Research Proposal: Inclusive Science Teaching in Higher Education

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Date: September 2025

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This research proposal focuses on improving science and mathematics learning outcomes among young adults in higher education, particularly in introductory STEM courses such as chemistry, biology, and physics. Students arrive at college with widely varying levels of preparation, learning styles, and abilities, which often translates into achievement gaps and inequitable outcomes. The goal of this study is to identify the most effective and inclusive ways to teach these students, combining evidence-based teaching practices with innovative support structures.

Purpose and Research Questions

The purpose of this project is to evaluate which teaching models best address the challenges of heterogeneity in ability levels among STEM students. Specifically, the study will test whether combining high-structure active learning, Universal Design for Learning (UDL), and just-in-time or corequisite math support results in higher academic achievement, reduced D/F/W rates, and narrower equity gaps compared to traditional lecture-based instruction. Additionally, the study will examine which components—active learning structure, UDL practices, or math corequisite support—have the most significant effect on student success, and whether short, targeted mindset and belonging interventions further enhance outcomes.

Theoretical and Empirical Rationale

There is extensive empirical evidence supporting the use of active learning in STEM classrooms. Freeman et al.'s meta-analysis (2014) demonstrated that active learning improves exam performance by nearly half a standard deviation and reduces failure rates by 50%. Building on this, Theobald et al. (2020) showed that active learning has disproportionately positive effects on historically marginalized student populations, thereby reducing achievement gaps. High-structure course design—characterized by frequent low-stakes assessments, guided worksheets, and peer interaction—has been especially effective in improving engagement and performance among first-generation and underrepresented students.

Universal Design for Learning (UDL) provides a complementary framework by offering multiple means of engagement, representation, and expression, thus supporting students with disabilities, neurodiverse learners, and others who benefit from flexible instructional design. However, studies by Deslauriers et al. (2019) reveal that students in active learning environments sometimes perceive they are learning less, even as their actual learning outcomes improve—suggesting that transparency and metacognitive framing are essential.

In addition, social-belonging and growth-mindset interventions (Walton & Cohen, 2011; Yeager et al., 2019) have been shown to significantly improve academic outcomes, particularly when combined with supportive classroom contexts. Math readiness also plays a crucial role: research by Logue, Watanabe-Rose, and Douglas (2016) found that students enrolled directly into college-level statistics with corequisite support outperformed those placed into traditional remedial pathways, with lasting effects on credit accumulation and degree progress. Finally, course-based undergraduate research experiences (CUREs) have been found to engage students in authentic scientific practices and broaden participation in STEM fields.

Design and Methods

This study will be conducted across twelve introductory STEM course sections at three different campuses, encompassing approximately 1,200 students. Sections will be randomly assigned to one of four instructional models: (A) traditional lecture as a control group, (B) high-structure active learning, (C) high-structure active learning combined with UDL practices, and (D) high-structure active learning with both UDL and just-in-time/corequisite math support. All treatment sections will also include a short social-belonging activity in the first week and embedded exam-preparation routines throughout the semester.

Primary outcomes will include pre- to post-test gains on standardized concept inventories, course exam averages, final course pass rates, and equity gaps measured across demographic subgroups such as underrepresented minority status, first-generation college attendance, Pell eligibility, and disability registration. Secondary outcomes will include persistence into subsequent STEM courses, mindset and belonging survey scores, and student perceptions of workload and learning.

Data Analysis

Data will be analyzed using multilevel modeling to account for students nested within course sections. Mixed-effects logistic regression will be applied to categorical outcomes such as pass rates. Pre-specified subgroup analyses will examine whether the interventions differentially benefit historically underserved populations. Mediation analyses will test whether participation in just-in-time math modules predicts improvements in course performance through enhanced formative assessment outcomes.

Accessibility and Inclusion Plan

Accessibility will be embedded into the design from the outset through Universal Design for Learning. This includes captioned videos, accessible documents with alt text, and flexible assignment formats. Transparency will be emphasized to address potential misperceptions of learning in active classrooms, including a clear explanation of how active learning enhances understanding. Additionally, equity-minded practices such as think-pair-share, inclusive participation protocols, and frequent checks for understanding will be implemented.

Timeline

The proposed study will be conducted over one academic year. During months one through three, faculty will participate in professional development on active learning and UDL practices, instruments will be finalized, and IRB approval will be obtained. Months four through nine will be devoted to the implementation of the interventions across participating sections. The final three months will focus on data analysis, preparation of manuscripts for publication, and the release of an implementation toolkit for faculty.

Budget

The estimated budget for one year is approximately $65,000. This includes $24,000 for faculty stipends and classroom observation, $18,000 for learning assistants or peer-led team learning leaders, $6,000 for accessibility services such as captioning and document remediation, $7,000 for survey licensing and student incentives, and $10,000 for data analysis and dissemination.

Anticipated Contributions

This study will provide one of the first causal tests of a combined instructional model that integrates high-structure active learning, Universal Design for Learning, and corequisite math support. It will generate practical, open-access resources including quizzes, syllabus templates, and math mini-modules that faculty can adopt. Finally, it will contribute to the evidence base on how inclusive, high-impact teaching practices can improve equity in STEM education, offering clear insights into the mechanisms by which these practices support diverse learners.