worth it:

> So, I wish to say, okay, outside this class, outside the classroom and recitation, they would have this number of hours to focus on the [lab] material, because they're very busy. – Faculty 1

> …and what it taught me was that students don't have the bandwidth to do that, and they don't have the time management skills to understand that if I do an hour before I come to class, I don't need to necessarily do that hour after class. – Faculty 2

At this institution, a class can require up to three hours of work per credit hour per week. To avoid exceeding this limit, faculty opted to cancel lecture and discussion sections during the lab week(s). While this strategy freed up time for students to devote to meaningfully engaging with the labs, it also freed up time for the faculty and teaching team to devote to their other responsibilities in the course and otherwise, creating a win-win situation for all.

***Too Much Class Time***

The strategy of canceling instructional class time was a compromise for our faculty, who all expressed a concern about "covering" the necessary material for the course while incorporating a lab component:

> I would say time. I think time is a challenge because- I don't know. I mean, every year I think the class is different. The past two years, I felt that we had, we were fortunate to have strong ChemEs. But if you go to a class and the class has a diverse background, and some don't feel comfortable with basics, that needs a lot of time to bring that part of class up…And I would say the big barrier is time, because we have just three hours per week of teaching and three hours of recitation, and the students are busy as well. – Faculty 2

> …you can't do active learning without compromise. – Faculty 1

Faculty did not acknowledge that learning may be occurring or that this experience could be teaching students the same learning objectives through different experiences. These results indicate an opportunity to help faculty reconsider how learning occurs and address misconceptions that passive coverage is the ideal way in which students learn.

In post-course interviews, faculty reaffirmed this compromise but acknowledged that the content they chose to cut to make room for labs was not necessary for student success in the course:

> What I did that worked: I used to have one review session before Prelim 1, before Prelim 2, and one before [the] Final. I excluded those because of the lack of time I could cover the content with that week gone. So, for review, then what we did before the exam, we included that in the recitation and online. We said that, 'okay, these are the review question[s], but we will give those to you as an assignment, which we are not going to grade, but we are going to give you the, the solution to those review questions.' In the past, I was solving them in the classroom, but I didn't do that. So that gave me three extra sessions for the lab. – Faculty 2
>
> So my solution to free up the time to add the experiential lab was to delete course material, in this case, an entire topic, Introduction to Dimensional Analysis for Design…It always used to be in Fluids. They'll come- they would just come into fluids less prepared, and hopefully they'll pick it up in Fluids. – Faculty 1

In both cases, these faculty acknowledged that course content needed to be reduced to create room for the lab components. One faculty member chose to allocate course time away from review sessions for exams, while another removed an entire topic. Both faculty members accepted this compromise as valuable, finding other ways to still accomplish the same goal (administering the review questions as ungraded homework) or acknowledging that the topic can still be taught in a different course in the curriculum (learning dimensional analysis in Fluids rather than their course). One faculty member also suggested rethinking the way the university structures class time for courses as a potential solution:

> I would happily take, like, this class down from four to three credits and fine, just give me two, two-hour blocks. I don't even need a recitation then, because I would have that time to reinforce concepts in the lab. So, shift my credit there. Just reallocate time, not create. Yeah, I don't need more time. I just want to allocate it differently. – Faculty 3

These results highlight the need for faculty to carefully consider class structure when planning to incorporate active learning, such as lab experiments, in their course. Outlining the most important learning objectives for the course helped our faculty decide where and how to rearrange class time allocations or remove content altogether. A department-wide curriculum analysis of what and where learning objectives are taught could streamline this process for faculty, easing concerns about cutting important content from their courses. Furthermore, shifting university classes away from the traditional lecture and recitation format could create more space for labs, allocating time more efficiently to cover content each week.

Our findings suggest that concerns about class time and content coverage are amplified by chemical engineering's highly standardized curriculum. Unlike disciplines with more flexible course structures, chemical engineering faculty operate within a consensus-driven sequence of topics that leaves little room for deviation. This rigidity makes reallocating time for active learning particularly challenging, as faculty perceive any reduction in lecture content as a potential gap in students' preparation for subsequent courses. The strategies faculty employed, such as removing review sessions or shifting topics to other courses, reflect attempts to navigate these structural constraints rather than a lack of commitment to pedagogical innovation. The discipline's historic norms of uniformity and tradition also shape faculty perceptions of risk. In a field where courses are expected to look similar across institutions, faculty may feel pressure to maintain conventional structures. This cultural expectation underscores the importance of framing active learning to strengthen, rather than disrupt, the integrity of the chemical engineering curriculum.

Altogether, although several barriers were salient for faculty before their course, their reflections on overcoming those barriers and positive perceptions of the labs' effect on their students suggest that these barriers are not insurmountable. Our findings underscore the need for faculty development programs that address both structural and cultural barriers in chemical engineering education. Training should go beyond introducing active learning techniques to include strategies for reallocating class time, prioritizing learning objectives, and leveraging departmental resources.

**Limitations and Future Directions**

Our mixed-methods approach provided an in-depth view of faculty-perceived barriers to active learning labs and strategies for overcoming them. However, we acknowledge that our study still had limitations. Because quantitative data collection began at the start of lab implementation in Fall 2024, we lack historical data on faculty attitudes for comparison. The department had been socializing the idea of curriculum innovation for two years before the start of the project to build a shared vision, so factors such as high willingness to engage in this change, low endorsement of the lack of evidence, and high value for these efforts may be contextual. These results may indicate which factors to address first to develop a shared vision for change. Once these issues are resolved, faculty appear willing to engage and may need greater resources and support for implementation. Due to the small sample size, we lacked statistical power to compare changes over time. Three more faculty will adopt active learning, inquiry-based labs in the coming year, so pre- and post-interviews with them, combined with continued surveys, should enrich longitudinal data. As we collect more data, we anticipate observing a decrease in barriers and assessing whether factors such as growth mindset, goal orientation, or intelligence beliefs influence barrier salience.

**Conclusions**

Our concurrent mixed-methods study clarified the most concerning barriers to active learning lab implementation for our chemical engineering faculty and how these barriers manifested in their class contexts. Quantitative results indicate faculty are highly willing to engage, yet persistent barriers remain—resources, class time, and prep time were most salient. Qualitative interviews revealed these barriers were contextual: resources meant space and logistics; prep time involved increased faculty and student effort; class time meant limited time and reduced content. Faculty suggested strategies to overcome these barriers, including investing in equipment and staff, restructuring promotion incentives, and prioritizing learning objectives to reallocate time. These findings provide a foundation for similar pedagogical change efforts and will inform our ongoing work.

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