UNIVERSITY OF CALIFORNIA

Los Angeles

Promoting Inclusivity with Student-Centered Instructional Approaches:

Evaluation of a Course Redesign of Undergraduate Research Methods in Psychology

A dissertation submitted in partial satisfaction

of the requirements for the degree Doctor of Philosophy

in Education

by

Virginia Sklar Muscatello

2023

ABSTRACT OF THE DISSERTATION

Promoting Inclusivity with Student-Centered Instructional Approaches:

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Doctor of Philosophy in Education

University of California, Los Angeles, 2023

Professor Jeffrey J. Wood, Chair

Background: Higher education is more diverse than ever with a drastic increase in college enrollment over the past two decades by those who have not traditionally sought undergraduate credentials, including students with disabilities (Espinosa, Turk, Taylor, & Chessman, 2019; Clouder et al., 2020). Despite the growing demographic diversity of students choosing to pursue postsecondary credentials, equity gaps in postsecondary participation and success still exist (Daempfle, 2003; Ishitani, 2006; Rumberger, 2010; Chang et al., 2011; Sithole et al., 2017; Whitcomb & Singh, 2021). This equity gap is markedly salient within science, technology, engineering, and mathematics (STEM) fields. Accordingly, numerous national efforts targeting improved classroom experiences, representation and retention, and academic achievement of

historically underserved and underrepresented undergraduate students in STEM have been conducted with differential rates of success (Ong et al., 2011; Maton et al., 2012; Wilson et al., 2012; LaCosse et al., 2020; Snidman et al., 2022; Palid, Cashdollar, Deangelo, et al., 2023). In particular, students with disabilities experience a multitude of barriers that prevent the effective receipt of needed services to support access to academic material with decreased rates of student success on measures of retention, academic achievement, and on-time graduation when compared to their peers without a disability (Marshak et al., 2010; Sachs & Schreuer, 2011; Kranke et al., 2013; Toutain, 2019; Los Santos et al., 2019).

Even with national efforts targeting improved classroom experiences, representation, retention, and academic achievement, this equity gap has been further exacerbated by the COVID-19 pandemic (Neuwirth et al., 2021) adding even greater urgency to reconceptualize instructional practices with an eye toward equity in our post-pandemic educational context. There is a clear call for interventions that better support the heterogeneous student experience in large-enrollment STEM courses. In utilizing student experiences to inform the iterative improvement of course materials, educators can center the principal stakeholder in the development of a student's learning - the student themselves. Further, course interventions that creatively integrate active, student-centered instructional approaches (Brame, 2016; Freeman et al., 2014; Theobald et al., 2020) may promote positive outcomes not only for target groups like students with disabilities but for all students, especially when inclusive teaching practices are implemented in a domain all students experience – the course curriculum.

Objective: This quasi-experimental study utilized a mixed methods approach to evaluate the impact of a course redesign intervention of student-centered instructional practices – including the addition of evidence-based and virtual, active learning modules (ALMs) designed with the

desirable difficulties (Bjork, 1994) and the Universal Design for Learning (UDL; CAST, 2018) frameworks – integrated into a redesigned model of a large enrollment undergraduate course in psychology research methods at a large public university. The mixed methods evaluation of the course redesign uses both course-level and student-level data from course evaluation surveys and course exams to develop a comparative understanding of student experiences and academic achievement rates from both before and after the integration of the course redesign intervention.

Findings: Student responses on course evaluations showcased the wide range of feedback that undergraduate students experienced in both iterations of the course. Independent samples *t*-tests evaluated the change in student ratings about instructional design elements. Analyses displayed that the post-redesign course model led to significantly more positive student experiences and greater impacts on learning in comparison with the pre-redesign course model ($p < .001$). Students perceived lecture slides, recordings of lectures, updated practice exams, and all components of the ALMs to be the most helpful for learning. The post-redesign course model also showed a relationship between student experiences and academic success. Two univariate ANOVAs analyzed the effect of phase and disability status on student exam scores. All enrolled students, regardless of disability status, performed significantly better on both the mid-quarter and end-quarter cumulative course exams ($p < .001$).

Conclusions: Considering the wide variability of learners in our classrooms, student ratings and feedback illustrated the benefits of blending physical and online evidence-based, active learning pedagogical practices in a large enrollment STEM course. Student-centered instructional strategies such as ALMs are a cost-effective, flexible tool to boost student learning experiences and academic outcomes while encouraging an equitable experience for a diverse student body.

The dissertation of Virginia Sklar Muscatello is approved.

Elizabeth Ligon Bjork

Robert A. Bjork

Jan Blacher

Iris Firstenberg

Jeffrey J. Wood, Committee Chair

University of California, Los Angeles

2023

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ACKNOWLEDGEMENTS

Although this dissertation lists my name, this project and doctorate was only possible because of the extraordinary support of others. I would like to express my deepest gratitude to:

The greater UCLA Community partners who supported this work in a multitude of ways, especially the entire team at the Center for Education Innovation and Learning in the Sciences and the Center for the Integration of Research, Teaching, and Learning including Rachel Kennison, Shanna Shaked, and Jess Gregg. Each of you offered expertise that greatly improved the quality of all elements of the course redesign. And Katie Ingraham Dixie, thank you for every brainstorming session, check-in email/text message, and coffee date. When I was all too often overwhelmed with self-doubt, you always made me feel seen and that my ideas had value. And Lori Okimoto-Wheatley and Jessica Helfond in the Department of Psychology, and Spencer Scruggs and his team at the Center for Accessible Education, thank you for your support obtaining demographic data to better capture the diversity of those in our classrooms. And to the undergraduate student participants who have been my motivation since beginning as a Psychology 100B Lab TA in 2018. Thank you for your engaged participation and insightful feedback over the years. Our interactions were my guiding light throughout this challenging journey. This course redesign and subsequent dissertation is for you.

My academic community including my graduate advisor and dissertation committee chair, Dr. Jeffrey Wood. Your guidance has molded me into the researcher, scholar, and leader I am today. I am eternally grateful. To my dissertation committee members, Dr. Elizabeth Bjork, Dr. Robert Bjork, Dr. Jan Blacher, and Dr. Iris Firstenberg, each of you provided fundamental mentorship and helped me to reach this goal I only ever dreamed of achieving. I am honored to have received such support and thoughtful feedback from scholars who I have admired – both professionally and personally – for years. And to my redesign team members, Elizabeth and Iris. I am exceptionally grateful to you both for trusting me with the course you both built. Collaborating to transform Psychology 100B has been the highlight of my time at UCLA.

My colleagues turned friends including the former Psychology 100B Lead TAs, Manisha, Mary, Jordan, Katie, and Jolie. It was an honor to be in the company of such driven and thoughtful peers. The impact of this course redesign was a direct result of each of you and your dedication – I (and all of our students) are so grateful. To the Wood Lab/DoD GSRs, Amanda, Jolie, Samara, Ingrid, Katherine and Keenan. It has been a privilege to lead such a committed and empathetic team. I am so proud of each of you and the researchers you are today and will continue to be in the future. To Amanda, Lauren, Sarah Jo, and my extended HDP cohort. Your kindness and warmth encouraged me during the moments when I needed it most. And to my academia partner turned dear friend, Amanda, I am so thankful our paths crossed. I could not have finished this dissertation or reached this point without you. I am so incredibly proud of us.

My family and friends, who showed up for me countless times and then some during this PhD marathon – thank you. Whether it was listening to my jargon-filled ramblings or sending words of encouragement, I am unbelievably lucky to be surrounded by such an amazing community. To the Muscatellos for welcoming me with the most loving arms and always cheering me on. And to my mom. You have modeled what being an exceptional educator looks like since I can remember. I hope to be a fraction of the educator – and person – you are one day.

Finally, to my husband, Frank and our Nugget. This is as much your PhD as it is mine. I am not here without you. Every meal. Every musical performance to make me laugh. Every family cuddle session. Every tear you wiped away. You reminded me of my worth when I lost sight of it and loved me unconditionally. Your partnership is my biggest blessing. I love you.

VITA

EDUCATION

University of California, Los Angeles, School of Education and Information Studies
M.A. in Education, Human Development and Psychology 2020

University of California, Berkeley
B.A. in Political Science and African American Studies, *Cum Laude* 2013

SELECTED CERTIFICATIONS AND AWARDS

Division of Graduate Education, Regents Fellowship Awards
University of California, Los Angeles 2020 – 2023

Associate, Practitioner, and Scholar of Teaching-as-Research Certifications
Center for Integration of Research, Teaching and Learning at UCLA 2021 – 2022

Best Student Researcher Award, Association for Behavioral and Cognitive Therapies
Autism Spectrum and Developmental Disabilities Special Interest Group 2021

Faculty-level Certification, Center for Education Innovation and Learning in the Sciences
Scientific Teaching Summer Institute: Equitable Course Design and Inclusive Teaching 2021

Long-term Trainee, Leadership Education in Neurodevelopmental Disabilities (UC-LEND)
University of California, Los Angeles 2020 – 2021

SELECTED PUBLICATIONS AND PRESENTATIONS

Muscatello, V. S., Firstenberg, I., & Bjork, E. L. (2023, January). *Utilizing the Science of Learning to Inform an Evidence-Based Approach to a Course Redesign of Psychology Research Methods*. UCLA Cognitive Psychology Quarterly Faculty Meeting, Guest Lecture (Virtual).

Johnson, A. R., Wolpe, S., Tien, I. S., **Muscatello, V. S.**, & Wood, J. J. (2023). Cognitive behavioral therapy for children with autism and anxiety. In *Handbook of Lifespan Cognitive Behavioral Therapy* (pp. 181-191). Academic Press.

Wood, J. J., Wood, K. S., Rosenau, K. A., Cho, A. C., Johnson, A. R., **Muscatello, V. S.,** Tien, I. S, Straus, J., Wolpe, S, Zeldin, A., Kazlauska, K., & McLeod, B. D. (*In Press*). Practitioner adherence and competence in MEYA, a free online self-instruction program in modular CBT for children's autism-related clinical needs. *Journal of Autism and Development Disorders (JADD).*

Muscatello, V. S. (2022, December). *The Impact of Innovative Online, Active Learning Modules for Students with Disabilities within a Course Redesign of Undergraduate Psychological Research Methods.* University of California Center for Research on Special Education, Disabilities, and Developmental (UCSPEDDR), Annual Conference, Riverside, California.

Muscatello, V. S. (2021, November). *The Impact of Adapted Cognitive Behavioral Therapy for School-Aged Youth with Autism and Interfering Anxiety on Caregiver-Defined Goals*. Association for Behavioral and Cognitive Therapies (ABCT), Annual Conference, (Virtual).

Johnson, A. R., **Muscatello, V. S.,** & Wood, J. J. (2021, May). *Caregiver Perspectives Informing Treatment: A Qualitative Study of Caregivers of Children with Autism on Treatment Planning and Trajectory*. International Society for Autism Research (INSAR), Annual Meeting, (Virtual).

SELECTED TEACHING EXPERIENCE

Lead Instructional Design Associate, Department of Psychology
Psychology Research Methods and Design 2021 – 2023

Lead Graduate Teaching Associate, Department of Psychology
Psychology Research Methods and Design 2020 – 2021

Graduate Teaching Associate, Department of Psychology
Psychology Research Methods and Design, Psychological Tests and Measurement, Introduction to Development Psychology, Developmental Psychology Research Lab 2018 – 2020

SELECTED RESEARCH EXPERIENCE

Lead Graduate Student Researcher & Study Coordinator, Wood Lab at UCLA
CBT for Youth with Autism, Emotional/Behavioral Needs in Community Settings 2021 – 2023

Graduate Student Researcher, Wood Lab at UCLA
Modular Evidence Based Practices for Youth with Autism (MEYA) 2017 – 2021

SELECTED UNIVERSITY SERVICE

Graduate Mentor, Division of Graduate Education
Graduate-Undergraduate Mentorship Program at UCLA 2019 – 2022

Facilitator, Center for Education Innovation and Learning in the Sciences
Active Learning Strategies Seminar for Faculty 2022

Moderator, Undergraduate Education, Research Center
Undergraduate Research and Creativity Showcase, Education and Psychology Panels 2022

Facilitator and Curriculum Designer, David Geffen School of Medicine at UCLA
Disability Curriculum Discussions for First Year Medical Students 2021 – 2022

Chapter 1

Introduction

Higher education is more diverse than ever with a drastic increase in college enrollment over the past two decades by those who have not traditionally sought undergraduate credentials (Espinosa, Turk, Taylor, & Chessman, 2019). A 2019 status report on race and ethnicity from the American Council on Education indicates that in 1996, students of color only made-up 29.6 percent of the undergraduate student population, but this grew to 45.2 percent two decades later in 2016 (Espinosa, et al., 2019). Moreover, there is also an increasing number of students with disabilities and neurodivergent learners entering higher education (Clouder et al., 2020) with nineteen percent of undergraduates in 2015–16 reported having a disability (National Center for Education Statistics [NCES], 2018). Despite the growing demographic diversity of students choosing to pursue postsecondary credentials to be competitive in the twenty-first century workforce (e.g., achieve higher earnings, obtain employment security, participate in rewarding work opportunities; Turks, 2019), equity gaps in postsecondary participation and success still exist (Daempfle, 2003; Ishitani, 2006; Rumberger, 2010; Chang et al., 2011; Sithole et al., 2017; Whitcomb & Singh, 2021). With the increasingly diverse undergraduate population enrolling in postsecondary educational contexts, there is a call for interventions that better support the heterogeneous student experience. In utilizing these student experiences to inform the iterative improvement of course materials, educators can center the principal stakeholder in the development of a student's learning - the student themselves.

Numerous national efforts have been conducted targeting the improved representation and retention of historically underserved and underrepresented groups at the undergraduate level, particularly within science, technology, engineering, and mathematics (STEM) fields (e.g., Ong et al., 2011; Maton et al., 2012; Wilson et al., 2012; LaCosse et al., 2020; Snidman et al., 2022; Palid, Cashdollar, Deangelo, et al., 2023). The share of postsecondary science and engineering (S&E) degree recipients and the STEM workforce in the United States gradually diversified from 2011 to 2021 as seen through the increased representation of women, underrepresented minorities (Hispanics or Latinos, Blacks or African Americans, and American Indians or Alaska Natives), and individuals with disabilities. Yet, the inclusion of these underrepresented groups in S&E degree programs and STEM occupations is uneven relative to their distribution in the working age population (National Center for Science and Engineering Statistics [NCSE], 2023). This disparity in representation is of utmost importance to address as a diverse workforce provides the potential for innovation by leveraging different backgrounds, experiences, and points of view. An investment in the continued recruitment and retention of students from an array of backgrounds into STEM fields is critical.

In conjunction with the growing number of women and underrepresented minorities enrolled in higher education, there is also an increasing number of students with disabilities and neurodivergent learners entering higher education (Clouder et al., 2020). As defined by the Americans with Disabilities Act (ADA), a person with a disability is a person who has a physical or mental impairment that substantially limits one or more major life activities. Any student who meets entry-level criteria of the college and can document existence of a disability in accordance with this ADA definition or Section 504 of the Rehabilitation Act (Section 504) is eligible to receive disability services in postsecondary education (ADA National Network, 2017). Nineteen percent of undergraduates in 2015–16 reported having a disability (National Center for Education Statistics [NCES], 2018). However, this data is not absolute as most college students with disabilities at both 2- and 4-year institutions do not inform their college of their disability. For example, of students confirming disability status while attending college, only 37 percent informed their college of their disability (NCES, 2018), showcasing that many undergraduate students enrolled across United States colleges and universities are not receiving services for their disabilities, even if they do possess a need.

There are a variety of reasons students do not disclose their disability to receive formal accommodations while in college. The postsecondary education environment is quite different when compared with K-12 educational settings with a shift in focus from supporting student success towards a focus on providing student access. Requests for accommodations also shift from being institution-initiated to student-initiated (Toutain, 2019). Students with disabilities play a much more active role in securing and utilizing academic accommodations in higher education. This can result in a multitude of barriers towards the effective receipt of needed services such as: (a) lack of student awareness of campus resources, (b) inability to provide appropriate documentation of a disability for accommodations students perceive as useful, (c) negative reactions of peers and instructional team members upon disability disclosure, and (d) overall reluctance to register for available services (Marshak et al., 2010; Kranke et al., 2013; Toutain, 2019).

With these added barriers and challenges, research indicates that even though students with disabilities are entering higher education at a greater rate, they often experience decreased rates of student success on measures of retention, academic achievement, and on-time graduation when compared to their peers without a disability (Sachs & Schreuer, 2011; Los Santos et al., 2019). Moreover, students across various disability categories do not form a unitary group. Instead, there is often heterogeneity and variability of symptom presentation for many students with disabilities, and students should be seen as individuals with unique strengths and support needs beyond their diagnosis (e.g., Verboom et al., 2011; Masi et al., 2017; Kroesbergen et al., 2022). The heterogeneous picture of students with disabilities suggests the need for pedagogical efforts beyond the medical model of individual accommodations towards a social model of disability (Hogan, 2019). Embracing the natural variability of learners in our classrooms is of utmost importance as the number of students who qualify for accommodations continues to increase, but the barriers to receiving such accommodations persist. In the face of the myriad of student needs, innovative evidence-based instructional practices that center the success of the increasingly diverse undergraduate student population are needed.

The inclusion of evidence-based strategies became even more critical with the unprecedented worldwide public health crisis – the novel Coronavirus Disease 2019 (COVID-19) outbreak. The role of COVID-19 completely shifted educational practices in the form of an unforeseen transition to emergency remote teaching once the outbreak was declared a global pandemic by the World Health Organization (WHO) in March 2020 (Cucinotta & Vanelli, 2020). There was, however, an eventual return to in-person instruction as guidance on safe returns to in-person instruction launched in May 2020 (California Department of Public Health [CDPH]) in conjunction with the national dissemination of safe, effective, and free COVID-19 vaccines and boosters in Winter 2020-2021 (Centers for Disease Control and Prevention [CDC]).

Most postsecondary institutions in the United States saw a complete return to in-person instruction at the start of the 2022 academic year through employing various precautionary measures to stop the spread of the virus (e.g., physical distancing, masking, testing and isolation). With classes moved back to lecture halls and lab classrooms, this return marked a move from crisis to control for the virus in the United States: the new normal. The beginning of this new normal of life with COVID-19 does not aspire towards the complete eradication of the virus. Rather, the new normal requires recognizing COVID-19 as but one of several circulating respiratory viruses and utilizing relevant mitigation measures in response (Emanuel et al., 2022).

As COVID-related challenges – and subsequent equity issues further exacerbated by the pandemic – are here to stay (Cook-Sather, 2022), employing lessons from remote teaching to meet our current reality is imperative. Rather than simply maintaining pre-pandemic models of teaching and learning, the COVID-19 pandemic offered educators a unique opportunity for curricular development that encourages greater diversity, equity, and inclusion for an increasingly diverse undergraduate student population (Neuwirth et al., 2021). By embracing lessons learned from emergency remote teaching, instructors have an unparalleled chance to reimagine meaningful, interactive student learning activities for a student body with a multitude of needs, particularly in large enrollment courses. Adaptations to course curriculum that integrate both in-person and online evidence-based learning strategies can enhance the learning experiences of students in the ever-evolving post-pandemic educational climate.

The higher education enrollment trends necessitate the continued research on STEM course-level curriculum and the application of evidence-based strategies in course refinement and development to advance inclusive education. Situating this research amongst STEM research contexts, the subject area of Psychology is an approved STEM field in social and behavioral sciences (National Science Foundation, [NSF], 2022). This study strived to understand the experiences and outcomes of undergraduate students enrolled in a large, Research Methods in Psychology course both before and after the integration of a course redesign intervention. The course redesign is an online, evidence-based, active learning strategy created using both the desirable difficulties (Bjork, 1994) and the Universal Design for Learning (UDL; CAST, 2018) frameworks, and is intended to improve learning and engagement for students with and without disabilities.

Chapter 2

Literature Review

To capture the importance of evaluating student experience and academic outcomes with the inclusion of evidence-based instructional strategies in a course redesign, literature on the growing diversity of undergraduate students in STEM higher education contexts – including students with disabilities – is reviewed. Then, the uptake in online and blended learning modalities with the differential impact of the COVID-19 pandemic for this increasingly diverse student population is discussed. Lastly, the various student-centered instructional approaches and learning theories relevant to this course redesign are examined.

Diversity in STEM Higher Education

The importance of postsecondary education and the impact on societal health and progress at large cannot be overstated. Most jobs within the twenty-first century workforce that provide a living wage and employment security often require college or university degrees (Espinosa et al., 2019). Further, individuals with college degrees are often more likely to be healthier, active citizens (Ma, Pender, & Welch, 2016; Turk, 2019). Research suggests that the intentional inclusion of all society members in the higher education landscape ensures the health and vitality of our democracy through fostering students' academic and social growth (Gurin et al., 2002). Despite the documented increase in college enrollment over the past two decades for those who did not traditionally seek out these degrees, there are vast equity gaps in academic success and degree completion for this population (Daempfle, 2003; Ishitani, 2006; Rumberger, 2010; Chang et al., 2011; Sithole et al., 2017; Whitcomb & Singh, 2021). Even with colleges and universities enrolling more underrepresented minorities and students with disabilities, many of these students will not graduate within six years (Wilson et al., 2015; NCSE, 2023). There remains a need for additional support and action to encourage persistence through academic challenges and to provide every student – particularly those who face additional barriers to entering and succeeding in college – with an equal opportunity for positive learning experiences and increased rates of academic achievement.

Racial and Ethnic Minority Students

In the United States, less than half of the students who enter science, technology, engineering, and mathematics (STEM) fields of study as first year students will graduate with a STEM degree. This disparity is even more salient for underrepresented racial and ethnic minority student groups (Hispanics or Latinos, Blacks or African Americans, and American Indians or Alaska Natives). When investigating the graduation rates of students of color, approximately three-fourths of minority students leave STEM disciplines entirely at the undergraduate level (Wilson et al., 2015). Although the share of postsecondary science and engineering (S&E) degree recipients in the United States gradually diversified from 2011 to 2021 with increased representation of women, students of color, and individuals with disabilities, the inclusion of these underrepresented groups in S&E degree programs and STEM occupations is uneven relative to their distribution in the working age population (National Center for Science and Engineering Statistics [NCSES], 2022). As disparities in S&E education may signal future differences in employment in related occupations, investigating the high-level patterns of demographic trends to find points of intervention is of great importance.

Underrepresented minorities (Hispanic, Black, and American Indian or Alaska Native persons) collectively accounted for 37 percent of the U.S. population ages 18–34 years in 2021 but only 26 percent of S&E bachelor's degrees in five broad STEM fields: social and behavioral sciences, agricultural and biological sciences, physical and earth sciences, mathematics and computer sciences, and engineering. Further investigation into data from National Center for Science and Engineering Statistics for S&E bachelor's degrees in the specific field of social and behavioral sciences (which include Psychology-based degrees), women accounted for 66 percent of bachelor's degrees with a very high share of degrees earned by women in psychology (79 percent of bachelor's degrees in 2020). Additionally, the share of social and behavioral sciences degrees earned by Hispanic students rapidly increased from 12 percent in 2011 to 21 percent in 2020, which is commensurate with the growth in the college-age population of Hispanic students in the United States (22 percent). For S&E bachelor's degrees earned by Black or African American Students across all broad subfields, Black students also have the highest representation in social and behavioral sciences, earning 12 percent of bachelor's degrees in 2020. Despite this representation in social and behavioral sciences, Black individuals are underrepresented at the bachelor's degree level relative to their share of the 18- to 34-year-old population (14 percent in 2021; Census Bureau Current Population Survey, Annual Social and Economic Supplement, 2011, 2019, 2021).

In comparison with the promising trends for Hispanic and Black students obtaining S&E bachelor's degrees in social and behavioral sciences, the share of degrees earned by American Indian or Alaska Native students declined from 2011 to 2020, dropping 22 percent. When compared to other S&E degree fields, American Indian or Alaska Native students did account for the largest share of S&E degrees in social and behavioral sciences (0.5 percent in 2020). However, Indigenous students are substantially underrepresented among S&E degree recipients for all broad fields at the bachelor's level and above (NCSES, 2022). Even with this demographic variability in pursuit and completion of S&E degrees, it is evident that underrepresented minorities are undoubtedly working towards undergraduate degrees in social and behavioral sciences at a rate almost commensurate with the changing racial and ethnic composition of the college-age population in the United States. Designing academic experiences with an eye towards equity and inclusion, particularly in Psychology where data suggests the student population is exceptionally diverse compared with other STEM fields, is essential.

Students with Disabilities

As the number of historically underserved groups in higher education and STEM fields continue to grow, there has also been a significant and steady increase of students with disabilities entering higher education (e.g., Yssel et al., 2016; Clouder et al., 2020). Enrollment of students with disabilities at higher education institutions has significantly increased with the passage of inclusive legislation (i.e., Americans with Disabilities Act [ADA], 1990; Section 504 of the Rehabilitation Act of 1973; Individuals with Disabilities Education Improvement Act [IDEIA], 2004) guaranteeing an increase of institutional support services. These services manifest in the form of college-level accommodation policies that aim to provide students equal access and participation and to mitigate the impact of disability on meeting course academic standards (Kayhan et al., 2015).

Since the passage of the Americans with Disabilities Act in 1990, students with disabilities constitute a substantial campus demographic (Kimball et al., 2016). Students with disabilities are those who reported having one or more of the following conditions: (1) blindness or visual impairment that cannot be corrected by wearing glasses; (2) hearing impairment (e.g., deaf or hard of hearing); (3) orthopedic or mobility impairment; (4) speech or language impairment; (5) learning, mental, emotional, or psychiatric condition (e.g., serious learning disability, depression, ADD, or ADHD); or (5) other health impairment or problem. In a higher education context, any student who meets entry-level criteria of the college and can document existence of a disability in accordance with this ADA definition or Section 504 of the Rehabilitation Act is eligible to receive disability services (ADA National Network, 2017). Nineteen percent of students enrolled in postsecondary institutions in the United States in 2015–16 met these entry-level criteria and were a part of these diagnostic categories (NCES, 2018). Additional evidence also suggests that as many as 96 percent of university classrooms have at least one student with a documented disability who is enrolled in a course at a time (Los Santos et al., 2019).

Although promising, these trends are likely incomplete or underestimated as many students with documented disabilities do not disclose their disability status for a range of reasons (Kimball et al., 2016). For example, only 37 percent of college students with a self-proclaimed documented disability informed their college of their disability in the 2015-16 academic year (NCES, 2018). Researchers have postulated as to why students do not disclose their disability to receive formal accommodations while in college (e.g., Cawthon & Cole, 2010, Marshak et al., 2010; Kranke et al., 2013). Of particular significance, the higher education accommodation process operates in stark contrast with the way that education plans are generated and applied in K-12 educational settings, which typically involve a support team of caregivers, school counselors, and teachers to implement school-based services to promote success (Kimball et al., 2016). Conversely, requests for accommodations in postsecondary contexts change from being institution-initiated to student-initiated and the focus shifts from centering student success to centering student access (Toutain, 2019). Many students who previously received legally mandated services in K-12 education now need to independently self-advocate, articulate their needs for services and accommodations, and actively pursue resources on campus for assistance. Although some students may proactively reject service utilization in college (e.g., they were academically successful without services in high school so they realize they do not need them in the college environment), it is much more likely that a student's choice to not disclose disability status and fully avail themselves of college disability service and accommodations are reactive to the institutional context (Lombardi et al., 2012; Kimball et al., 2016).

Even though students may have access to services, research demonstrates themes of potential barriers to college student use of disability services including: (a) insufficient knowledge or lack of awareness on available services and corresponding utilization processes, (b) desires to avoid negative social reactions as seen in concerns about stigma or fears of differential treatment by faculty compared to peers without disabilities, and (c) perceived quality and usefulness of provided services (Marshak et al., 2010; Kranke et al., 2013; Toutain, 2019). To further elaborate upon one salient theme – negative social reactions – a review of self-reported attitudes of college faculty on inclusive instruction suggests a tension between efforts to promote the least-burdensome path to equitable access to course content and the perceptions of some faculty that providing accommodations can compromise academic standards and course rigor (Jensen et al., 2004; Lombardi et al., 2011a). Additionally, instructors often have perceptions of students with disabilities that are at odds with student capabilities. More problematic, these perceptions frequently shape an instructor's teaching (Baker et al., 2012).

Love and colleagues (2015) conducted semi-structured interviews with STEM faculty and discovered similar perceptions of declared challenges when working with students with disabilities. Researchers found that faculty shared descriptions of added burdens including: (a) supplemental planning to mitigate space environment barriers, (b) consistently optimizing instructional modes and materials to meet individual student needs, (c) and the importance of attempting to support students with disabilities while still maintaining confidentiality for the student (Love et al., 2015). These faculty indicated burdens clearly illustrate the negative social reactions to disability status disclosure that many students with disabilities hope to avoid.

With these added barriers to college student use of disability services, further investigations into classroom and academic experiences showcase that students with disabilities do not perform as well as their peers without disabilities (Sachs & Schreuer, 2011; Los Santos et al., 2019). Though never simple – for students with disabilities – the discussion around student outcomes such as persistence, degree completion, academic achievement, student learning and development, and major choice is especially complex (Kimball et al., 2016). Adding to the complexity, students across and within various disability categories do not form a unitary group as there is immense heterogeneity within this population (e.g., Verboom et al., 2011; Masi et al., 2017; Kroesbergen et al., 2022). Because of this, most studies examining academic achievement focus on much more narrow sub-groups of students with disabilities (e.g., learning disabilities, Attention Deficit/Hyperactivity Disorder [ADHD], autism) and subsequent academic outcomes (e.g., persistence and degree completion, academic achievement, specific learning and development outcomes like study strategies, career/professional development).

For example, in a sample of studies of students with ADHD, strong study habits and time management skills were shown to be predictive of higher GPAs and elevated course-level academic performance; however, these are skills in which these students were often less prepared to execute in comparison with their non-ADHD peers (Kaminski et al., 2006; Proctor et al., 2006; Prevatt et al., 2011). The addition of an explicit study skills support intervention potentially addressed students with disabilities' lower achievement relative to students without disabilities (Proctor et al., 2006). However, it can be argued that a study skills intervention is likely beneficial for all students to promote increased learning of course content for greater rates of academic achievement. The adoption of such a curriculum feature – instead of an individually tailored accommodation – anticipates and incorporates the expected multitude of learning needs of all students, not only those with disabilities like ADHD (Hogan, 2019).

Nonetheless, research does indicate that students who utilized accommodations through campus disability service centers see higher academic achievement than those who did not access the same accommodations (Dong & Lucas, 2013, 2014). This data suggests that the more informed students with disabilities are about their legal rights and the presence of support systems on campus and their access to these provided services, the more successful they are on measures of degree completion and academic achievement (Becker & Palladino, 2016). However, with the documented barriers to service access and evidence that many undergraduate students do not disclose their disability to receive formal accommodations, institution-provided accommodations cannot be the only strategies for addressing classroom and academic experiences of students with disabilities.

Another important academic experience for undergraduate students is the choice of an academic major. STEM fields often attract students with disabilities due to students' wealth of STEM-relevant skills and strengths (e.g., spatial ability, mathematical-reasoning; Wai et al., 2009). Interestingly, students with disabilities are pursuing STEM majors at similar rates as students without disabilities (Lee, 2022). Unfortunately, though, due to the multiple barriers outlined showcasing a lack of social and academic support, students with disabilities often have limited opportunities to access rigorous STEM programs (Bargerhuff et al., 2010). Further, for students with disabilities who do access STEM curriculum, many leave their initially intended

STEM majors before completing a degree, including in social and behavioral sciences (National Science Foundation [NSF], 2019).

Compared with the wealth of data on women and minorities earning S&E degrees, specifically bachelor's degrees in the subfield of social and behavioral sciences which include Psychology-based degrees, data on social and behavioral sciences bachelor's degrees earned by persons with disabilities is limited. Although a differing sample of interest from this dissertation, data from NCSES's Survey of Earned Doctorates in 2021 illustrates that 10.8 percent of S&E doctorate recipients were individuals with at least one disability. Among S&E doctorate recipients, individuals earning degrees in psychology and social sciences had the highest rate of disability at 13.1 percent (NCSES, 2022). The record of individuals with disabilities earning advanced degrees in Psychology suggests there is likely an even greater portion of students with disabilities enrolled in this subfield at the undergraduate level as successful completion of a doctoral degree requires both bachelor's and master's degrees. Even with limited data, the enrollment trends of students with disabilities, particularly in STEM fields and in Psychology, necessitates a call for interventions that support the expanding and diverse student population in this STEM subfield.

To better understand points of intervention, literature does identify multiple factors contributing to the attrition of students with disabilities from STEM including barriers and challenges similar to those that all students with disabilities in higher education face. Additional factors for attrition in STEM courses and labs for students with disabilities include challenges accessing effective academic accommodations, difficulties with both physical and digital accessibility, insufficient knowledge of disability and accommodation use by STEM instructors, and student-given perceptions of STEM as an unwelcoming climate for students with disabilities (e.g., Dunn et al., 2012; Love et al., 2015; Thurston et al., 2017; Friedensen et al., 2021; Nieminen & Pesonen, 2022). Even if the differential impact of these factors in Psychology is unclear, these factors are still of particular importance in Psychology courses. Not only can the rate of enrolled students with disclosed disabilities already be assumed to be high in comparison with other STEM subfields (NCSES, 2022), but these rates are also likely underreported with the number of students who do not disclose their disability (Cawthon & Cole, 2010, Marshak et al., 2010; Kranke et al., 2013). Thus, a better understanding of overall student experience as well as methods to address these barriers for students with disabilities that may lead to attrition is imperative.

One identified factor that leads to the attrition of students with disabilities in STEM and may be a potential point of intervention are unwelcoming STEM classroom climates that are frequently characterized by stereotyping, discrimination, and social oppression towards students with visible and non-visible disabilities. This kind of classroom climate not only contributes to a sense of non-belonging for students with disabilities within STEM, but also in higher education contexts as a whole (Nieminen & Pesonen, 2022; Pfeifer et al., 2023). As feelings of connectedness are a contributing factor to students' social belonging, instructional practices that encourage social connectedness can address the issues of an unwelcoming STEM classroom climate and promote student satisfaction, academic success, and retention for not only student with disabilities, but for all students with diverse learning needs (Christe, 2013).

Students with disabilities are a substantial campus demographic, but they are often overlooked in campus discussions around diversity, equity, and inclusion (Bryan & Myers, 2006). Potentially a result of the relative scarcity of high-quality empirical studies about college and university students with disabilities, disability is still a pressing equity concern to be considered within higher education contexts (Kimball et al., 2016). Students with disabilities remain all-too-often on the periphery of higher education research, treated as distinct from other college student identities that are more frequent subjects of scholarship (Lombardi et al., 2012). However, there is an intersectional nature of disability that cannot be overlooked. Students with multiple marginalized identities (e.g., disabled and/or an underrepresented minority, and/or lesbian, gay, bisexual, transgender, and queer, [LGBTQ]) have a range of higher education experiences that should be explored in order to improve the classroom and overall campus environment for students (Miller & Downey, 2020).

Although inclusive legislation is in place to ensure the availability of reasonable accommodations for students with disabilities on college campuses, it is evident that many students do not make regular use of support services for a multitude of reasons. Moreover, many previous studies of STEM students with disabilities aggregate students with diverse disability types into one category. Yet, the individual experiences of disability differ. Students should be seen as individuals with unique strengths and support needs through pedagogical efforts beyond their diagnosis (e.g., Verboom et al., 2011; Masi et al., 2017; Kroesbergen et al., 2022). The simple act of recognizing that learners are diverse and designing curriculum around this reality is imperative for not only the academic success of students with disabilities (McTighe & Brown, 2005), but for *all* students.

The Increase of Online Learning

Coupled with the outlined enrollment trends in undergraduate education becoming more diverse over time, the popularity of online learning is also becoming increasingly prominent (Muñoz-Cristóbal et al., 2018). As technology rapidly develops, higher education has seen a growing transition to online instruction with many students opting for online education instead of traditional face-to-face modalities of teaching and learning for a multitude of reasons (e.g., convenience, flexibility; Dumford, & Miller, 2018). For example, the development of asynchronous, open-access Massive Open Online Courses (MOOCs) designed for large numbers of geographically dispersed and demographically diverse students continue to expand into educational spaces as a means of creating more accessible learning opportunities for the masses (Wong et al., 2019; Blum et al., 2020). Regardless of the benefits of MOOCs' flexible approach to learning which also includes little instructor burden of monitoring student academic success, systematic reviews evaluating MOOCs shows inconsistencies in student enrollment and completion rates in MOOCs (Jordan, 2014) and varied rates of academic achievement (Liyanagunawardena et al., 2013). There is also insufficient evidence showing how individual learners specifically benefit from the experience of participating in MOOCs, including and beyond outcomes directly related to learning (Blum et al., 2020).

In a systematic review of effective instructional practices in online learning from 2013 - 2019, researchers found that most of the strategies with promising effectiveness for student learning in the online environment are the same practices that are considered to be effective in face-to-face classrooms (e.g., active learning strategies, self-regulated learning strategies, course design factors, student support, faculty pedagogy; Lockman & Schirmer, 2020). However, arguably more important in an online learning environment among all instructional practices is the incorporation of self-regulated learning processes and strategies. Research dictates a significant positive relationship between self-regulated learning strategies and online academic success (Broadbent & Poon, 2015; Littlejohn et al., 2016). Thus, course components including the use of multiple pedagogies and learning strategies to address student learning needs and promotion of classroom cohesion are useful in both in-person as well as online instruction (Lockman & Schirmer, 2020; Muñoz-Cristóbal et al., 2018).

Blended Learning

MOOCs are an example of a complete transition to online learning. However, with the increase in technological advancements, blended learning has become more commonplace across the past decade. Blended learning, or the combination of traditional face-to-face instruction with online learning, may allow for more interactive and reflective knowledge construction as it uses education techniques from face-to-face instruction and technologies from online learning to develop an innovative approach to optimizing student learning (Graham, 2006; Graham & Robison, 2007; Köse, 2010). In comparison to the plethora of studies on the impact of online learning on student achievement, there is limited evidence about the role of blended or hybrid learning on student academic achievement, particularly in higher education contexts.

Of available research evaluating the impact of blended learning on academic achievement in higher education, one study showed that using asynchronous technology tools in addition to synchronous lectures promoted deeper reflection on course content, which then led to higher order thinking and increased rates of course level performance (Robinson & Hullinger, 2008). Additionally, a systematic review of the existing literature comparing online learning and blended/hybrid learning on student performance showed that self-regulated learning strategies such as cognitive strategies for retaining information (e.g., elaboration connecting prior knowledge with new material, synthesizing and evaluating) and resource management strategies that help learners to control external resources (e.g., time and environment management, effort regulation to maintain focus, asking for assistance) are predictive of increased student grade performance in both online and blended contexts (Broadbent, 2017). Moreover, a meta-analysis of the impact of blended learning on undergraduate student performance compared to traditional face-to-face instruction measured by objective outcomes, namely final course grades, found a standardized mean effect size $g+ = 0.385$, with a 95% *CI* between 0.239 and 0.531, $p < 0.001$ (Vo et al., 2017). This effect size falls within a similar range as other meta-analyses that evaluate the use of blended learning in higher education confirming the inclusion of blended learning components in course designs are an advantageous alternative to traditional face-to-face classroom instruction because it demonstrates a larger effect size on student performance (Means et al., 2013; Bernard et al., 2014; Schmid et al., 2014).

Despite the breadth of studies on the impact of blended learning course components on student academic achievement, student learning experiences and academic performance specifically with virtual, asynchronous learning modules that are supplemental to in-person course components in large enrollment STEM courses have been minimally explored. To optimize student academic outcomes and long-term learning, the addition of accessible and effective self-guided instructional strategies into these asynchronous, online contexts may be needed to better support the wide range of students pursuing postsecondary degrees. The combination of traditional face-to-face instruction with remote instruction may optimize student learning beyond each modality in isolation, at least for some students.

COVID-19 and Remote Instruction

Despite continuing research on the advantages and disadvantages of student engagement in various forms of online learning (e.g., asynchronous, synchronous, hybrid/blended) in higher education over the past two decades (Dumford & Miller, 2018; Alqurashi, 2019), an unprecedented worldwide public health crisis – the novel Coronavirus Disease 2019 (COVID-19) outbreak – completely shifted educational practices once the outbreak was declared a global pandemic by the World Health Organization (WHO) in March 2020 (Cucinotta & Vanelli, 2020). The years following the mass spread of COVID-19 resulted in significant and devastating consequences to political, social, and economic life on a global scale (Ozili & Arun, 2023). For higher education, the pressing health considerations of the pandemic necessitated the rapid adoption of online emergency remote teaching through the application of virtual distance teaching, learning, and assessment approaches as an immediate response to the pandemic (Karakose, 2021).

In response to the abrupt transition from in-person to distance learning, most campuses trained faculty to ensure curriculum maintenance in a virtual classroom space (Neuwirth et al., 2021). University teaching centers also provided recommendations of best practices amid crisis (e.g., Cross-Campus Teaching Innovations Group, 2021) to support faculty instruction and student learning across an array of classroom structures and teaching modalities to enable a quick pivot to remote instruction should the need arise. Yet, even with instructional resources, faculty and students experienced a multitude of challenging circumstances during the transitional periods of the 2020 and 2021 academic years. In addition to the pandemic, worldwide uprisings against anti-black racism further revealed socio-economic inequities and injustices in colleges and universities (Fain, 2020). These unprecedented historical moments added urgency to the need for reconceptualizing instructional practices with an eye toward equity in higher education (Cook-Sather, 2022).

During the pandemic, students from underrepresented groups were more likely than others to agree that inconsistent access to technology reduced their ability to participate in remote instruction, and that expectations to help siblings with remote learning and balance academics with household responsibilities interfered with learning in remote environments

(Ramachandran & Rodriguez, 2020). Further, individuals with disabilities and neurodiverse backgrounds also experienced challenges when learning remotely as these students often require accommodations, and students reported losing access to the learning assistance and support they typically receive during in-person instruction (Blagg et al., 2020). Even with the eventual return to in-person instruction in the 2022 academic year, colleges and universities are still dealing with the repercussions of the new normal in the ever-evolving post-pandemic educational climate (Emanuel et al., 2022).

By leveraging lessons learned regarding remote instructional strategies to address the inequities within our higher education system, redesigning existing academic courses may promote learning for all students. Further, course redesigns to include virtual, asynchronous learning modules that are supplemental to in-person course components may promote student perceptions of course inclusivity (i.e., a student's unique learning needs are being met via course design and instructional strategies), supporting an ever-growing and diverse student body.

Student-Centered Instructional Approaches

With the increasingly diverse undergraduate student population, reimagining student learning activities from "teaching by telling" to "teaching by doing" is powerful in promoting students' retention of course concepts (Brame, 2016). Aligned with constructivist learning theory, a shift to a student-centered instructional approach that promotes active learning places less emphasis on information acquisition and focuses more on activities that require knowledge construction through performing actions with the acquired information (Vygotsky, 1963, 1978; Bransford et al., 1999). Moreover, active learning places emphasis on students' exploration of their own attitudes, values, and reflection of their individual learning process (e.g., metacognitive reflection).

Evidence continues to accumulate about the increase in course effectiveness when designed with an active learning approach as demonstrated by notable increases in undergraduate student self-efficacy, self-advocacy, and academic achievement (Ballen et al., 2017; Pfeifer et al., 2023). The inclusion of active learning strategies is also associated with reduced probability of course failure for all students, with particular impact for students from underrepresented groups (Freeman et al., 2014; Theobald et al., 2020).

Active Learning Pedagogies

Curriculum interventions that center evidence-based instructional approaches as a means of advancing inclusion in undergraduate classrooms have shown promise. The integration of specific evidence-based pedagogies in large-enrollment classes, typically characterized collectively as "active learning pedagogies," or ALPs, have rapidly increased over the last decade (Brame, 2016). Active learning activities can vary, but they are commonly defined as activities that students do to construct knowledge and understanding through the use of higher order thinking (Bransford et al., 1999l; Brame, 2016). Based on constructivist learning theory, active learning rests on the assumption that students actively construct—rather than passively acquire–their own knowledge by integrating new information with past experience and prior knowledge to form new and enhanced understanding (Vygotsky, 1963, 1978; Bransford et al., 1999). Because of this broad definition, many instructional strategies can be defined as active learning strategies (e.g., demonstrations, think-pair-share, peer instruction, small-group work, concept mapping, student-generated test questions, case-based learning; Brame, 2016).

Higher education, and namely STEM fields, have emphasized the importance of active learning (Freeman et al., 2014) and seen a rapid increase in the inclusion of ALPs as a response to the national calls for change across STEM disciplines (Olson & Riordan, 2012). Empirical evidence highlights the value of active ALPs due to their positive impact on student academic performance, particularly for underrepresented groups (Freeman et al., 2014; Ballen et al., 2017; Theobald et al., 2020). Additionally, due to the inclusion of elements not often present in traditional lecture, the interpersonal aspects of active learning strategies have also shown improvements in classroom social climates and enhanced rates of overall student well-being (e.g., Eddy & Hogan, 2014; Eddy et al., 2015; Freeman et al., 2017; Snidman et al., 2022). As such, active learning is considered an important inclusive teaching practice (Dewsbury & Brame, 2019), and it may be assumed to be more equitable than traditional lecture.

Despite the overarching benefits of ALPs in comparison to traditional lecture, the social aspects of many active-learning techniques, such as in-class group work, may differentially impact students who feel pressure to conceal certain aspects of their identity, such as sexual orientation, political affiliation, or religion (Henning et al., 2019). The effective implementation of active learning strategies is essential to their success in supporting diverse student populations, including women, students with anxiety, and LGBTQ+ students (Eddy et al., 2015; Cooper & Brownell, 2016; England et al., 2017; Downing et al., 2020). Moreover, students with disabilities, an additional underrepresented group in STEM, may face unique challenges in active learning such as feelings of increased isolation from peers and feelings of non-belong when this pedagogical strategy is not implemented properly (Gonzalez, 2016; Hall, 2017). Although recommendations to create more inclusive active-learning college science classes for students with disabilities have recently been shared (Gin et al., 2020), the evaluation of these strategies and their impact are limited. Further, due to the active-learning barriers that may be attributed to issues related to fidelity of implementation, strategic evaluations of evidence-based, active-learning strategies and their possible differential impact on student achievement is needed.

Metacognitive reflection. Although not always explicitly noted, promoting metacognition – or students' thinking about their own thinking – is an important element within active learning, providing a clear link between activity and learning (Brame, 2016). There are three general types of metacognitive knowledge that are often positively linked to student learning. These include strategic knowledge (i.e., knowledge of strategies for learning and thinking), knowledge of cognitive tasks (i.e., knowledge about different conditions and tasks where certain strategies are used most appropriately), and accurate self-knowledge (i.e., accurate knowledge of one's strengths and weaknesses; Pintrich, 2002). Metacognitive reflection can be perceived as an inclusive learning strategy within active-learning pedagogies as it allows students to proactively engage with their learning process. Through explicitly teaching students metacognitive strategies and building a classroom culture grounded in metacognitive reflection, this helps to foster a framework for students to talk about their own cognition and can support greater learning (Tanner, 2012).

Of particular interest, students with disabilities may benefit from classes specifically targeted toward improving metacognitive knowledge (Burchard & Swerdzewski, 2009). Students with disabilities may also see increased benefit from curricular interventions that explicitly provide course-specific strategy instruction that include content practice that not only provides correct answers, but also demonstrates how to acquire the desired content or skills (Allsopp, Minskoff, & Bolt, 2005). This demonstrates that both general and course specific assistance may improve performance for some students with disabilities. Yet, research addressing curricular needs of students with disabilities in higher education and the impact of an instructional tool like metacognitive reflection is unfortunately scarce overall, particularly compared to the K-12 research base (Kimball et al., 2016).

Of the existing research into specific active learning pedagogies, the added benefits for students from underrepresented groups and students with disabilities suggest the importance of inclusive pedagogical practices in higher education classrooms. Considering the wide variability of learners in our classrooms, additional research is needed to cement the importance of inclusive strategies, such as metacognitive reflection, as an effective tool for increased learning for all students (Hackman & Rauscher, 2004; Mino, 2004). To better understand the effectiveness of active-learning pedagogies in promoting student learning, it is essential to also investigate the extent to which instructors consider student metacognition when they implement active-learning strategies as the reflection on one's learning enhances the learning process itself (Tanner, 2012).

Desirable Difficulties Framework

Even with the breadth of evidence-based practices available, instructors are faced with a challenge when designing and implementing curriculum to optimize student learning for a diverse student body. Many instructional team members in higher education are involved in instructional design activities without formal training in learning theories and the science of instruction (Khalil & Elkhider, 2016). This predicament is especially salient as the conditions of instruction that make performance improve rapidly often fail to support long-term learning and transfer; whereas conditions of instruction that create difficulties for the learner – often slowing the rate of *apparent* learning – can actually optimize long-term learning and transfer (Bjork, Little, & Storm, 2014). Instructors are faced with a central challenge: while we can observe performance through formative and summative assessments, we can only infer learning. And if learning is our ultimate goal, the former – performance – is an unreliable index of the latter – learning (Bjork, Soderstorm, & Little, 2015). If instructors design courses only with an eye towards performance as a valid measure of learning, instructors may become susceptible to preferring poorer conditions of instruction and learning.

An effective evidence-based learning strategy that captures the often-challenging conditions of learning that promotes long-term learning is captured in the desirable difficulties framework (Bjork, 1994). Such conditions include distributed practice (e.g., spacing as opposed to massing study trials), varying the conditions of practice (e.g., studying or practicing in different contexts rather than a constant context), providing contextual interference (e.g., interleaving study trials of different to-be-learned topics, skills, and/or categories rather than blocking them), and testing (e.g., engaging in retrieval practice of to-be-learned information rather than repeatedly studying it; Bjork, 1994; Bjork, Little, & Storm, 2014). However, desirable difficulties, rather than the array of undesirable difficulties that undoubtedly exist in instruction, are desirable because they trigger encoding and retrieval processes that support learning, comprehension, and remembering (Bjork & Bjork, 2011). Ensuring that instruction promotes more desirable instead of undesirable difficulties, the inclusion of a desirable difficulties framework within instruction (e.g., spacing vs. massing; retrieval practice or testing; contextual variation; interleaving) can encourage students to take an active role in learning.

Universal Design for Learning Framework

Universal Design for Learning (UDL) is a flexible, research-based pedagogical framework designed to support diverse learners (Center for Applied Special Technology [CAST], 2018; Rose & Meyer, 2002; Hackman & Rauscher, 2004; Mino, 2004; Rao & Meo, 2016). UDL originated from a collaboration between architects, designers, and engineers as a response to calls by disability activists for designing learning environments and curriculums that are accessible to all students (CAST, 2018). UDL is an educational approach based on the learning sciences with three primary principles including: (1) multiple means of representation of information, (2) multiple means of student action and expression, and (3) multiple means of student engagement (CAST, 2018; Rose & Meyer, 2002). The UDL framework proactively assesses and addresses potential needs of all students prior to students asking for individualized accommodations.

Aligning with the social model of disability rather than the medical model of disability, UDL recognizes student differences as part of the predictable spectrum of variation where barriers to learning are within the curriculum, instruction, and assessment methods rather than deficits within the students (Kieran & Anderson, 2019). The social model of disability understands impairment as distinguished from disability defining impairment as individual and private (e.g., individual has limited mobility, experiences emotional dysregulation), and defining disability as structural and public (e.g., society's reaction to an impairment "disables" an individual; Shakespeare, 2006; Kattari et al., 2017; Hogan, 2019). While the medical model treats disability as an individual problem, one that should be "fixed," the social model acknowledges impairments as differences, not as problems, encouraging the creation of more accessible and inclusive spaces for all (Shakespeare, 2006). Similarly, UDL appreciates that students possess diverse motivations, backgrounds, interest levels, and skills related to course content. UDL embodies a flexible, research-based framework to guide instructional decision making that can be customized and adjusted for individual needs (Kieran & Anderson, 2019).

The UDL Guidelines are used as a set of concrete suggestions in the implementation of the UDL framework across any discipline or domain to ensure that all learners can access and participate in meaningful, challenging learning opportunities (CAST, 2018). UDL is not an accommodation, rather it is an evidence-based curricular mechanism to offer students greater agency in their learning process (Behling & Tobin, 2018). As educators aim to increase opportunities to learn for all students, these guidelines serve as a tool with which to critique and minimize barriers inherent in curriculum. Considering the wide variability of learners in undergraduate classrooms – namely learners who were previously relegated to "the margins" of our educational systems such as students with disabilities – the integration of the UDL guidelines into learning environments signals a deep understanding, appreciation, and commitment to supporting individual variability above and beyond individualized classroom accommodations.

Gaps in the Literature

Despite the preponderance of research on the benefits of online learning and student-centered instruction, important gaps remain. Even with developing knowledge of evidence-based, cost-effective, and user-friendly resources available to support practitioners in implementing more inclusive approaches that appreciate diverse learners and make students active participants in their learning, the rates of implementation remain slow, particularly in STEM (Henderson et al., 2011; Borrego & Henderson, 2014; Andrews, Speer, & Shultz, 2022). Although some higher education instructors in STEM are moving beyond the transmission model of teaching to embrace inclusive pedagogy, investigations into the ingredients for the fidelity of effective implementation of evidence-based practices are needed (Offerdahl, McConnell, & Boyer, 2018). Despite significant expenditures of time and money on research and development to improve teaching and learning, traditional lecture formats in large universities are still employed and are often anything but inclusive (e.g., a single instructor for over 400 students with little to no chance for individual attention to specific learning needs). Before the pandemic, undergraduate lecture halls and laboratories provided much of the infrastructure for teaching students in STEM. However, in the post-pandemic educational context, leveraging an online space in conjunction with active learning strategies may provide a new horizon for opportunities that positively affect student learning experiences and academic achievement.

Chapter 3

Methods

This quasi-experimental study utilized a mixed methods approach to evaluate the impact of evidence-based and virtual active learning modules (ALMs) integrated into a redesigned model of a large enrollment undergraduate course in psychology research methods at a large public university on student experience and academic outcomes. The mixed methods evaluation of the course redesign uses both course-level and student-level quantitative and qualitative data from online surveys as well as additional quantitative data from course exams to help develop a deeper level of understanding of the student experience before and after the integration of the redesigned course components.

This study aimed to understand student perceptions of course inclusivity and course academic achievement to inform the iterative improvement of course materials by centering the principal stakeholder in the development of a student's learning - the student themselves. The reported findings from this study hope to shed light on the importance of blending physical and virtual evidence-based pedagogical practices to enhance the postsecondary experiences of students, particularly in large enrollment STEM courses. Further, the intentional redesign of academic courses to include an active learning component, which is both asynchronous and virtual, may foster greater perceptions of inclusivity and increased rates of academic achievement for diverse undergraduate students. Investigating the impact of evidence-based practices as a tool to boost students' learning experience and academic outcomes can begin to encourage an equitable student experience for a diverse student body.

Research Aims and Hypotheses

This dissertation aimed to characterize the range of experiences that undergraduate students enrolled in a large Research Methods in Psychology course share both before (Fall 2019) and after (Fall 2022) the integration of a course redesign intervention. Further, the current study evaluated the impact of this redesign intervention for students with and without disabilities on a measure of course-level academic achievement. Applying mixed methods to examine student self-report course evaluations and academic achievement data from an instructor-created multiple-choice exam, the current study had two main aims:

Aim 1: Characterize the student experience in the research methods course before and after the course redesign.

The first aim of this dissertation was to better understand the range of experiences that undergraduate students enrolled in a large Research Methods in Psychology course share both before and after the integration of a course redesign intervention on self-report course evaluations. These evaluations, Evaluation of Instruction Program (EIP) Online Survey and Student Experience Online Survey, were used to characterize the following student experience themes: (1) student attitudes around the teaching and learning quality of course characteristics in the instructional design (Merrill, 2002, Frick et al., 2009; Frick et al., 2010), (2) learner satisfaction with the course evaluated through self-reported grades, perceptions of learning progress (how much they learned, if they learned something valuable), and perceived mastery of course objectives (Kirkpatrick's Levels of Evaluation 1: reaction to the course experience and 2: perceived mastery of course objectives; Kirkpatrick & Kirkpatrick, 2006), (3) overall (global) ratings of the course and the instructor (Cohen, 1981), as well as (4) student social experiences around social-psychological constructs of self-efficacy (i.e., confidence in and estimation of one's abilities to succeed; Bandura, 1997; Bandura & Locke, 2003) and social connectedness (i.e., creation of learner-instructor relationships and learner-learner relationships, Moore, 1989; Ascend Measures Summary, Student Experience Project [SEP], 2021). As evidence suggests active and student-centered instructional practices that promote self-efficacy (Bandura & Locke, 2003) and encourage social connectedness (Christie, 2013) can also foster positive student attitudes around teaching and learning (Frick et al., 2010), these measures are central to the first aim of this dissertation.

It was hypothesized that the quantitative and qualitative analyses of student survey responses would showcase the wide range of feedback that undergraduate students experienced in both iterations of the course. It was anticipated that there would be a significant difference in student survey ratings such that students would describe the post-redesign course model to have a more positive impact on overall student experience in comparison with the pre-redesign course model. With the implementation of the ALMs in the course redesign intervention, student qualitative feedback would validate and expand on the quantitative ratings from both the EIP and Student Experiences Online surveys as evidenced by the increased frequency of all student experience thematic categories apart of the surveys (i.e., perceived quality of course characteristics, learner satisfaction as evaluated through perceived mastery of course objectives, overall course rating, social-psychological constructs of self-efficacy and social connectedness) that positively affect student learning. By zooming in on qualitative feedback in addition to student ratings, this feedback would provide depth and precision in explaining the student experience in the Psychology research methods course at both time points and further illustrate the diverse needs of enrolled students. Considering the wide variability of learners in our classrooms, it was expected that student ratings and feedback would showcase the benefits of blending physical and virtual evidence-based, active learning pedagogical practices in a large enrollment STEM course highlighting the value of such an inclusive strategy for enhancing the overall student learning experience.

Aim 2: Assess potential differential effects for students with and without disabilities on course-level academic outcomes.

The second aim of this dissertation was to elaborate upon student experience data through the evaluation of an objective measure of student academic achievement – a non-standardized, instructor-created multiple-choice exam – to better understand the impact of student experience factors on academic achievement within the context of this course. As the post redesign course model shifted from norm-referenced grading (i.e., grading on a curve) to criteria-referenced grading (i.e., grading all students against a predetermined standard such that all students who meet a given standard can earn a certain grade in the course), exam scores – rather than course grades – were used in this study as a measure of student academic achievement. Although the primary goal of the outlined instructional changes with the inclusion of the desirable difficulties framework (Bjork, 1994) in the ALMs was to facilitate long-term learning (e.g., to create relatively permanent changes in comprehension, understanding, and skills of the types that will support long-term retention and transfer; Bjork & Bjork, 2014), student exam scores – which are arguably a measure of performance, not learning – were used to capture changes in student academic achievement while enrolled in the course. However, it was anticipated that analyses would suggest a positive impact of the redesign for all students, including for those with disabilities, indicating the groundwork has been laid for long-term learning in future research.

It was hypothesized that the redesigned course model would benefit all students enrolled in the course such that all students would perform significantly better on both cumulative course exams in the post-redesign course model in comparison with the pre-redesign course model. Moreover, a significant interaction effect between the independent variables of phase (before or after course redesign) and disability diagnosis (i.e., registered with the Center for Accessible Education [CAE] or not registered with CAE) was also predicted such that students with a disability diagnosis would experience significantly higher academic achievement in the redesigned course model above and beyond their non-CAE peers. A significant interaction effect would suggest that students registered with CAE experienced the greatest benefit of the redesigned course model as evidenced by improved exam scores after the redesign beyond exam scores of peers not registered with CAE.

Even with the hypothesized presence of an interaction effect, research suggests inclusive instructional strategies are effective for all students (Dewsbury & Brame, 2019) with particular impact for underrepresented groups including students with disabilities (Freeman et al., 2014; Theobald et al., 2020). Therefore, it was expected that students would not only report significantly more positive experiences in the redesigned course model that included evidence-based, active learning strategies, but that these attitudes would also be substantiated by increased rates of academic achievement for all students, including students with disabilities. Significant improvement in performance in the post-redesigned course model would convey the impact of integrating such an intervention while also elucidating the relationship between positive student experiences and increased rates of academic achievement within the context of this large enrollment course.

Participants

The current study evaluated course-level measures of student experience and academic achievement for undergraduate students enrolled in Psychology research methods at a public

Research 1 university in Fall 2019 (before redesign) and Fall 2022 (after redesign). Psychology research methods is the required research methods course for all undergraduate students majoring in Psychology, Cognitive Science or Psychobiology. Students enrolled in the course range in age, year in school, entry level (i.e., an undergraduate who entered as a first year student or as a transfer student), academic major, racial and ethnic background, sex, first-generation college student status (i.e., an undergraduate whose parents do not have a bachelor's or higher degree; RTI International, 2019), underrepresented minority (URM) student status (i.e., Black/African American, Chicano(a) / Latino(a) / Hispanic, and American Indian/Alaskan Native; University of California Office of the President, 2021), and receipt of formal disability-based accommodations (i.e., registered with the Center for Accessible Education [CAE] or not registered with CAE).

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All students, regardless of if they entered as a first-year student or as a transfer student must first declare the Pre-Psychology, Pre-Cognitive Science, or the Pre-Psychobiology majors upon taking at least one preparation courses for their respective majors for a letter grade and earning an average GPA of 2.5 or higher. For all departmental majors, the Psychology research method course is a required preparation course to formally declare the Psychology, Cognitive Science or Psychobiology majors, and a "C" grade or better is required to declare the major. As such, this course is of utmost importance as positive academic performance is directly related to an undergraduate student's capacity to formally declare the Psychology, Cognitive Science or Psychobiology majors. Demographic statistics for university wide and Department of Psychology undergraduates by total undergraduates, academic major, sex, ethnicity, entry-level, first-generation college student status, and underrepresented minority (URM) identification are displayed in Table 1 below. Table 1 depicts these demographic characteristics of undergraduate students at the university-level and department-level in Fall 2019 and Fall 2022, before and after the course redesign respectively.

Table 1

Demographic Characteristics of Undergraduates at University-level [1] and Departmental-level [2] in Fall 2019 (Before Redesign) and Fall 2022 (After Redesign)

	Fall 2019 (Before Redesign)	Fall 2022 (After Redesign)
University-level Characteristic	*n* %	*n* %
Total Enrolled	31,541 (100%)	32,372 (100%)
Sex [3]		
Female	18,369 (58.2%)	19,369 (59.8%)
Male	13,072 (41.4%)	12,696 (39.2%)
Unstated, Unknown, Other	100 (0.4%)	307 (1.0%)
Ethnicity [4]		
International	3,484 (11.0%)	2,847 (8.8%)
American Indian, Alaskan Native	187 (0.6%)	207 (0.6%)
Asian, Pacific Islander	10,019 (31.8%)	11,208 (34.6%)
Black, Non-Hispanic	1,751 (5.6%)	1,988 (6.1%)
Hispanic	6,761 (21.4%)	6,711 (20.7%)
White, Non-Hispanic	8,168 (25.9%)	8,328 (25.7%)
Unstated, Unknown, Other	1,171 (3.7%)	1,083 (3.5%)
Entry Level		
Freshman	24,171 (76.6%)	24,624 (76.1%)
Transfer	7,370 (23.4%)	7,748 (23.9%)
First Generation College Student	10,295 (32.6%)	9,354 (28.9%)
Underrepresented Minority (URM)	8,699 (27.6%)	8,906 (27.5%)
Departmental-level Characteristic		

Total Enrolled, Psychology Department	3,681 (100%)	4,384 (100%)
Academic Major		
Pre-Psychology	1,116 (30.3%)	1,292 (29.5%)
Psychology (Declared)	648 (17.6%)	813 (18.5%)
Pre-Cognitive Science	367 (10.0%)	538 (12.3%)
Cognitive Science (Declared)	153 (4.2%)	250 (5.7%)
Pre-Psychobiology	1,010 (27.4%)	1,079 (24.6%)
Psychobiology (Declared)	388 (10.5%)	414 (9.4%)
Sex [3]		
Female	2,781 (75.6%)	3,393 (77.4%)
Male	894 (24.3%)	957 (21.8%)
Unstated, Unknown, Other	6 (0.1%)	34 (0.8%)
Ethnicity [4]		
International	268 (7.3%)	208 (4.7%)
American Indian, Alaskan Native	22 (0.6%)	29 (0.7%)
Asian, Pacific Islander	1,307 (35.5%)	1,565 (35.7%)
Black, Non-Hispanic	244 (6.6%)	322 (7.3%)
Hispanic	815 (22.1%)	1,010 (23.0%)
White, Non-Hispanic	902 (24.5%)	1,125 (25.7%)
Unstated, Unknown, Other	125 (3.4%)	126 (2.9%)
Entry Level		
Freshman	2,955 (80.3%)	3,424 (78.1%)
Transfer	726 (19.7%)	960 (21.9%)
First Generation College Student	1,250 (34.0%)	1,451 (33.1%)
Underrepresented Minority (URM)	1,080 (29.3%)	1,360 (31.0%)

[1] University-level data for undergraduate students in Fall 2019 and Fall 2022 is from the enrollment dashboard from the University's Office of Academic Planning and Budget (APB) database, which is housed within the Chancellor's Office of Data Analytics. This dashboard and database are only accessible to university faculty and staff.

[2] Department of Psychology level data for undergraduate students in Fall 2019 and Fall 2022 is from the University's Life Science Information Gateway (LSIG). This public database is housed in the University's Registrar's Server.

[3] Options for reporting an undergraduate's sex were limited to "male", "female", "prefer not to disclose" or "other" with the latter two options captured as "unstated, unknown, or other" when aggregate statistics were obtained. The university's database reported statistics as gender rather than sex, but the above table references sex. Other gender identities were not intentionally excluded from demographic statistics. Research conducted in the future should collect information in ways that are inclusive to all identities.

[4] Race and ethnicity were aggregated in the university and departmental databases. Research conducted in the future should collect information in ways that are inclusive to all identities (e.g., clearly disaggregate race and ethnicity by splitting large, general categories into more specific groups to provide important nuance for descriptions of a population).

Center for Accessible Education

The Center for Accessible Education (CAE) is responsible for the administration of the university's commitment to ensuring access and participation for all students with qualifying disabilities or medical conditions. At the postsecondary level, a "qualified student with a disability" is a student with a disability "who meets the academic and technical standards requisite for admission or participation in the institution's educational program or activity" (ADA National Network, 2017). The CAE facilitates academic accommodations in accordance with Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act (1990), and the ADA Amendments Act of 2008 (ADAAA). The CAE mission is to provide access to the numerous educational opportunities that are available to students on campus and to empower students to realize their academic potential.

Reasonable accommodations are determined through an interactive process between the CAE, the student, and instructional staff. Student's accommodations are designed to mitigate the functional limitations associated with a student's disability. The most commonly utilized classroom accommodations include: (1) testing accommodations (e.g., additional time, distraction-reduced environment, private room), (2) adjusted assignment deadlines in consultation with CAE, (3) adjusted attendance requirements, (4) notetaking support (e.g., use of Glean, Otter Voice Notes, Livescribe Smartpen, Audio Record Lectures, Notetaking Express, peer notetaking), (5) breaks during class, (6) disability and/or preferential seating, (7) remote access (e.g., student remotely participates in an otherwise in-person class), and (8) adjusted participation requirements (CAE Faculty Handbook, 2023). The CAE Disability Specialists do their due diligence to gather required medical documentation, student rationale, and knowledge on common practice from colleagues in Disability Services to make the most measured decisions in determining which accommodations a student may be eligible to receive. However, there is no disability or diagnostic category that immediately qualifies a student for any specific accommodation. Rather, the academic accommodations CAE registered students receive to experience full access to learning and engaging on-campus are evaluated on an individual basis. To ensure alignment with the mission of the university's disability services center, the Director of CAE was engaged as a community partner throughout the duration of this research project.

Design

The designed study adopted a quasi-experimental framework, as the undergraduate students were not randomly assigned to an enrollment quarter in the course (Mertens, 2020). Students enrolled in the course either before the implementation of the course redesign (Fall 2019) or after the implementation of the course redesign (Fall 2022). Thus, the students being compared at each time point were a different group of students.

Because of the quasi-experimental nature of the study, causal conclusions cannot be drawn. However, quasi-experimental designs, particularly in a study focused on implementation (e.g., maximizing the adoption, appropriate use, and sustainability of effective instructional practices in a real-world classroom setting) can be used to answer implementation questions such as those posed in this study in the absence of randomization (Miller et al., 2020).

Procedure

Study procedures were approved by the university's Institutional Review Board (IRB). Participants were obtained using a convenience sample of students enrolled in the research methods course in both Fall 2019 and Fall 2022 academic quarters. In order to better understand the range of experiences that undergraduate students shared both before and after the integration of a course redesign intervention, participants were given student experience surveys in the final week of the course (Week 10) for both pre-redesign and post-redesign conditions. Additionally, to elaborate on student experience data and evaluate rates of academic achievement, student exam scores from the mid-quarter (Week 5) and the end-of-quarter (Week 10) summative exams were reviewed. The instructor of the course, the exam structure and level of difficulty, and the timeline of survey administration were all held constant across both time points to ensure effective comparison and to eliminate the possibility of treatment effects due to instructor bias or potential history effects.

Fall 2019 Pre-Redesign Course Model

The Fall 2019 pre-redesign structure of this 6-unit course included two components: lecture and lab. The lecture component was in person and synchronously delivered once per week for two hours. One instructor traditionally lectured face-to-face on course concepts to enrolled students (N = 376). Instructor notes were written on a whiteboard during lecture and lectures were not recorded. Live interactions between the learner and the instructor were facilitated through instructor provided examples and probed questions on discussed content.

Students with further questions on course concepts addressed in lecture were encouraged to attend instructor office hours outside of lecture.

Students purchased a textbook with weekly required readings to supplement content learned in lecture. The university's learning management system (LMS) was only used as a repository for course documents including the one-page syllabus listing weekly assignment due dates, instructional team contact information, and copies of a practice exam uploaded before the mid-quarter (Week 5) and the end-of-quarter (Week 10) summative exams, respectively. Both summative exams were administered in person in lieu of that week's live lecture.

The small-group lab component was conducted twice per week totaling four hours of instruction divided across 10 weeks, which totaled 20 labs. Lab sessions were led by one graduate student Teaching Assistant (TA) who taught the same 21 undergraduate students throughout the quarter. Lab content was designed to develop upon conceptual frameworks learned in lecture for students to apply this information to conduct research in psychology. The ultimate instructional goal of lab was for students to collaboratively work in small groups to create and administer a 2x2 within-subjects factorial design research study. After designing and administering their study with peers as participants, students were evaluated on an independent scientific research report that reviewed the findings from their small group designed research study. Students purchased a workbook with activities to supplement content practiced in lab (e.g., tips for writing an APA-style scientific research report, utilizing the balanced Latin Square to counterbalance and control for treatment effects). Student participation was assessed on a subjective basis by Lab TA and group members. All enrolled students experienced the same lab content and summative assessments regardless of their enrolled lab section.

The lab component in the Fall 2019 pre-redesign course model required 18 TAs all with varying levels of teaching experience and familiarity with psychological research methods. Recognizing this variability, the instructional team exerted considerable effort to ensure equity across lab sections. This effort included requirements for inexperienced and non-Department of Psychology TAs to attend lecture to learn how concepts were explained to students, for all TAs (inexperienced and experienced) to attend weekly team meetings led by two experienced graduate student TAs to review and practice lab content, and to standardize TA grading of student assignments through the use of internal rubrics. Further, in order to control for any variability among TA grading, labs used norm-referenced grading (i.e., grading on a curve), where students in each section were evaluated in relationship to one another to assess performance. Despite efforts, the management of such a large team of TAs was not sustainable, particularly as department enrollment of undergraduate students with a myriad of diverse learning needs continued to increase (Table 1).

Course Redesign Intervention

The course redesign intervention was developed in Summer 2021. Utilizing lessons from remote instruction during the pandemic (Neuwirth et al., 2021) and incorporating active learning strategies to better support underrepresented students (Theobald et al., 2020), one goal of the course redesign intervention was to create flexible instructional materials to honor learner variability. By incorporating flexible instructional materials into the course redesign, students would access content in ways that align with individual strengths and preferences in order to promote increased learning and academic success.

An additional goal of the redesigned course was to reduce instructor and TA workload. Despite growing evidence in support of student-centered instruction, implementing such strategies in large classes – including one with the Fall 2019 course structure – can lead to increased organizational work and required grading that could become insurmountable over time. Nevertheless, the benefits of student-centered instructional approaches that position students as active participants in their learning outweigh the challenges. The course redesign intervention sought a creative, evidence-based solution to efficaciously implement active learning strategies in this large-enrollment STEM course.

While preserving the positive aspects of the Fall 2019 pre-redesign course model (e.g., learning conceptual frameworks in lecture in conjunction with applying those learned skills in lab), three members of the instructional team intimately involved with the course (i.e., course creator and previous instructor of record, current instructor of record, experienced graduate student teaching assistant) led the creation of the course redesign intervention. With over five decades of combined expertise in models of adult learning and inclusive pedagogical approaches (e.g., desirable difficulties, Bjork, 1994; UDL, CAST, 2018), this team was appropriately poised to integrate various evidence-based instructional practices to iteratively redesign the course to center student experience as a means of improving academic outcomes and – ideally – long term learning. Moreover, representatives from the university's campus teaching center, which actively collaborates with regional, statewide, and national organizations to drive change forward and increase equity, diversity, and inclusion in STEM, were regularly consulted throughout the creation and implementation of the course redesign process. These representatives ensured that the evidence-based course changes were indeed advancing excellence towards the enhancement of student learning experiences.

Before beginning any course changes, the intervention development team reviewed student feedback questionaries given after each quarter during the 2019-2020 and 2020-2021 academic years. As student feedback provides important evidence for assessing course quality (Richardson, 2005), it was the cornerstone for course improvements. In addition to items about teaching quality and learner satisfaction, students were asked if there were any course concepts, they hoped to spend more time learning about and additional activities, resources, or instructional methods that would have been helpful towards facilitating deeper learning in the course. In utilizing student feedback to inform the iterative improvement of course materials, the intervention team centered the principal stakeholder in the development of a student's learning - the student themselves.

Student-centered instructional practices. Various inclusive, evidence-based elements were integrated in the redesigned course model. Guided by the UDL principles and student feedback from quarterly surveys for continuous improvement, the course redesign intervention focused on providing multiple means of representation, action and expression, and engagement in order to make learning accessible and meaningful for all students (CAST, 2018; Rose & Meyer, 2002; Richardson, 2005). The redesign intervention utilized backward course design to develop a results-based course that focused on student-centered learning (Reynolds & Kearns, 2017). Student-learning outcomes (SLOs) for each course component were first identified to explain the changes in knowledge and skills that students should achieve by the end of the course. All activities and assessments – both formative and summative – were subsequently aligned to these transparent SLOs. For instructors, clearly defined SLOs make it easier to align content, activities, and assessments. While for students, clearly defined SLOs help students understand the value of activities for overall learning and the establishment of expectations such that students can self-assess their own mastery of SLOs (Reynolds & Kearns, 2017).

All SLOs for course components and individual assignments were first aligned within Bloom's revised taxonomy to determine the cognitive complexity of student tasks and vary levels of outcomes from the lowest order of cognition (remembering) to the highest order of cognition (creating; Anderson & Krathwohl, 2001; Krathwohl, 2002). An example of a SLO for the lab component of the redesign course was to demonstrate skills to conduct research in psychology (applying) by designing a simple experiment to test a research question (creating). Before a student can reach the highest order of cognitive complexity, they must first retrieve knowledge about the elements of an experimental design (remembering), discriminate between experimental, quasi-experimental, and non-experimental studies (analyzing), determine the validity of various features of experimental research (evaluating), in order to construct a valid and reliable simple experiment design (creating). SLOs with varying levels of complexity were used as a scaffolding device when creating assignments that build students' critical thinking and synthesis skills throughout the course (Stanny, 2016).

Fink's taxonomy of significant learning (Fink, 2013) was also consulted when developing SLOs to incorporate additional factors that contribute to learning beyond foundational knowledge and skill application encapsulated by Bloom's revised taxonomy (Anderson & Krathwohl, 2001; Krathwohl, 2002). The additional significant learning categories included were human dimension (e.g., gaining a new understanding of self and others), caring (e.g., acquiring new interests, seeing value in what is being learned), and learning how to learn (e.g., learning strategies in general and learning about the process of a student's particular learning; Fink, 2013). In the added course component of active-learning modules, students engaged with course concepts at a self-regulated pace to enhance understanding and long-term learning of course material. Aligned with the learning how to learn category of significant learning, students reflected on the range of utilized learning strategies to calibrate self-assessment of knowledge of course concepts.

The SLOs which were aligned with Bloom's revised taxonomy (Anderson & Krathwohl, 2001) and Fink's taxonomy of significant learning (Fink, 2013) were used as a framework for designing course activities and for assessing student learning in the course redesign intervention. High-impact teaching practices (Fink, 2016) were integrated into these activities and assessments. Examples of high-impact teaching practices used across the course components included the following: (1) helping students become meta-learners (e.g., metacognitive reflection templates, exam wrappers to encourage learners to actively process feedback and reflect on future preparation, metacognitive modeling by the instructor for students, preassessments to encourage students to examine current thinking, muddiest point activities to give students practice in identifying confusions to drive independent learning), (2) employing student-centered instructional approaches for active learning (e.g., formative assessments to improve the learning process and performance on later summative assessments, rubrics with regular feedback to guide future assignment performance, assignments increasing from lower to higher stakes as students get more feedback and exposure to course content, student-generated exam questions, concept maps, creating and presenting a conference poster), and (3) using small groups in a powerful way (e.g., guided instruction with modelling by the instructor ["I do"], small-group student practice time ["We do"], and independent practice ["You do"], think-pair-share, jigsaw technique to break classes into small-groups that each assemble a piece of an assignment and synthesize all work when finished, collaborative scenario-based discussions).

Another essential component of the course redesign intervention was the shift from norm-referenced grading (i.e., grading on a curve) to criteria-referenced grading (i.e., grading all students against a predetermined standard such that all students who meet a given standard can earn a certain grade). With student feedback and evidence that grading on a curve is an issue of equity (Bowen & Cooper, 2021), this transition to a learner-centered grading approach was built into all course assessments. There was also a detailed syllabus to outline clear course expectations (Wagner et al., 2023), a reorganization of lab content with the integration of community building activities to foster social connectedness (Christie, 2013), completion-based, low-stakes assignments to mitigate the role of subjective participation scores and to increase student motivation (Finn, 2015), writing templates to support organization of ideas in psychological report writing (Wiener & Costaris, 2012), and detailed rubrics to clarify assignment expectations making students accountable for their performance in an easy-to-follow format (Lipnevich et al., 2014). Aligned with Reeves' (2006) model of effective course design, the success of the course redesign intervention was determined by the degree to which there was adequate alignment among eight critical factors: (1) SLOs, (2) course content, (3) instructional design and practices, (4) learner tasks, (5) instructor roles, (6) student roles, (7) technological affordances, and (8) assessments (Reeves, 2006). As student feedback provides important evidence for assessing course quality (Richardson, 2005), student feedback also informed the iterative improvement of course materials.

A virtual, active learning approach. The unique facet of this course redesign intervention was the inclusion of online, active learning modules (ALMs). Recognizing the benefits of student-centered instructional approaches, multiple strategies were integrated into the overall course redesign intervention as outlined above. However, with an unsustainable course model coupled with increasing undergraduate student enrollment at both university and departmental levels (Table 1), a creative solution to efficaciously implement active learning strategies in this large-enrollment STEM course was needed. Thus, the asynchronous, virtual ALMs were created as an additional course component used in conjunction with synchronous lectures and lab-based small group instruction.

The ALMs were evidence-based and designed in the frameworks of desirable difficulties (Bjork, 1994) and UDL (CAST, 2018) to promote student metacognition, encourage critical thinking, and enhance long-term learning while honoring learner variability. This accessible, self-guided instructional tool was for students to have additional exposure to course concepts presented during lecture and labs in ways that align with individual strengths and preferences (CAST, 2018). The ALMs were also a tool for students to develop skills of self-regulated learning as there is a significant positive relationship between self-regulated learning and academic achievement (Zimmerman, 1990).

Particularly in online settings, the self-regulated learning strategies of time management, metacognition, critical thinking, and effort regulation have significant positive correlations with academic success (Broadbent & Poon, 2015; Littlejohn et al., 2016). These research-based strategies were integrated into the virtual, asynchronous ALMs. For example, the weekly ALMs were broken down into manageable steps with time ranges to complete each step (i.e., time management), student responses on weekly reflection templates were not graded for correctness, but for completion where relevant and thoughtful responses received full marks (i.e., metacognition), activities with higher order cognitive complexity (i.e., critical thinking), and time for self-reflection to allow students to have a better idea of how to approach learning and use available resources effectively (i.e., effort regulation).

In the post-pandemic educational context, the ALMs leveraged the online space with evidence-based, student-centered instructional approaches to attempt to positively affect student learning and academic achievement. Through the combination of traditional face-to-face instruction (lecture, lab) with remote instruction (ALMs), the redesigned blended course model hoped to optimize student learning beyond each modality in isolation.

Features of the ALMs. The asynchronous modules were designed to be student-guided allowing individual learners to proceed at their own pace (i.e., students had a week to complete the week's ALM, did not have to complete the ALM in one sitting, could practice as many times as desired). There were three categories of ALMs which map on to the content learned in lecture and supplemented by weekly lab lessons. The first category of the ALM were lecture-based practice questions adapted from previous scenario-based, multiple-choice exam questions that require students to apply their knowledge of psychological research methods to analyze hypothetical research designs (i.e., Week 2 - Basic Design, Weeks 4, 6 - Factorial Designs, Week 8 – Quasi and Non-experimental Designs). Student feedback and academic achievement data from the 2019-2020 and 2020-2021 academic years were used to select specific scenario-based exam questions that tested course concepts students found to be the most challenging from each week's lesson (e.g., Week 2 - Basic Design, discriminating between the features of a correlational design and an experimental design; Weeks 4, 6 - Factorial Designs, controlling for extraneous variables to prevent confounding variables).

The next category of ALM were scenario-based, critical evaluation lessons and activities (i.e., Weeks 3, 7). In these lessons and activities, students reviewed a real-world scenario of a research design and identified the type of research described (i.e., correlational, experimental, quasi-experimental) and subsequent research design elements including relevant variables (e.g., independent variables, dependent variable). Students then analyzed the collected data and evaluated any conclusions that are drawn while capturing any possible problems with the design of the study and implications that could be drawn from the results.

The final category of ALM is the selecting a research question and literature search activity (i.e., Week 5). In this activity, students are introduced to the literature search cycle by accessing databases, identifying appropriate search terms for a topic of interest, and searching for relevant empirical articles. Students develop research questions that align with a research topic of interest and reflect on the literature search process by identifying challenges and next steps for proceeding with the research process to continue learning more about the selected research question and topic.

All three categories of the ALM were also designed to include lecture-based review videos and slides to model how to breakdown and annotate scenario-based examples (Doo & Heo, 2020). Suggestions for using the spacing effect in practice (i.e., completing the practice questions one time, watching the review video, and then waiting some time before completing the practice questions once again) were also included (Kornell & Bjork, 2008; Kornell et al., 2010; Bjork & Bjork, 2019). ALM review videos were designed for use at various points in the progression of a lesson, such as prior to the start of the entire lesson or before subparts of the lesson. Thus, the divided instruction into mini-lessons with periodic checkpoints acted as pretests, which have been shown to enhance learning of subsequently presented material whether presented in text, lectures, or videos (e.g., Carpenter, Rahman, & Perkins, 2018; Little & Bjork, 2016; Pan, Yue, Soderstrom, & Bjork, 2015) or at the end of the video lesson, where they can serve as measures of overall comprehension of the presented materials (e.g., Roediger & Karpicki, 2006). The efficacy of desirable difficulties for enhancing long-term learning and transfer has been well documented in the laboratory; however, this study explicitly aimed to understand how to best introduce them into actual course instruction. The ALMs were designed in this framework to build upon certain lecture topics and to allow students to use prior knowledge in meaningful ways, while receiving guidance and practice opportunities to eventually reach the course's learning outcomes independently (e.g., summative exams in lecture, designing a study in lab).

After all steps of an ALM were completed, students submitted a metacognitive reflection-based response template to inform future practice and support student academic achievement. These responses templates included exam wrappers to encourage learners to actively process feedback from practice questions (Gezer-Templeton et al., 2017; Hodges et al., 2020) and muddiest point activities to give students practice in identifying confusions to drive independent learning (Angelo & Cross, 2012; Tanner, 2012). Each ALM is also designed with both overarching student learning outcomes as well as weekly student learning outcomes for students to use as a tool for self-assessment. Thus, the evidence-based ALM features provided multiple means of engagement and flexibility to promote deeper learning of all students enrolled in the course. However, with the increase in diverse learners (e.g., neurodiverse learners, students with disabilities, ethnically/racially diverse students, students from historically marginalized communities) who are disproportionately affected by the challenges in the post-pandemic educational landscape, the ALMs hoped to enhance student learning beyond outcomes possible with only lecture and lab.

Fall 2022 Post-Redesign Course Model

In the Fall 2022 post-redesign course model of this 6-unit course, there were now three course components: lecture, lab, and the addition of ALMs. Similar to the Fall 2019 pre-redesign course model, the lecture component was in person and synchronously delivered once per week for two hours. However, unlike the pre-redesign course model, lecture included various inclusive, evidence-based elements accessibly designed for all learners, including those from diverse cultural backgrounds and with disabilities. Although the same instructor lectured face-to-face on course concepts to enrolled students (*N* = 410), the university's learning management system (LMS) was a central repository for most course materials including general student resources such as a student resource master list with compiled links for a variety of university resources to support student health and wellness to scientific writing to tips for getting the most out of lectures as well as a quick guide to reading empirical journal articles. The course LMS also included document and interactive versions of the detailed course syllabus, weekly announcements recapping central concepts learned and assignment reminders, and updated copies of practice exams uploaded before the mid-quarter (Week 5) and the end-of-quarter (Week 10) summative exams, respectively.

Lecture slides created with accessibility in mind (e.g., high contrast colors, descriptive slide titles, text formatted for legibility) were released on the LMS platform one day before the weekly, live lectures allowing students to use the slides as guided notes during lecture. Lectures were also recorded providing students flexibility to attend lecture remotely and to revisit lectures to review course concepts where additional clarity was possibly needed. Interactions between student and instructor were still facilitated through instructor provided examples and probed questions on discussed content. However, active learning strategies such as think-pair-share, scenario-based examples, case study analyses, polling tools, and formative assessment were also included in lecture to gauge student understanding in real time and to capture actionable insights to target instruction. The active learning strategies used also facilitated discussions between peers and encouraged students to reflect on material all to provide feedback during the learning process while students still had time to develop their understanding.

Students with further questions on course concepts addressed in lecture were encouraged to attend instructor office hours outside of lecture; however, instructor office hours were held remotely for increased flexibility. Additionally, discussion boards were enabled on the course's LMS allowing both instructors and students to start and contribute to as many discussion topics as desired. Guided by UDL principles to support all students, attendance was also no longer required. In the lecture component of the redesigned course model, students were offered multiple means of engagement to enhance learning based on individual preferences.

The small-group lab components also employed student-centered instructional approaches to supplement the course material presented in lecture. Addressing the increased undergraduate enrollment coupled with the challenging management of such a large team of TAs in the previous course structure, labs were conducted once a week for only two hours of instruction divided across 10 weeks. Lab sessions were still led by one graduate student Teaching Assistant (TA) who taught the same 21 undergraduate students throughout the quarter. Although labs in the Fall 2022 post-redesign course model saw a reduction in formalized TA and student interaction time (i.e., 4 hours a week versus 2 hours a week), this new format decreased the number of qualified TAs required to teach the course. With a smaller team of TAs, the instructor was able to select TAs poised to provide the best support to enrolled students (e.g., TAs with practice using inclusive teaching strategies, familiarity with psychological research methods). Moreover, with a smaller TA team and the transition to criterion-referenced grading, additional strategies such as rubrics co-created by instructor and TAs as well as grade norming sessions were more effectively used. TAs worked together to collectively assess student work in a consistent way. This process also reduced TA workload and TA time spent grading.

The lab was still focused on applying course concepts from lecture to evaluate the validity of various research designs by designing a study to test a research question. However, instead of working in small groups to create and administer a research study and write a scientific research report reviewing the findings, students utilized proverbs and scenarios to design scaffolded research studies from a correlational, an experimental, and ultimately, a factorial design. Students still worked in small groups; however, time was spent in guided, scaffolded instruction that followed a similar format each week (i.e., Lecture to Small Group to Individual Homework), extensive instructor modeling and small group practice time, and assignment exemplars for reference during individual practice (Doo & Heo, 2020).

Yet, the largest change in the Fall 2022 post-redesign course model was the addition of the ALMs used asynchronously as a supplement to lectures and lab-based small group instruction in order to promote students' learning, retention, and understanding of course concepts. These modules that were created within the framework of desirable difficulties (Bjork, 1994) incorporated the use of retrieval practice, generation, spacing, contextual interference, and interleaving which have been demonstrated to enhance both long-term learning and transfer. Further, the principles of UDL (CAST, 2018) were built within the redesign model to ensure that all learners can access and participate in meaningful, challenging learning opportunities.

Measures

Course evaluation surveys are a commonly used tool in higher education for understanding student experience and if a course is meeting student learning needs (Richardson, 2005; Frick et al., 2009). Findings from several decades of research indicate that student ratings of teacher effectiveness are positively related to student learning (Cohen, 1981), contributing to the widespread belief that students learn more from highly rated instructors. However, new meta-analyses of multisection studies show that student course evaluations of an instructor's teaching effectiveness are unrelated to student learning and are an inadequate assessment tool for evaluating instructor performance (Uttl, White, & Gonzalez, 2017; Hornstein, 2017).

Despite higher education institutions reconsidering the value of course evaluations (e.g., no longer using ratings of instructor effectiveness for promotion and tenure decisions), these surveys are an incomparable tool to consult when modifying and improving courses. Rather than focusing on items about a specific instructor's teaching effectiveness, surveys that evaluate overall course characteristics and student perceived learning gains and attitude shifts can inform the iterative development of course materials (Frick et al., 2010). Assessing this feedback in conjunction with subsequent course performance can help instructional teams gain a better understanding of how well a course is meeting the learning needs of their students. Thus, this study used both course evaluation surveys and objective measures of course performance to characterize student experiences before (Fall 2019) and after (Fall 2022) and to investigate potential differential effects of the course model for students with and without disabilities.

Evaluation of Instruction Program (EIP) Online Survey

The Evaluation of Instruction Program (EIP) under the university's Center for the Advancement of Teaching (CAT) facilitates over 7,700 instructor and course surveys each 10-week academic quarter and serves over 125 departments and programs across campus. The EIP online survey is an online evaluation tool that provides students an opportunity to anonymously and confidentially give both ratings and qualitative feedback on their instructors and courses at the end of the 10-week academic quarter. The EIP's goal for encouraging students to share their thoughtful ratings and constructive comments are for student evaluations to be used to enhance the undergraduate student learning experience (CAT, 2023). Aggregated report summaries of these end-of-quarter evaluations are returned to the instructor and to the department chair only after student final grades have been submitted. As the survey is anonymous, it is not possible for an instructor to trace back which student gave any answer.

To collect the online survey data, the EIP sends an e-mail to students and instructors to inform them that the evaluation period has begun, which is often one week before the end of the academic quarter. The e-mail lists the specific course sections that are being evaluated and the deadline for students to submit their responses. Students can complete the evaluation survey anytime during the evaluation period until the window has closed, which is typically the last day of the quarter.

The EIP items are aligned with the following student experience themes: (1) student attitudes around the teaching and learning quality of course characteristics (Merrill, 2002, Frick et al., 2009; Frick et al., 2010), (2) learner satisfaction with the course evaluated through self-reported grades, perceptions of learning progress (how much they learned, if they learned something valuable), perceived mastery of course objectives (Kirkpatrick's Levels of Evaluation 1 and 2; Kirkpatrick & Kirkpatrick, 2006), and (3) overall (global) ratings of the course and the instructor (Cohen, 1981). Despite shifting focus away from items about a specific instructor's teaching effectiveness, evidence suggests specific active and student-centered instructional practices that promote self-efficacy (Bandura & Locke, 2003) and encourage social connectedness (Christie, 2013) can also foster positive student attitudes around teaching and learning (Frick et al., 2010). Thus, items around social-psychological constructs of self-efficacy (i.e., confidence in and estimation of one's abilities to succeed; Bandura, 1997; Bandura &

Locke, 2003) and social connectedness (i.e., creation of learner-instructor relationships and learner-learner relationships, Moore, 1989) were also included.

The EIP online survey asks students to first share their thoughtful ratings to what extent they agree with a range of items assessing student experience and student view of course characteristics. Student begin the survey by rating their feelings about: (1) the instructor's concern for student learning, (2) course organization as class presentations were well prepared and organized, (3) instructor interaction where students feel welcome in seeking instructor help in and outside of class, (4) the instructor has good communication skills, (5) students feel they have learned something they consider valuable, and (6) overall rating of the instructor and the course. Students are asked to rate each item on a scale of: 1 *(very low, never)* to 9 *(very high, always)*. Next, students are asked to rate their view of course characteristics on a scale of: 1 *(low, too slow, poor)* to 3 *(high, too much, excellent)* by expressing: (1) level of subject interest before and after the course, (2) perceived mastery of course material, (3) course difficulty relative to other courses, (4) pace of course workload, and (5) evaluation of course materials including textbook, homework, graded materials/examinations, lecture presentations, and class discussions. Table 2 below maps survey items included in subsequent analyses onto these themes.

Upon completion of ratings, students are invited to provide constructive qualitative comments for what they perceive to be the real strengths and weaknesses of the overall course. Thus, the EIP survey is a combination of both closed-ended formats and open-ended formats that allow respondents to answer in their own words to describe their experiences while enrolled. In the Fall of 2019, the pre-redesign time point, there were 185 responses for an enrollment of 376 which was a 49.20% response rate. For Fall 2022, there were 88 responses for an enrollment of 410 which was a 21.46% response rate.

Student Experience Online Survey

Elaborating on the EIP, a survey instrument was constructed containing additional items targeting Merrill's First Principles of instructional design (Merril 2002), and two of Kirkpatrick levels of evaluation (Level 1: reaction to course experience, Level 2: perceived mastery of course learning outcomes; Kirkpatrick & Kirkpatrick, 2006), in addition to global ones like those reported in Cohen (1981), which indicated overall ratings of the course. To further capture student experience, items around social-psychological constructs of self-efficacy (i.e., confidence in and estimation of one's abilities to succeed; Bandura, 1997; Bandura & Locke, 2003) and social connectedness (i.e., creation of learner-instructor relationships and learner-learner relationships, Moore, 1989; Ascend Measures Summary, Student Experience Project [SEP], 2021) were also included.

The online instrument was reviewed by representatives from the university's campus teaching center that focusses on increased diversity, equity, and inclusion in STEM (Center for Education and Innovation in the Learning Sciences, [CEILS]). Survey question clarity was also iteratively improved from Fall 2021 to formal administration in Fall 2022. Based on feedback, wording of items considered to be confusing or ambiguous were modified.

Before beginning the survey, students were instructed that the purpose of the survey was for them to provide valuable insights into their experience with the redesigned course structure. This included student perspectives about which evidence-based instructional strategies they felt promoted long-term learning of core course concepts as well as increased rates of inclusive achievement. The survey took about 10 minutes, unless students opted to provide any additional qualitative feedback, as indicated within specific questions. Students were ensured there was no penalty if they chose not to participate in the survey or answer any questions (Mertens, 2020).

First, students rated the value of specific evidence-based instructional strategies across the lecture, lab, and ALM components of the redesigned course. Students rated the course characteristics on a 4-point Likert scale of: 1 *(No help at all)*, 2 *(Very little help)*, 3 *(Some help)*, 4 *(A lot of help)*, or *N/A; Did not use*. Students then rated their view of the overall course answering to what extent they agree with various statements about their experience throughout the quarter. Students rated their level of agreement with given statements on a 5-point Likert scale of: 1 *(Strongly disagree)*, 2 *(Disagree)*, 3 *(Neither Agree nor Disagree)*, 4 *(Agree)*, to 5 *(Strongly Agree)*. In all sections where students provided ratings, students could optionally elaborate on any ratings with a qualitative response. Next, students provided feedback to qualitive free response questions gathering additional comments or constructive feedback about the course. Finally, self-disclosed demographic information was collected. Upon completion, students were thanked for their time and instructor contact information was provided if students wanted to discuss responses in more detail with a member of the instructional team.

This survey was only administered post-redesign in the last week of the academic quarter to capture the impact of the implemented intervention on the student learning experience. The survey link was included as a step in the final ALM. To promote flexibility in the course design, one ALM could be missed without penalty. Consequently, if students had completed all other ALMs for course credit, they could opt out of the final ALM, including this survey. However, if a student needed to complete the final ALM for course credit, they may have felt required to complete the survey. Due to this limitation, students were reminded in survey instructions and through course announcements that survey participation was voluntary, and all questions were optional.

There were 313 responses for an enrollment of 410 which was a 76.34% response rate. Considering this 76.34% (N = 313) response rate in comparison to the 21.46% (N = 88) response rate on the EIP in Fall 2022, the inclusion of the Student Experience Survey in the final ALM may account for this survey's higher response rate. Table 2 below depicts relevant survey items included in analyses and corresponding student experience thematic categories used to meaningfully characterize the student course experience.

Table 2

Relevant Survey Items on the EIP and Student Experiences Online Survey Outcome Measures and Corresponding Student Experience Themes

Survey	*Survey Item*	*Theme*
EIP Survey	To what extent do you feel that:	
	Instructor Concern – The instructor was concerned about student learning.	Social-psychological Construct; Social Connectedness in Learner-Instructor Relationships [4]
	Organization – Class presentations were well prepared and organized.	Perceived Quality of Course Characteristics [1]
	Interaction – Students felt welcome in seeking help in or outside of the class.	Social-psychological Construct; Social Connectedness in Learner-Instructor Relationships [4]
	Value – You have learned something you consider valuable.	Learner Satisfaction with the Course; Perceptions of learning progress and value [2]
	Overall – Your overall rating of the course.	Global Ratings of the Course [3]
	Your view of course characteristics:	
	Mastery of course material	Learner Satisfaction with the Course [2]
	Course difficulty (relative to other courses)	Social-psychological Construct; Self-efficacy [4]

	Workload/pace was	Perceived Quality of Course Characteristics [1]
	Texts, required readings	Perceived Quality of Course Characteristics [1]
	Graded materials, examinations	Perceived Quality of Course Characteristics [1]
	Lecture presentations	Perceived Quality of Course Characteristics [1]
	What is your expected final grade?	Learner Satisfaction with the Course; Self-reported grades [2]
Student Experience Survey	LECTURE: How helpful do you think the following activities and resources have been for your learning in lecture?	
	Detailed Syllabus	Perceived Quality of Course Characteristics [1]
	In-person Lectures with Added Active-Learning Strategies (e.g., polling, scenario-based examples)	Perceived Quality of Course Characteristics [1]
	Lecture Slides	Perceived Quality of Course Characteristics [1]
	Recordings of Lectures Posted After In-Person Lectures	Perceived Quality of Course Characteristics [1]
	General Student Resources within Course LMS (e.g., Student Resource Master List, Reading Empirical Journal Articles Guide)	Perceived Quality of Course Characteristics [1]
	Practice Exams	Perceived Quality of Course Characteristics [1]
	Discussion Forums	Perceived Quality of Course Characteristics [1]
	SLOs and Goals	Perceived Quality of Course Characteristics [1]
	ALMs: How helpful do you think the following activities and resources have been for your learning of overall course concepts (e.g., on exams, further	

conceptualizing and applying course concepts)	
Lecture Based Practice Questions (i.e., Week 2 - Basic Design, Week 4 & 6 - Factorial Designs Practice Questions, Week 8 - Quasi + Non-experimental Designs)	Perceived Quality of Course Characteristics [1]
Critical Evaluations I and III Lesson and Activity (i.e., Weeks 3, 7 ALMs)	Perceived Quality of Course Characteristics [1]
Selecting a Research Question & Literature Search Activity (i.e., Week 5 ALM)	Perceived Quality of Course Characteristics [1]
ALM Review Videos with Corresponding Slides	Perceived Quality of Course Characteristics [1]
Spacing out your learning (i.e., completing the practice questions one time, watching the review video, waiting some time before completing the practice questions again)	Perceived Quality of Course Characteristics [1]
Reflection-based ALM Response Templates	Social-psychological Construct; Self-efficacy [4]
OVERALL COURSE: To what extent do you agree with the following statements about your experience in the course during Fall 2022?	
I felt well prepared to succeed in this course.	Social-psychological Construct; Self-efficacy [4]
I felt supported by the instructional team.	Social-psychological Construct; Social Connectedness in Learner-Instructor Relationships [4]
I felt a sense of connection to my classmates.	Social-psychological Construct; Social Connectedness in Learner-Learner Relationships [4]

	I developed meaningful skills of scientific literacy to become a more educated, critical consumer of research.	Learner Satisfaction with the Course; Expressed mastery of course SLOs [2]
	I can effectively discriminate between various kinds of research methods and designs used in Psychology.	Learner Satisfaction with the Course; Expressed mastery of course SLOs [2]
	I am confident in my ability to communicate the critical aspects of a research study in scientific writing or in an oral presentation.	Learner Satisfaction with the Course; Expressed mastery of course SLOs [2]
	I developed metacognitive awareness and skills to support the self-assessment of my own learning.	Learner Satisfaction with the Course; Expressed mastery of course SLOs [2]

Note. EIP = Evaluation of Instruction Program Online Survey. ALMs = Active Learning Modules. LMS = Learning Management System. SLOs = Student Learning Outcomes.

The EIP online survey was administered at the same timepoint (Week 10) both before (Fall 2019) and after (Fall 2022) the course redesign intervention. Students provided a rating for the items with the question stem "To what extent do you feel that" on a scale of: 1 (*very low or never*) to 9 (*very high or always*). Students provided a rating for the items with the question stem "Your view of course characteristics" on a scale of 1 (*low, too slow, or poor*) to 3 (*high, too much, or excellent*).

The Student Experience Online Survey was only administered in the final week of the academic quarter (Week 10) after the course redesign intervention (Fall 2022). Students provided a rating for items about course characteristics on a 4-point Likert scale of: 1 *(No help at all)*, 2 *(Very little help)*, 3 *(Some help)*, 4 *(A lot of help)*, or *N/A; Did not use*. Students providing a rating about the overall course on a 5-point Likert scale of 1 *(Strongly Disagree)*, 2 *(Disagree)*, 3 *(Neither Agree nor Disagree)*, 4 *(Agree)*, to 5 *(Strongly Agree).*

[1] Perceived Quality of Course Characteristics Theme: Student attitudes around the teaching and learning quality of course characteristics in the instructional design (Merrill, 2002, Frick et al., 2009; Frick et al., 2010).

[2] Learner Satisfaction with the Course Theme: Evaluated through student self-reported grades, perceptions of learning progress (how much they learned, if they learned something valuable), and perceived mastery of course objectives (Kirkpatrick s Levels of Evaluation, Level 1: reaction to course experience, Level 2: perceived mastery of course learning outcomes; Kirkpatrick & Kirkpatrick, 2006).

[3] Global Ratings of the Course Theme: Overall ratings of the course (Cohen, 1981).

[4] Social-psychological Themes: Student social experiences around social-psychological constructs of self-efficacy (i.e., confidence in and estimation of one's abilities to succeed; Bandura, 1997; Bandura & Locke, 2003) and social connectedness (i.e., creation of learner-instructor relationships and learner-learner relationships, Moore, 1989; Ascend Measures Summary, Student Experience Project [SEP], 2021).

Academic Achievement

A non-standardized, instructor-created multiple-choice exam was used to assess student academic achievement. Despite the changes in the course design between Fall 2019 and Fall 2022, the course continued to use timed summative exams with 40 total questions, all multiple-choice, spread across a variety of scenarios given at the quarter midpoint (Week 5) and the quarter endpoint (Week 10). The summative exam required students to apply their knowledge of psychological research methods to analyze scenarios of hypothetical research designs. Exams tested the same material and was created by the same instructor both before (Fall 2019) and after (Fall 2022) the course redesign.

In the Fall 2019 pre-redesign course model, timed exams were administered in person, while in the Fall 2022 post-redesign course model, exams were delivered online via the course's LMS. Recognizing the potential of academic dishonesty through the online administration of course exams, additional precautions were taken when administering the Fall 2022 exams. All questions were randomized, the exam was only open during a specific time window, students were required to work independently, and the exam was entirely sequential such that questions were displayed one-at-a-time and students were unable to return to previous questions once answered. Despite differences in exam administration, comparisons of students' exam scores were taken both before and after the course redesign for insight into student performance and learning of course concepts. Furter, due to the quasi-experimental nature of the designed study, no causal conclusions about exam scores and academic achievement were made.

Chapter 4

Results

The following data analyses focused on undergraduate students' perceptions of their learning experiences and student academic outcomes in the context of a course-wide pedagogic shift to include active, student-centered instructional practices and evidence-based, online ALMs. To better capture the sample of enrolled students in the undergraduate research methods in Psychology course, Table 3 below showcases course-level demographic characteristics of students in the post-redesign course model (Fall 2022). Of voluntary student respondents to demographic questions (N = 299), students ranged in age from 15 - 28 years (M = 20.03, SD = 0.93) with the majority of enrolled undergraduate students in their 3rd academic year (n = 233, 77.9%). Optional student responses on the anonymous Student Experience Survey to the question, "Do you receive formal classroom accommodations through the University Center for Accessible Education (CAE)?" were used to determine if a student was registered with CAE. Due to the CAE academic accommodation process, if a student responded in the affirmative, it was assumed that student had a qualified disability that required formalized support services from CAE. Course-level demographic statistics (Table 3) mirror university and departmental data trends (Table 1). Frequencies and cross tabulation chi-square results for demographic variables with testable sample sizes and self-disclosed receipt of formal CAE accommodations are also included in Table 3 below.

Table 3

Frequencies and Chi-Square Results for Course-level Demographic Statistics on Self-disclosed Receipt of Formal CAE Accommodations in Fall 2022 (After Redesign) (N = 299)

	No Self-Disclosed Receipt of CAE Accommodations	*Yes* Self-Disclosed Receipt of CAE Accommodations	
Course-level Characteristic	*n* %	*n* %	X^2
Academic Major			1.22
Psychology	92 (32.9%)	8 (42.1%)	
Cognitive Science	50 (17.9%)	4 (21.1%)	
Psychobiology	124 (44.3%)	6 (31.6%)	
Double Major	14 (5.0%)	1 (5.3%)	
Race and/or Ethnicity [1]			
American Indian or Alaska Native	1 (0.4%)	0 (0.0%)	
Asian	115 (41.1%)	3 (15.8%)	4.76*
Black or African American	3 (1.1%)	0 (0.0%)	
Caucasian/White	83 (29.6%)	9 (47.4%)	2.62
Native Hawaiian or Pacific Islander	1 (0.4%)	0 (0.0%)	
Hispanic or Latino/a/x	44 (15.7%)	4 (21.1%)	0.38
Middle Eastern or North African	4 (1.4%)	1 (5.3%)	
Multiracial	22 (7.9%)	2 (10.5%)	
Asian, Caucasian/White	11 (3.9%)	0 (0.0%)	
Asian, Black or African American	1 (0.4%)	1 (5.3%)	

Asian, Latino/a/x	4 (1.4%)	1 (5.3%)	
American Indian, Latino/a/x	3 (1.1%)	0 (0.0%)	
Black or African American, Caucasian/White	1 (0.4%)	0 (0.0%)	
Black or African American, Latino/a/x	2 (0.7%)	0 (0.0%)	
Prefer not to disclose	7 (2.5%)	0 (0.0%)	
Sex and/or Gender [2]			
Female	224 (80.0%)	14 (73.7%)	0.44
Male	47 (16.8%)	2 (10.5%)	0.51
Agender	1 (0.4%)	0 (0.0%)	
Genderqueer	1 (0.4%)	0 (0.0%)	
Non-binary/Third gender	0 (0.0%)	1 (5.3%)	
More than one category	4 (1.4%)	2 (10.5%)	
Non-binary/Third gender, Genderqueer	2 (0.7%)	0 (0.0%)	
Female, Non-binary/Third gender, Transgender, Genderqueer	0 (0.0%)	2 (0.7%)	
Male, Agender	1 (0.4%)	0 (0.0%)	
Male, Transgender	1 (0.4%)	0 (0.0%)	
Prefer not to disclose	3 (1.1%)	0 (0.0%)	
First Generation College Student	76 (27.1%)	7 (36.8%)	0.99
Entry Level			0.35
Freshman	272 (97.1%)	18 (94.7%)	
Transfer	8 (2.9%)	1 (5.3%)	
Total	**280 (100%)**	**19 (100%)**	

*$p < .029$

Note. Data is from the anonymous, optional Student Experience Online Survey administered in Fall 2022, after the implementation of the course redesign intervention. Similar data was not obtained at the pre-redesign time point (Fall 2019) as the survey was not yet created. Only cross tabulations for demographic variables with testable sample sizes are noted.

[1] Race and ethnicity were queried in the same question of the survey, leading some students to report on race or ethnicity but not both. Future research will more clearly disaggregate race and ethnicity in the demographic survey to provide important nuance for descriptions of a population.

[2] Gender and sex were queried in the same question of the survey. Students were encouraged to select all that apply or utilize the fill in the blank option where participants could describe their identities in their own words. For increased inclusivity, future research will ask about Gender, Sexual Orientation/Sexual Identity/Sexuality, and Sex Assigned at Birth separately.

As seen in Table 3, no group differences were significant for any of the demographic variables with the exception of one. There was a significant association between self-disclosed racial background and self-disclosed receipt of formal CAE accommodations ($X^2(1) = 4.76$, $p < .029$), such that there were fewer Asian than non-Asian students in the CAE group, proportionally. Although there was a non-significant association between sex and receipt of CAE accommodations, there was a greater proportion of females in the CAE than in the non-CAE group (Table 3).

In reviewing additional student survey responses to demographic questions of interest, there was a greater proportion of students who agreed to disclosing to the university or instructional faculty as needing additional academic assistance (e.g., extended assignment deadlines, extended time on exams; $n = 44$) than those who receive formal classroom accommodations through the CAE ($n = 19$). Further, 23 students (including 8 of the 19 who self-disclosed receipt of formal CAE accommodations, 42.11%) disclosed they had been diagnosed as neurodivergent (e.g., Dyslexia, Autism, ADHD, Dyspraxia, and other neurological conditions) during their life course. Supporting existing research that some undergraduate students do not disclose their disability to receive formal accommodations due to a multitude of reasons

(Kimball et al., 2016; Toutain, 2019), this self-disclosed course-level statistic provides further evidence that there may be more students with disabilities in postsecondary classrooms. Moreover, many previous studies of students with disability in STEM aggregate students with diverse disability types into one category; however, the large percentage of students who identified as neurodivergent even in this small sample alludes to the heterogeneous experience of students with disabilities (e.g., Verboom et al., 2011; Masi et al., 2017; Kroesbergen et al., 2022). The three levels of demographic statistics at the university-level (Table 1), department-level (Table 1), and course-level (Table 3) validate the increasing diversity of undergraduate students, specifically in a large-enrollment STEM course.

Aim 1: Characterization of Student Experience

Addressing the first research aim to characterize the range of experiences that students shared on self-report course evaluations both before and after the integration of a course redesign intervention including ALMs, the analysis of this quasi-experimental study utilized the validating quantitative data model variant of triangulation (Creswell & Plano Clark, 2011; Creswell et al., 2011), a well-known approach to mixing methods (Creswell, Plano Clark, et al., 2003). The EIP and Student Experiences Online survey outcome measures collected quantitative ratings and a few open-ended qualitative questions within a single survey instrument. Because the qualitative items expanded upon quantitative ratings, the items generally did not result in a rigorous qualitative data set. However, they provided interesting quotes to validate and embellish the quantitative survey findings (Creswell & Plano Clark, 2011). Table 2 above included relevant survey items and corresponding student experience thematic categories to situate the findings.

Evaluation of Instruction Program (EIP) Online Survey Results

A quantitative evaluation of EIP student ratings in Fall 2019 (pre-redesign) and Fall 2022 (post-redesign) was first used to investigate comparative student ratings from both iterations of the course. Removing EIP survey items about a specific instructor's teaching effectiveness (Uttl, White, & Gonzalez, 2017; Hornstein, 2017), independent samples *t*-tests evaluated the change in student ratings to capture student perceptions of course improvement. All analyses conducted to address the first aim were independent samples *t*-tests due to the nature of this quasi-experimental study comparing different students in the pre-redesign and the post-redesign groups (Mertens, 2020). Table 4 below shows the differences in EIP student ratings from Fall 2019 (Before Redesign) and Fall 2022 (After Redesign).

Table 4

Independent Samples T-Test for Differences in Student Ratings on Evaluation of Instruction Program (EIP) Survey in Fall 2019 (Before Redesign) and Fall 2022 (After Redesign)

	Fall 2019 (*Before* Redesign)			Fall 2022 (*After* Redesign)			
EIP Survey Item	*N*	*M*	*SD*	*N*	*M*	*SD*	*t(df)*
To what extent do you feel that:							
Instructor Concern – The instructor was concerned about student learning.	183	7.51	1.66	87	8.20	1.37	-3.35(268) *
Organization – Class presentations were well prepared and organized.	184	7.82	1.53	87	8.43	1.02	-3.39(269) ***
Interaction – Students felt welcome in seeking help in or outside of the class.	184	7.10	2.01	87	8.09	1.44	-4.14(269) **

Value – You have learned something you consider valuable.	183	7.49	1.73	87	8.20	1.22	-3.44(268) **
Overall – Your overall rating of the course.	183	5.92	2.55	87	7.94	1.37	-6.93(268) ***
Your view of course characteristics:							
Mastery of course material	184	2.28	0.59	86	2.48	0.55	-2.58(268)
Course difficulty (relative to other courses)	184	2.65	0.51	86	1.90	0.55	10.94(268) **
Workload/pace was	182	2.54	0.50	86	2.02	0.31	8.81(266) ***
Texts, required readings	183	2.04	0.63	86	1.95	0.61	1.04(267)
Graded materials, examinations	183	1.82	0.68	86	2.26	0.62	-5.07(267)
Lecture presentations	183	2.47	0.68	86	2.60	0.52	-1.70(267) **

*p < .05 **p < .01 ***p < .001

Note. EIP = Evaluation of Instruction Program Online Survey. N = Sample Size which varied by question. M = Mean. SD = Standard Deviation. t = Computed inferential test statistic.

df = Degrees of Freedom, used the equal-variances-assumed test statistic or the equal-variances-not-assumed test statistic dependent on Levene's test for equality of variance.

The EIP online survey was administered at the same timepoint (Week 10) for both groups. Completion of the EIP was voluntary and anonymous. Students rated items about the course and the instructor. As the instructor was held constant at both timepoints, only EIP items relevant to course structure and design were reported.

Students provided a rating for the items with the question stem "To what extent do you feel that" on a scale of 1 (*very low or never*) to 9 (*very high or always*). Students provided a rating for the items with the question stem "Your view of course characteristics" on a scale of 1 (*low, too slow, or poor*) to 3 (*high, too much, or excellent*).

Investigating how learners perceived the quality of instruction they experienced, student attitudes around the teaching and learning quality of course characteristics were first reviewed (Merrill, 2002, Frick et al., 2009; Frick et al., 2010). There was a significant increase in student perceptions of course organization from before the redesign (M = 7.82, SD = 1.53) to after the redesign (*M* = 8.43, *SD* = 1.02), such that students believed class presentations were significantly better prepared and organized after the course redesign intervention, $t(269) = -3.39$, $p < .001$. Providing further detail on specific aspects of course characteristics, there was a significant increase in student ratings of lecture presentations from before the redesign (*M* = 2.47, *SD* = 0.68) to after the redesign (*M* = 2.60, *SD* = 0.52); $t(267) = -1.70$, $p < .01$. Students also felt the workload and pace was significantly more reasonable after the course redesign (*M* = 2.02, *SD* = 0.68) as seen in the significant reduction in ratings where students initially perceived the course as "too much" work (*M* = 2.60, *SD* = 0.52), $t(266) = 8.81$, $p < .001$. There was no significant difference in student ratings from before and after the course redesign on other included survey items assessing student perceived quality of course characteristics (i.e., texts, required readings, graded materials, examinations), likely because these items remained relatively constant across both time points.

Next, learner satisfaction with the course was evaluated through perceptions of learning progress and perceived mastery of course objectives (Kirkpatrick & Kirkpatrick, 2006). There was a significant increase in student perceptions of learning progress from before the redesign (*M* = 7.49, *SD* = 1.73) to after the redesign (*M* = 8.20, *SD* = 1.22), such that significantly more students believed they learned something they considered valuable in the post-redesign course model, $t(268) = -3.44$, $p < .01$. However, there was no significant difference in perceived mastery of course material from before (*M* = 2.28, *SD* = 0.59) to after (*M* = 2.48, *SD* = 0.55) the implementation of the course redesign intervention, $t(268) = -2.58$, $p = .63$. Although non-significant, there was a trend of improvement in the post-redesign model, even if slight.

Additionally, items around the social-psychological constructs of self-efficacy (i.e., confidence in and estimation of one's abilities to succeed; Bandura, 1997; Bandura & Locke,

2003) and social connectedness (i.e., creation of learner-instructor relationships and learner-learner relationships; Moore, 1989) were evaluated. From before the redesign (*M* = 2.65, *SD* = 0.51) to after the redesign (*M* = 1.90, *SD* = 0.55), there was a significant reduction in student perceptions of course difficulty relative to other courses. Due to this reduction in course difficulty, students had significantly more confidence in their ability to succeed in the post-redesign model of the course, $t(268) = 10.94$, $p < .01$.

As social connectedness in the form of positive learner-instructor relationships may foster student sense of belonging – which may build a foundation for greater academic achievement – items about instructor concern and learner-instructor interactions were measured. Students felt significantly more welcome in seeking help in or outside of class after the course redesign (*M* = 8.09, *SD* = 1.44) compared to before (*M* = 7.10, *SD* = 2.01), $t(269) = -4.14$, $p < .01$. There was also a significant increase in student belief that the instructor was concerned about student learning, such that before the redesign (*M* = 7.51, *SD* = 1.66) to after the redesign (*M* = 8.20, *SD* = 1.37), significantly more students believed there was a greater focus on student learning, $t(269) = -3.35$, $p =.04$.

Further, analyzing student expected grades is also important as evidence suggests an association between expected student grades and student ratings on course evaluations. Student grade satisfaction – regardless of the underlying cause for why students earn such grades – appears to be an important driver of feedback on course evaluations (Kogan et al., 2022). In other words, if students expect to perform at a higher level, then their evaluations of the course may also be higher. Even with the uptake of interventions with goals to reduce the magnitude of the association of grades and course satisfaction by reminding students to focus on relevant teaching and learning considerations, many interventions have proven ineffective in muting the relationship between grades and student feedback (Kogan et al., 2022). Thus, the relationship between expected grade and the impact on course evaluations is essential for situating understanding of the above student ratings.

An independent-samples *t*-test was conducted to compare student expected grades from before (N = 183) and after (N = 87) the course redesign. In the pre-redesign course model, 51 students expected to earn an "A" grade (27.9%), 73 students expected to earn a "B" grade (39.9%), 14 students expected to earn a "C" grade (7.7%), and 44 students (24.0%) were unsure what grade they would receive. Comparatively, in the post-redesign course model, 57 students expected to earn an "A" grade (65.5%), 16 students expected to earn a "B" grade (18.4%), 14 students expected to earn a "C" grade (2.3%), and 12 students (13.8%) were unsure what grade they would receive. There was a significant difference in the final grades student expected to receive such that significantly more students predicted earning a higher course grade after the implementation of the redesign intervention; $t(268) = 3.11$, $p < .001$. Before the redesign, the majority of students expected to earn a "B" grade; however, after the redesign, the majority of students expected to earn an "A" grade. Moreover, significantly less students were unsure where they stood in terms of a final grade, which may be because of the transition from norm-referenced to criterion-referenced grading in the post-redesign course model. As significantly more students expected to perform better after the course redesign intervention, this may contribute to the significant increase in positive student ratings and course feedback seen in the post-redesigned course model.

The above findings on undergraduate students' perceptions of their learning experiences are encompassed by the increase in student's overall (global) ratings of the course (Cohen, 1981). After the inclusion of active, student-centered instructional practices and evidence-based, online ALMs (M = 7.94, SD = 1.37), students significantly rated the overall course more favorably compared to before the implementation of the course redesign intervention (M = 5.92, SD = 2.55), $t(268) = -6.93$, $p < .001$. Thus, the quantitative analyses of all EIP student ratings showcased that students described the post-redesign course model to have a more positive impact on overall student experience in comparison with the pre-redesign course model.

Student Experience Online Survey Results

Providing even greater detail for which specific course characteristics potentially attribute to increased overall course quality, the post-redesign Student Experience Online Survey items and student ratings elaborated upon the previous analyses. The EIP showed a significant increase in the perceived effectiveness of lecture presentations after the implementation of the course redesign intervention ($p < .01$). On the Student Experience Online Survey, voluntary student respondents provided additional insight into the impact of lecture characteristics on the student learning experience. Of 313 voluntary student respondents, a strong majority of students found the detailed syllabus to be a lot of help (n = 209, 66.8%) or some help (n = 89, 28.4%). Additionally, most students perceived in-person lectures with added active-learning strategies (e.g., polling, scenario-based examples) to be at least some help for their learning of course material (n = 265, 84.7%), with almost half saying these strategies were a lot of help (n = 145, 46.3%). The general student resources within the course LMS (e.g., Student Resource Master List, Reading Empirical Journal Articles Guide) had similar consensus as most students felt these resources were a lot of help (n = 138, 44.1%) or some help (n = 104, 33.2%). Further, most students perceived course and assignment learning outcomes (i.e., SLOs) to be at least some help for their learning of course material (n = 205, 65.5%), with about a fourth saying these strategies were a lot of help (n = 74, 23.6%). The discussion forums posted on the course's LMS had more mixed results with a smaller percentage of students that believed they were at least some help (*n* = 131, 41.9%); however, a sizeable portion of students did not use them at all (*n* = 115, 36.7%).

Student ratings, additionally, declared three instructional design elements to have a substantial impact on learning including accessible lecture slides, recordings of lectures, and updated practice exams. A super majority of students found the accessible lecture slides to either be a lot of help (*n* = 274, 84.6%) or some help (*n* = 40, 12.3%) for learning. Further, most students perceived lecture recordings to be at least some help for their learning of course material (*n* = 265, 84.7%), with the majority saying these recordings were a lot of help (*n* = 236, 75.4%), and remaining students claiming the question was not applicable as they did not use the recorded lectures (*n* = 32, 10.2%). The updated practice exams were also exceptionally valuable with another super majority of students believing these practice exams were either a lot of help (*n* = 258, 82.4%) or some help (*n* = 41, 13.1%), and only a small percentage of students not using this provided resource (*n* = 7, 2.2%).

Elaborating on EIP ratings that the post-redesign course model had a more positive impact on overall student experience and learning in comparison with the pre-redesign course model ($p < .001$), the Student Experience Survey items and student responses ($N = 313$) described the impact of the implemented intervention in greater detail. Learner satisfaction with the course was evaluated through perceptions of learning progress and perceived mastery of course objectives (Kirkpatrick & Kirkpatrick, 2006). The EIP showed a significant increase in student perceptions of learning progress ($p < .01$), but no significant difference in perceived mastery of course material after the implementation of the course redesign intervention ($p = .63$). Although non-significant, there was a trend of improvement in the post-redesign model, so further investigation into students' expressed mastery of course SLOs was conducted.

Most students agreed that they developed meaningful skills of scientific literacy to become a more educated, critical consumer of research (n = 279, 89.8%). A substantial majority of students also agreed they could effectively discriminate between various kinds of research methods and designs used in Psychology (n = 301, 84.7%), with most students strongly agreeing (n = 165, 52.7%). Additionally, students were confident in their ability to communicate the critical aspects of a research study in scientific writing or in an oral presentation (n = 267, 85.3%, strongly agree or agree). Finally, most students agreed (n = 150, 48.2%) or strongly agreed (n = 117, 37.4%) that they developed metacognitive awareness and skills to support the self-assessment of their own learning.

As the social-psychological constructs of self-efficacy (i.e., confidence in and estimation of one's abilities to succeed; Bandura, 1997; Bandura & Locke, 2003) and social connectedness (i.e., creation of learner-instructor relationships and learner-learner relationships; Moore, 1989) may be positively related to academic achievement, these items were also evaluated on the Student Experience survey. On the EIP, there was a significant reduction in student perceptions of course difficulty relative to other courses such that students had significantly more confidence in their ability to succeed in the post-redesigned model ($p < .01$). Most students in the post-redesign course model agreed that they felt well prepared to succeed in this course (n = 275, 87.9%), indicating many students may have achieved greater rates of self-efficacy in the post-redesign course model through incorporated changes.

Moreover, changes in EIP ratings showed that students felt significantly more welcome in seeking help in or outside of class ($p < .01$) and believed that the instructor was concerned about student learning ($p = .04$) after the course redesign. Confirming these results, a super majority of students in Fall 2022 also strongly agreed or agreed that they felt supported by the instructional team such that the course instructor and Lab TAs were responsive to student needs, (*n* = 292, 93.3%). Students were also asked about learner-learner relationships and if they felt a sense of connection to their classmates. The results were mixed with a large portion of students neither agreeing or disagreeing (*n* = 114, 36.4%), compared to fewer students agreeing (*n* = 88, 28.2%), and a small minority strongly agreeing (*n* = 34, 10.9%) they felt connection to classmates. Despite the muted impact of learner-learner relationships, students appeared to overwhelmingly agree that the post-redesign course model was a supportive course environment for student learning. As perceptions of a supportive course environment may foster students' belonging beliefs – which in turn can impact engagement and academic achievement (Zumbrunn et al., 2014) – these findings are of utmost importance.

Student Perceptions of the Active Learning Modules (ALMs)

As the unique facet of this course redesign intervention was the inclusion of online ALMs, the benefit of this instructional tool was specifically considered in the Fall 2022 student ratings. Capturing the impact of the implemented intervention on the student learning experience, the Student Experience Online Survey asked students how helpful they thought each ALM activity and subsequent resources were for student learning of overall course concepts (e.g., on exams, further conceptualizing and applying course concepts). Almost all students agreed that the ALMs with lecture-based practice questions were exceptionally helpful for conceptualizing course concepts and exam preparation (*n* = 304, 97.1%), with most students strongly agreeing (*n* = 222, 70.9%). Similarly, a sizeable portion of students also strongly agreed (*n* = 168, 53.7%) or agreed (*n* = 120, 38.3%) that the Critical Evaluation lessons and activities ALMs were helpful for learning. Despite less favorable student ratings for the usage of the Selecting a Research Question and Literature Search activity ALM as the application of this lesson may be more ambiguous than other ALMs (e.g., resources for potential scientific research reports students may write in the future versus resources for confirmed summative exams students must take in the enrolled course), most students still agreed that the lesson was helpful (n = 225, 71.9%).

Investigating specific facets of the ALMs, a majority of students found the ALM review videos that discussed practice-questions and elaborated on study strategies to be a lot of help (n = 177, 56.5%) or some help (n = 106, 33.9%). Most students also perceived the metacognitive reflection based ALM response templates to be at least some help for their learning of course material (n = 224, 71.5%). Students were also encouraged in the ALM steps to space out their learning (i.e., completing the practice questions one time, watching the review video, waiting some time, completing the practice questions once again). Considering this instructional strategy, most students saw spacing as some help (n = 140, 44.7%) with slight less seeing it as a lot of help (n = 113, 36.2%). As spacing versus massed studying is counterintuitive for many learners (Kornell & Bjork, 2008), the smaller percentage of students who only agree that spacing was some help may speak to student reluctance to include such a desirable difficulty in practice (Bjork & Bjork, 2019). Overall, student ratings displayed that students believed the ALMs were not only a valuable resource for learning course material, but they were also embedded with valuable skills and strategies students could take into future courses.

Qualitative Thematic Analysis

Through a triangulation design to validate the quantitative data (Creswell & Plano Clark, 2011), a deductive, “top-down” qualitative approach (Mertens, 2020) was utilized. The purpose of this mixed-methods evaluation approach was to review student open-ended qualitative free responses in addition to the above student given ratings to investigate how qualitative feedback expanded on the quantitative findings. As a deductive approach involves coming to the data with predetermined themes, the student experience thematic categories (Table 2) were used to organize all student responses from online surveys at the following time points: EIP in Fall 2019 (pre-redesign), EIP Fall 2022 (post-redesign), and the Student Experience Online Survey Fall 2022 (post-redesign).

Data familiarization of all provided feedback was conducted before coding student responses in the student experience thematic categories (Table 2) to help avoid confirmation bias (Mertens, 2020). Qualitative feedback about the instructor's teaching effectiveness or the instructor in general (Uttl, White, & Gonzalez, 2017; Hornstein, 2017) were removed to focus on student feedback about elements of instructional design probed by both surveys. Due to the open-ended nature of the qualitative queries, a single student's feedback could be coded with multiple themes. Table 5 below depicts sample quotations for each thematic category from Fall 2019 (Before Redesign) and Fall 2022 (After Redesign).

Table 5

Selected Quotations of Qualitative Student Feedback on EIP and Student Experience Surveys from Fall 2019 (Before Redesign) and Fall 2022 (After Redesign)

	Fall 2019 (Before Redesign)	Fall 2022 (After Redesign)
Student Experience Theme	Selected Quotations	Selected Quotations
Perceived Quality of Course Characteristics; Course Organization and Grading	Organization: "The structure of the course was incredibly frustrating. It felt as though the course was purposefully attempting to trip students up over nothing so that it could make us fail and get a 'better curve'." Organization: "Lab and lecture felt completely separate, and the pacing of the assignments was too much." Organization: "I think this course has a lot of potential to be meaningful and	Organization: "This class was honestly such a great and organized class that other classes should take notes!" Organization: "I thought this class was very well-organized. The LMS was a little intimidating at first, with all of the links and modules, but

	valuable, but the course was very disorganized; there was a huge gap between the lecture and lab content and too much overlap of deadlines for assignments and exams." Grading: "There was too much power to Lab TA's who did not have enough knowledge on lecture and be biased grading because of the curve."	there were many resources provided to us to help us succeed in this class. Organization: "This course was strong in that it provided many opportunities to engage with the material such as weekly ALMs and labs relevant to lecture." Grading: "I greatly appreciated the structure and format of this class because I was able to easily follow along and manage my grade with the point system."
Perceived Quality of Course Characteristics; Lecture	"The lack of slides with definitions (to have access to after lecture ended) made it harder to take notes about the concepts." "I liked everything I learned in the lectures, but the curve and worrying about my grade took away my focus from enjoying the material." "All class notes were written on the board, so it motivated me to go to class. However, this became a disadvantage when I had questions, or it was difficult to follow the lecture."	"This was the first class that I was completely engaged in lecture and could pay attention for the whole duration of lecture." "Having posted slides and recordings were extremely helpful for reviewing content. It was also a convenient resource if I ever missed lecture one week." "I really appreciated the practice exams, especially since a lot of professors don't share these for some reason, but it is always a crucial resource."
Perceived Quality of Course Characteristics; ALMs	Not Applicable, not a course component in Fall 2019	ALMs: "The ALM review videos were definitely one of the most helpful things because when I got a

		question wrong, I was not just told the right answer, it was explained why the answer I chose was wrong." ALMs: "ALMs practice scenarios really helped me understand the material and prepare for exams. I also found the reflections each week very helpful in my understanding my learning process." ALMs: "The ALM practice questions and review videos were very helpful when applying lecture material to actual scenarios. I also like (they) were open the whole quarter so we could retest ourselves before exams."
Learner Satisfaction with Course (e.g., perceptions of learning progress, if learned something valuable, mastery of course objectives)	"I wish I was given more feedback during the class to know if I was actually learning the material, beyond just how I did on the exams." "Even though this class was intimidating, I do have a newfound appreciation for unbiased research and what it takes to design a good study." "The content is so important, and I have learned something valuable, but this class appears to have the intention of making students' miserable rather than trying to get them to actually understand the material taught."	"I learned a lot of important material and I understand research methods better than I did before. Because of what I've learned, I can better discern between poorly executed studies and reliable studies." "The course prepared me for critical thinking on research designs and identifying the flaws in my own research as well." "I never thought this was possible, but I loved what we learned I am now considering doing

		research while at university.”
Global Course Ratings; Negative Perceptions	“I had a lot of preconceptions going into this course about its notorious difficulty. Even if the difficulty of the material was manageable, the exams were written to be so tricky, and I felt unprepared for the style in which we were tested…Unfortunately, this class confirmed all my preconceptions.” “I feel like this course was unnecessarily hard… The curve is fine for those who are already succeeding but makes it a lot harder for students like me who are struggling in comparison with my peers.” “There comes a point where (the instructional team) has to realize that stress to this extent isn't beneficial for a student's growth or mental health. This class – the material and content – is not challenging, but the whole experience is so stressful. Hopefully in the future, academia and this class will prioritize student development as opposed to running them into the ground for the sake of a 'challenging' course.”	“I wish there was another way to show my level of mastery on the exams like an added written portion. Multiple choice questions are more difficult for me since I often over think when answering even if I know the concept.” “Having exams where you can’t go back to previous questions deeply inhibited my ability to accurately display my knowledge of the course. There were many times when I made a simple mistake and immediately knew the correct answer but was unable to go back and fix it.” “I learned a lot, this course is very relevant for the career I want to go into, and I felt prepared for exams with all the resources. But the exams were difficult where a lot of the questions felt designed to trick you rather than test your knowledge.”
Global Course Ratings; Positive Perceptions	“Everyone dreads this course, but I thought it was reasonable most of the time. The course as a whole was very demanding, but with dedication of time and effort it is manageable.”	“I have nothing bad to say about this course. I've heard scary things, but none of them applied to me this quarter… I have already recommended my friends to take this

		course as soon as they can because it is not scary, it is actually one of the best classes I have taken at university!" "I never knew that learning about research methods can be fun and engaging, but the instructional team definitely succeeded in showing us this." "I loved this class and the structure of it. I felt like my learning and understanding of course material was prioritized even in such a big class which, honestly, was so refreshing." "I know this class has been changed, and I just wanted to say I really appreciated the entire instructional team and all you have done. All the changes made me feel like a student rather than a number… Thank y'all for creating a great course."
Social-psychological Construct; Self-efficacy (i.e., confidence in and estimation of one's abilities to succeed)	"It seemed as though studying and working hard and understanding course material was not enough to succeed in this course."	"This class definitely increased my self-assessment skills, as I now have more effective studying methods, spacing DOES work!" "Taking all this information in was challenging, but it became manageable by learning how to approach the material.

		Learning how to take better notes, chunking, and spacing are all things I will certainly do in the future because they definitely helped me do well in this course.”
Social-psychological Construct; Social Connectedness (i.e., Learner-Instructor Relationships, Learner-Learner Relationships)	“The nature of the curved class caused students to be very competitive when I would much rather have a cohort of supportive peers who want to help each other. A peer made offensive comments towards me because she saw that I got a better grade than her on an assignment. I wish the curve was not so competitive, so that students would feel more compelled to help each other.”	“The instructor was very helpful and accommodating, and it was obvious everyone on the team cares deeply about their students and our learning.” “What I appreciate and love so much about this class is how much support there is. If students were to ever need help, they have so many sources to reach out to.”

Note. EIP = Evaluation of Instruction Program Online Survey. ALMs = Active Learning Modules.

Qualitative question from EIP online survey asked after students provided ratings was, “Please identify what you perceive to be the real strengths and weaknesses of this course.” In Fall 2019, there were 185 students out of an enrolled 376 (49.20% response rate) who replied to the EIP survey, with 147 opting to provide qualitative feedback. For Fall 2022, there were 88 students out of an enrolled 410 (21.46% response rate) who replied to the EIP survey, with 47 opting to provide qualitative feedback.

Qualitive questions from Student Experience Online Survey after students provided ratings per each subsection was, “Please elaborate on any of your ratings above.” For the overall survey, there were 313 responses of an enrolled 410 (76.34% response rate). In the “Lecture” survey section, 61 students qualitatively elaborated on ratings. In the “ALMs” survey section, 32 students elaborated on ratings via qualitative feedback. In the “Overall Course” section, 18 students qualitatively elaborated on ratings. In the Qualitative Feedback portion of the survey, 91 students replied to the question, “Do you have any additional comments or constructive feedback you would like to provide that will help ease your worries/concerns/stress at this point in the quarter?” after removing feedback such as “N/A” or “No.”

Reviewing student qualitative feedback, the items generally did not result in a rigorous qualitative data set because the qualitative items expanded upon quantitative ratings. However, they did provide interesting quotes validating the quantitative survey findings (Creswell & Plano Clark, 2011). In the pre-redesign course model, the majority of student feedback about the instructional design and perceived quality of course characteristics included negative perceptions about the curved grading scheme, a lack of alignment between lecture and lab, and a need for more accessible support materials in lecture. Considering learner satisfaction if students perceived mastery of course objectives or if they learned something valuable, selected quotations showcased a common pattern. Many students recognized that the presented material was interesting and meaningful, but the course structure often prevented students from fully engaging with the content as desired. Students also expressed an appreciation for small-group work. However, because of the curved grading scheme, many students shared that small-group work did not foster collaboration as intended, rather it promoted unnecessary competition. Although some students found the course to be relatively reasonable in the previous iteration, student global perceptions of the course before the redesign echoed student ratings on the EIP such that the grading scheme unequally impacted disadvantaged students who were struggling to learn the material and that the course caused immense stress for a large portion of students. Overall, students expressed that being engaged, actively participating, and understanding the course material felt like it was all not enough to academically succeed.

Comparatively, student feedback in the post-redesign course model painted an incredibly different picture. The Fall 2022 student feedback showed that students were appreciative of the organization of the course and the support of the instructional team. In particular, the majority of student feedback about perceived quality of course characteristics further elaborated on the importance of the instructional design elements that student ratings suggested had a substantial impact on learning such as accessible lecture slides, recordings of lectures, updated practice exams, and all components of the ALMs, particularly review videos and lecture-based practice scenarios. Student feedback also indicated that many students feel like they learned something valuable with many students specifically naming components of the learning goals they feel capable of executing as a result of their learning progress throughout the course. Some students did note that the wording of exam questions was confusing, the sequential exam format inhibited student ability to accurately display knowledge on exams, and some resources were unnecessarily verbose. However, the overall qualitative feedback further validated findings that the implemented course redesign intervention had a significantly positive impact on overall student experience and learning in comparison with the pre-redesign course model.

Despite the inability to make causal claims due to the nature of the quasi-experimental design, the use of a rigorous mixed methods evaluation approach provided interesting insights into student experiences both before and after the implementation of the course redesign intervention. The quantitative and qualitative analyses of student survey responses showcased the wide range of feedback that undergraduate students experienced in both iterations of the course. However, with the implementation of the ALMs in the course redesign intervention, students described the post-redesign course model to have a more positive impact on the overall student experience in comparison with the pre-redesign course model. Considering the wide variability of learners in our classrooms, the student ratings and feedback illustrated the benefits of blending physical and virtual evidence-based, active learning pedagogical practices in a large enrollment STEM course.

Aim 2: Differential Effect on Course-level Academic Achievement

Addressing the second research aim to elaborate upon student experience data, exam score results from an objective measure of student academic achievement – the non-standardized, instructor-created multiple-choice exam – was analyzed to better understand the impact of student experience factors on academic achievement within the context of this course. Recognizing that student perceptions of a supportive course environment may promote academic success (Zumbrunn et al., 2014), analyses into the impact of implemented course changes on academic achievement were conducted. Despite the implemented course changes fostering an increase in positive student attitudes around teaching and learning, the following analyses were employed to determine if the course changes also academically benefited all students, including students with disabilities.

Two univariate Analysis of Variance (ANOVA) were performed to analyze the effect of phase and disability status on student exam scores at Weeks 5 and 10, the mid-quarter exam and end-of quarter exam respectively. Both two-way ANOVAs were conducted with independent variables of phase (before or after course redesign) and disability status (i.e., registered with the Center for Accessible Education [CAE] or not registered with CAE). Student CAE status was determined by instructor received accommodation letters that were delivered via the university faculty portal directly from the CAE office. Accommodation letters were populated in the faculty portal before each exam to ensure any needed testing accommodations could be administered. In Fall 2019 (Before Redesign), 16 students were registered with CAE (4.23% of enrolled students), and in Fall 2022 (After Redesign), 23 students were registered with CAE (5.61% of enrolled students).

Considering student exam scores on the mid-quarter exam administered in Week 5, a two-way ANOVA was conducted that examined the effect of phase and disability status on Week 5 raw exam scores out of 120 available points. There was a non-significant interaction between the effects of phase and disability status on Week 5 exam scores, $F(1, 782) = 1.15$, p =

.284. Despite the non-significant interaction effect potentially suggesting that students registered with CAE did not experience the predicted benefits of the redesigned course model on the mid-quarter exam, CAE students actually had the largest gains in terms of raw exam scores when compared with their non-CAE peers. In Fall 2019 before the implemented course redesign intervention, non-CAE students (N = 360) reported higher mean exam scores (M = 96.27, SD = 13.11) than peers registered with CAE (M = 92.06, SD = 12.09). However, in Fall 2022 after the implemented course redesign intervention, this was reversed as the students who were registered with CAE (N = 23) reported slightly higher mean exam scores (M = 103.57, SD = 9.78) in comparison to their non-CAE peers (N = 387; M = 102.80, SD = 14.83). Reviewing these mean exam scores, a simple main effect analysis showed that all students, regardless of CAE status, performed significantly better on the Week 5 exam after the implemented course redesign, $F(1, 782) = 15.14$, $p < .001$.

Additionally, a two-way ANOVA was conducted that examined the effect of phase and disability status on the end-of-quarter, Week 10 raw exam scores that were also out of 120 available points. Similar to Week 5 exam scores, there was not a statistically significant interaction between the effects of phase and disability status on Week 10 exam scores, $F(1, 782) = 0.38$, p = .537. However, looking closer at mean exam scores before and after the redesign, in Fall 2019 non-CAE students (N = 360) outperformed their peers registered with CAE (N = 16) such that non-CAE students reported higher mean exam scores (M = 94.13, SD = 14.02) compared with their CAE peers (M = 89.63, SD = 12.34). After the implemented course redesign in Fall 2022, this difference was much smaller where students registered with CAE (N = 23) reported similar mean exam scores (M = 98.35, SD = 11.90) when compared to their non-CAE peers (N = 387; M = 99.97, SD = 14.17). As the end-of-quarter, Week 10 exam is cumulative and covers more complex topics than the mid-quarter, Week 5 exam, it is often more challenging as evidenced by lower mean exam scores for all students both before and after the course redesign. Nevertheless, a simple main effects analysis of phase on Week 10 exam scores showed that all students performed significantly better after the implemented course redesign, regardless of CAE status, $F(1, 782) = 9.70$, $p < .001$.

Above analyses illustrate that the redesigned course model benefited all students enrolled in the course such that all students, regardless of disability status, performed significantly better on both cumulative course exams in the post-redesign course model in comparison with the pre-redesign course model. Even though there was not a significant interaction effect between phase and disability status, students registered with CAE experienced increased academic benefits of the redesigned course model as evidenced by improved mean exam scores after the redesign and in comparison, with mean exam scores of students not registered with CAE. These findings contribute to evidence that inclusive instructional strategies are effective for all students (Dewsbury & Brame, 2019), with particular impact for underrepresented groups including students with disabilities (Freeman et al., 2014; Theobald et al., 2020). Significant improvement in student academic performance in the post-redesigned course model supports the integration of student-centered instructional strategies while also illustrating the relationship between positive student experiences and increased rates of academic achievement within the context of this large enrollment STEM course.

Chapter 5

Discussion

The data provides clear evidence in support of redesigning existing academic courses to integrate evidence-based, student-centered instructional practices, such as online ALMs. Student-centered instructional approaches with goals to improve student experience conditions show subsequent academic achievement in a redesigned course model. More specifically, the use of ALMs in a large enrollment lecture course may be an effective solution for advancing both equity and inclusion in STEM courses. Before the pandemic, undergraduate lecture halls and laboratories provided much of the infrastructure for teaching students in STEM. However, in the post-pandemic educational context, leveraging an online space in conjunction with active learning strategies provide a new horizon for opportunities that positively affect student learning experiences and academic achievement.

Limitations and Future Research

Despite the significant impact of the course redesign intervention on student experiences and academic achievement, the study did have some limitations. The designed study adopted a quasi-experimental framework, as the undergraduate students were not randomly assigned to an enrollment quarter in the course (Mertens, 2020). Students enrolled in the course either before the implementation of the course redesign (Fall 2019) or after the implementation of the course redesign (Fall 2022). Thus, the students being compared at each time point were a different group of students. Because of the quasi-experimental nature of the study, causal conclusions cannot be drawn. However, quasi-experimental designs can be used to answer implementation questions such as those posed in this study in the absence of randomization (Miller et al., 2020).

Further, course evaluation surveys are a commonly used tool in higher education for understanding student experience and if a course is meeting student learning needs (Richardson, 2005; Frick et al., 2009). However, meta-analyses show that student course evaluations of an instructor's teaching effectiveness are often unrelated to student learning. As such, these evaluations are an inadequate assessment tool for evaluating instructor performance (Uttl, White,

& Gonzalez, 2017; Hornstein, 2017). Although analyses removed survey items about a specific instructor's teaching effectiveness and the instructor from before and after the redesign were held constant to account for this, the relationship between an instructor and student experience ratings may be inextricably linked. Even if surveys that evaluate overall course characteristics and student perceived learning gains and attitude shifts can inform the iterative development of course materials (Frick et al., 2010), it is unclear how much student perception of the instructor of record, even if constant across timepoints, does or does not impact student ratings.

Moreover, an institutional-wide strike of graduate student TAs in the final weeks of the post-redesign quarter may have impacted student ratings, feedback, and course exam scores. TAs withheld labor during the strike such that the small-group labs were not held and students did not get feedback on an essential formative assessment. The lab section coupled with TA and small-group feedback on the final lab formative assessment were designed to help students prepare for the end-of-quarter exam and to provide support on the final graded assignment. Consequently, many students expressed concern for their grade on these two items without access to these valuable resources. Although students were instructed to reflect on the overall course and instructional design elements before the strike, it is unclear the level of impact this may have had on student ratings and exam performance. Future comparative analyses in academic quarters where students experienced all content as intended should be conducted.

This student only reviewed measures of student experience and academic achievement within the context of the single course. Larger scale projects that investigate the impact of the ALMs situated within additional STEM subject matters or courses sizes are needed to better understand the conditions for which materials are successfully implemented and relevant pedagogy is supported. Additional research examining if the ALMs were successful in promoting the continued student perceptions of course inclusivity and belonging related to continued retention in the major is also needed.

Finally, although the primary goal of the outlined instructional changes with the inclusion of the desirable difficulties framework (Bjork, 1994) in the ALMs was to facilitate long-term learning (e.g., to create relatively permanent changes in comprehension, understanding, and skills of the types that will support long-term retention and transfer; Bjork & Bjork, 2014), student exam scores – which are arguably a measure of performance, not learning – were used to capture changes in student academic achievement while enrolled in the course. Analyses shoed an impact of the course redesign intervention for all students, including for those with disabilities, indicating the groundwork has been laid for long-term learning in future research. However, longitudinal studies investigating the impact of active learning strategies on the long-term learning that leverage technological components like the ALMs is also needed.

Conclusion

In studying the effectiveness of the ALMs as a student-centered instructional approach, instructional teams may have found an innovative approach to the real-world implementation of evidence-based learning frameworks (i.e., desirable difficulties, UDL) in course redesign interventions. Moreover, the use of ALMs within a course redesign may be an evidence based as well as pragmatic solution to supporting the increasingly diverse undergraduate student population. At a time of shrinking funding for higher education, the ALMs provide both a pedagogically innovative as well as an economically viable approach to supporting student learning experiences and academic outcomes.

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