THE EFFECTS OF ACTIVE LEARNING ON MOTIVATION AND GRADES AMONG A DIVERSE STUDENT POPULATION: MIXED METHODS ACTION RESEARCH OF LARGE, ONLINE, INTRODUCTORY BIOLOGY COURSES

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Dedicated to my husband Jason and our daughter Margo.

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Equity gaps are a persistent problem in education. The literature points to active learning as an effective way to close equity gaps in large undergraduate biology courses. Theorists suggest that active learning increases student motivation. Through mixed methods action research, I explored how my active learning interventions impacted my online students' motivation and grades. Analysis revealed that students come to class inherently motivated, which is further bolstered by active learning and hindered by passive learning. Students were mixed on the importance of peer interaction, although the Skeletal Notes combined with engaging lectures increased student expectancy, and the options in the You-pick Assignments offered enjoyable real-world learning. My students' sense of expectancy and value significantly increased, and their sense of cost significantly decreased after taking my online courses. Among most demographic groups there was little to no significant difference in motivation or grades. There was a significant correlation between students' final grades and their change in value and cost.

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Chapter 1: Introduction

Statement of the Problem

It is the responsibility of educators to create an equitable education system that affords everyone the opportunity to realize their own potential in whatever field they choose. Science in particular is an important field to make accessible to all, with its democratic effect affording students the opportunity to ask questions, make observations, and draw their own conclusions about the world based on their logic without constraint by authority (DeBoer, 2013). Science education has become more accessible in recent history, and it has been posited that economics has largely been a catalyst for this, in order to ensure a well-trained workforce without leaving out potential talent from underrepresented groups (DeBoer, 2013).

It is the responsibility of the institutions to serve the entirety of their diverse population of learners and enable them to succeed. Unfortunately, gaps in rates of scholastic achievement between different demographics still widely persist, including in science classes (Morgan et al., 2016). It is the responsibility of educators to provide instruction and curriculum that best support learning for a diversity of students – from various backgrounds and with various perspectives. Instructors should reflect on their curriculum and instruction to ensure they are not placing unfair obstacles to learning, particularly those that disproportionately effect certain students, and that they are utilizing practices that foster learning for all of their students, not just certain groups.

Equity Gaps in the California State University

Closing equity gaps is a major priority of the California State University (CSU) (Closing the Equity Gap, 2021). The Graduation Initiative 2025 Advisory Committee made recommendations in summer 2021, which the CSU built upon to identify five equity goals and priorities to address the gap: Reengage and reenroll underserved students, expand credit opportunities, access to a digital degree planner, eliminate barriers to graduation, and promote equitable learning and reduce rates of D, F, or W (Withdrawal) grades (DFW rates) (Closing the Equity Gap, 2021). Of these five goals, promoting equitable learning to reduce DFW rates is an intervention instructors can put into practice immediately. As such, methods that have been shown to close gaps should be considered and implemented.

The CSU Student Success Dashboard has the latest data on equity gaps across all CSU campuses. Gaps in graduation rates persist for students who are Underrepresented Minorities, First-generation college students, and Pell Grant eligible. At Cal Poly Pomona, for the 6-year graduation rate of Freshman there is a 14.4 percentage point gap between Underrepresented Minorities (URM) and Non-URM, an 8-percentage point gap between Pell and Non-Pell students, and an 11.8 percentage point gap between First-generation college students and Non-First-generation college students. Interestingly, the gaps are much smaller or even inverted for Transfer students at both Cal Poly Pomona and CSU Dominguez Hills. It would appear that attending community college before transferring to a university is particularly beneficial to these students. Universities should explore the ways that community colleges are better preparing transfer students for their education than they are getting as university freshman admits. Equity gaps also exist within courses, including science courses. For example, in the Fall 2022 Cal Poly class Cell and Molecular Biology, the

average male student GPA was 0.73 points higher than female student, and the average First-Generation student GPA was 0.97 GPA points higher than Not First-Gen student. The gap where Non-URM student average GPA was higher than URM in Fall 2022 courses included a 1.36 GPA gap in the Stars, Galaxies, and Universe; a 1.25 GPA gap in Chemistry in Our World; a 1.24 GPA gap in Age of the Dinosaurs; and a 1.00 GPA gap in the Freshman introductory biology class Energy, Matter, and Info. (Graduation Initiative 2025, 2023)

Repercussions of Equity Gaps

That students gain an understanding of science is critical for society at large. Youth who lack achievement in their science education will one day become adult citizens, and their judgement could be marred by their science illiteracy when they participate in public policy decisions. These inadequacies in scientific understanding among the electorate may have disastrous repercussions on our national economy and the environment (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011). Committees from the National Academies go as far as to call this "storm" of scientific illiteracy "rapidly approaching a Category 5."

The economic benefits of higher education are obvious, such that California graduates with Bachelor's degrees earn a median yearly income of $56,720, which is almost double than the mean of what those with only a high school diploma earn (Zaback et al., 2012). This benefit may be more pronounced for CSU graduates considering the tuition is much lower than private colleges. Not only that, but *not* earning a college degree could be economically disastrous. In January 2020, the national unemployment rate for those with at least a bachelor's degree was 2%. At the same time, the unemployment rate for those with just a High School diploma was 3.7%. But in the wake of the COVID pandemic in April 2020,

it spiked to 17.3% for High School graduates, and a more modest 8.4% for college graduates (Bureau of Labor Statistics, U.S. Department of Labor, 2021).

Nationally, most college students who drop out do so their freshman year; an astounding 24.1% of all first-time, full-time freshman dropped out between Fall 2019 and Fall 2020, according to the National Center for Education Data Statistics (Hanson, 2022). As my Life Science/General Biology classes are freshman-level classes, I believe it is absolutely critical that students feel motivated and able to succeed for them to complete their education.

Among the United States, California is tied for the third highest percentage of the population with some college, but without a degree at 16.1%, and a dropout rate of 30.2%, according to data from the National Student Clearinghouse Research Center (Hanson, 2022). Compared to the average U.S. resident, Californians are 33.6% more likely to be college students, yet 46.5% more likely to be dropouts.

Furthermore, Historically Underrepresented Minorities (HUM) are more likely to drop out: College students with household incomes in the lowest quarter are 79.3% more likely to dropout than students from households with incomes in the highest quarter. The dropout rate for first-generation college students is 23.5% higher than average, and 92.2% higher than non-first-generation college students. The highest dropout rate among ethno-racial demographics is American Indian/Alaskan Native, at 45.1%. Black students are 33.8% more likely to dropout compared to the average college student. And students with disabilities are 58.7% more likely to dropout than students without disabilities (Hanson, 2022).

Practices to Close Equity Gaps

There has been considerable research on teaching practices that have been shown to close student equity gaps between students of historically underrepresented backgrounds (HUB) and students of non-historically underrepresented backgrounds (non-HUB). The vast majority of these studies point to active learning as a means to close equity gaps in large introductory science courses. However, most of these studies are not consistent in examining what types of specific active learning strategies are effective, but instead often compare before and after a class has been converted from traditional lecture type classes to a more active learning approach. This has left a need to explore what teaching strategies specifically are most impactful to students and how they influence students. Furthermore, most studies that I have found on equity gaps only examined student grades as measures of achievement. Most research on equity gaps use large quantitative study designs to focus on what practices work for a general population of students, without using qualitative methods to ask students to share their own thoughts and experiences on what specifically works for them.

Interaction of Motivation on Equity Gaps

Throughout my teaching career, as I have learned and grown as an educator, I have incorporated many types of active learning strategies into my large, online, general biology classes, which, according to the literature, should close equity gaps in my classes. However, there is a dearth of research on *why* certain practices are effective for certain students, particularly my own diverse population of students. I believe the key to understanding the connection between effective teaching practices and student performance (grades), is the influence of these effective teaching practices on student motivation.

While I found a plethora of quantitative research publications comparing different teaching practices and their efficacy at closing equity gaps, the exploration of why these practices work is much more scarce. There is however, a substantial field of work on student motivation in general, particularly its effect on student performance, engagement, and persistence (Elliot et al., 2017). The Persistence Framework, based on social and cognitive psychology, cites confidence (belief in one's own ability) and motivation (deliberation in pursuing goals), in conjunction with active learning and learning communities as pathways for students to learn science; which leads to further confidence and motivation, nurturing students' identity as scientists (Graham et al., 2013). Because active learning and a sense of belonging have likewise been shown to close equity gaps, I believe these two fields (equity gaps and motivation) should be explored together to examine the interactions they have on one another.

I predicted that students who were more motivated to learn biology would earn better grades in my biology class. I also predicted that students would cite active learning as methods that increase their motivation, although I was interested in gaining new insights from what my students shared. I was curious to look for differences in responses among students of various backgrounds, including race, socioeconomic status, first-generation college student status, and gender.

Purpose and Significance of Study

Statement of Purpose

The purpose of this study is to explore the impact that various active learning practices have on the motivation of my students, and to uncover the interactions of student

motivation and class performance (grades) among students of various backgrounds in my online undergraduate biology classes. I explored differences in motivation and grades between students of various races/ethnicities, genders, Pell Grant statuses, and First-generation college student statuses. My goal is to uncover classroom practices that increase student motivation and thusly decrease equity gaps. I expected to learn how specific active learning strategies impact motivation and grades among a diverse student population, and I made suggestions on how to incorporate effective teaching strategies into other classes, with the intent to potentially close equity gaps.

Importance of Action Research on Exploring Equity Gaps

The point of research should be to improve people's lives (Hostetler, 2005). My goal as an educator is to create a learning environment that is accessible, inclusive, and equitable. I want every student to realize not only can they succeed in a science class, but that they *are* scientists and science is for everyone. Despite great progress in equity and social justice in recent years, inequalities nevertheless persist throughout society, and scholars and educators must remain vigilant in creating an education that is equitable to all students. With my passion for improving the learning experience of my own students, an action research dissertation is ideal. With action research, the emphasis is on real-world problem solving within the community for the betterment of society (J. S. Lederman & Lederman, 2015). Even without writing up formal reports, educators can improve their teaching through the cyclical process of action research by proposing changes, engaging in the action, observing the results, reflecting on the action, and proposing new changes again.

Action research, such as this dissertation project, that deeply explores the experiences of students within classrooms can uncover insights that may have been

overlooked by more widescale research. These insights could be used to implement immediate change to improve the learning experience within the local context, having profound impact on the unique population of students.

Necessity of this Dissertation Action Research Project

Demographics paint an extremely generalized portrait of whomever they describe, and often hide the fact that diversity exists within demographic groups, which are far from homogenous. For this reason, we cannot assume that interventions will have the same effect on different groups of ostensibly similar populations, although they may appear demographically similar. The research I found strongly indicates that active learning can help close equity gaps. However, I have not yet systemically researched this in my own classes or campuses, of which our students are diverse, dynamic, and unique. I needed to research my campus student populations to determine what interventions and strategies worked best for their unique situations, and to discover patterns in impact between different demographic groups. While we are privy to ample quantitative data on equity gaps, it is important to understand that students are dynamic, complicated individuals, and for this reason I believe that a mixed method approach that leans towards a qualitative exploration of students' own experiences can help create classes that better serve a wider diversity of students, from an intersection of backgrounds.

Research Questions

In my biology classes, I heavily utilize active learning techniques with the aim to help all of my students succeed in my class and have motivating and meaningful experiences with biology. These practices should theoretically close equity gaps among my

diverse student population. I am interested in exploring the connection between how using these active learning practices influence my students' motivation, and how their motivation and grades differ among my diverse population of students.

Research Question 1: In what ways do my various active learning practices impact my online biology students' motivation?

To answer research question 1, I used qualitative methods to solicit feedback directly from my students from various sources. Using the pre-class and post-class motivation surveys, I asked them to share in their own words what specific things both increase and decrease their motivation to learn biology. By conducting follow-up interviews, I asked my students how our active learning assignments specifically impacted their motivation, including their expectancy, value, and cost to learn biology. I contextualized my students' responses with my own researcher journal, in which I reflected on my own motivation and my students' perceived motivation.

Research Question 2: How does the impact of active learning on motivation and grades differ among my diverse biology student population?

To answer research question 2, I used quantitative methods to look for correlations between motivation and grades between students of various backgrounds including race/ethnicity, gender, Pell-grant status, and First-generation college student status. I integrated my findings using a mixed methodology to gain a deeper understanding of the relationship between student motivation and active learning practices to close equity gaps.

Local Context/Background

The two California State University (CSU) campuses where I teach are incredibly diverse. Both are Hispanic-Serving Institutions (HSIs). CSU Dominguez Hills (CSUDH) is in Carson, CA, centrally located in the greater Los Angeles South Bay region. According to data compiled by University Communications & Marketing, 78.8% of CSUDH undergraduates are from Under-represented Groups, the highest in the CSU system. The student population of CSUDH is 65.5% Hispanic/Latino, 10.8% Black/African American, 7.6% Asian, 6.2% White, 4.8% Non-Resident, 2.7% unknown, 2% two or more races, 0.2% Native Hawaiian/Other Pacific Islander, and 0.1% American Indian/Alaskan Native. 47.5% of undergraduates are First-generation, among the highest in the CSU. 70.7% of students' parents have little or no college, the highest in the CSU. 66.5% are Pell Eligible, among the highest in the CSU. 32.5% of students are all three: First-Generation, Underrepresented Group, and Pell Eligible. CSUDH is ranked first among public universities in California in awarding bachelor's degrees to African Americans (*California State University Dominguez Hills*, 2020).

California State Polytechnic University, Pomona (Cal Poly Pomona or CPP) is located in Pomona, CA on the eastern edge of Los Angeles County, bordering San Bernardino County (The Inland Empire). An HSI, 49% of students are Hispanic, 21% Asian, 15% White, 7% other, 5% International, and 3% Black; and 44% are Pell recipients (Office of Institutional Research, & Planning, and Analytics, 2021). In Fall 2022, 57% of students were First-Generation (Fall Student Characteristics, 2022).

Role of Researcher/Positionality

I am an alum of Cal Poly Pomona – the campus where I teach full-time, and which has felt like my second home for nearly two decades. This campus is also located in my hometown where I have lived my entire life, so in many ways I feel like an insider within my campus. Ways in which I may be an outsider within my student population is that I am White, highly educated, and affluent. Nevertheless, I am an extremely popular instructor among my students. Ways in which I may relate to my students outside of commonly registered demographics is that I have been employed, have cared for family members, and struggled academically during my entire undergraduate education. These personal challenges I experienced as an undergraduate made me an empathetic instructor with a growth mindset, committed to removing barriers to my own students' education.

My goal as a teacher has always been to create accessible, equitable, and inclusive science education that supports all students from a diversity of backgrounds. I pursued a bachelor's in environmental biology because I wanted to create a healthier world for us all. My master's program, where I worked to save endangered native plant species, introduced me to my other life's passion: Teaching. I am now focusing my energy on improving science education, inspiring the next generation to work towards making the world a better place. The coalition of citizen/scientists who work towards a better future should be diverse so that the needs of all are considered. To serve our diverse world, science must be for everyone, and I am devoted to creating learning environments where students are allowed to become the scientists that they always had the potential to be. My goal as a teacher-scholar is to make science education inclusive and accessible to all students from a wide diversity of backgrounds, perspectives, and experiences. My research and teaching methods

utilize student-centered strategies such as active learning, inclusivity, and accessibility to reach every single student. Despite great progress in equity, achievement gaps in science unfortunately persist for students from historically underrepresented backgrounds. My research explored ways to close these gaps and to give all students the opportunity to achieve their goals, improve their lives, and work towards a better future for the world. Fostering an understanding of science in all students and providing the opportunity for them to thrive in their education is why closing equity gaps is a priority for me as an educator and researcher. The goal of my research is to identify ways in which instructors can help students succeed and close achievement gaps for students who are from an intersection of historically underrepresented backgrounds in science.

In my thirteen years of college teaching, I have always prioritized creating relevant and engaging courses that serve the diverse population of my students. My philosophy of teaching is based on the theory of constructivism, where I create classes that value students' perspectives, experiences, and cultures. Accessibility is the foundation of my classes, where I ensure every student has the chance to succeed. I strive to create a class where my students feel capable and included, and I make my classes interesting and relevant to their lives while providing a multitude of opportunities for them to learn and succeed, such as by using a variety of assessments and offering students choices with their assignments. Since starting my teaching career, I have constantly sought input from students and professional development to continuously improve my already exemplary classes. I recently conducted a self-study, examining my instruction through a critical researcher lens (Marin Rothman, 2022b), and I will continue to reflect on and improve my teaching and research throughout my career.

My Teaching Philosophy

My Concept of Learning

I believe that biology education should extend beyond the classroom and lead to improvements in students' lives. It is my duty to inspire the love of science in my students, and to impart upon them that biology is interesting, understandable, and relevant to their lives. I believe in the constructivist theory of learning (McLeod, 2019), valuing the diverse cultural aspects my students bring to the classroom, where I encourage them to reflect on their perspectives and form new knowledge by building upon their own lived experiences.

My Concept of Teaching

Teaching is my calling, and my students are the reason why I love my job. I reach my students through engaging teaching, whether in-person or online, where I employ student-centered and active learning strategies (S. Freeman et al., 2014). These methods are particularly important to my very diverse student population because they can decrease achievement gaps (E. J. Theobald et al., 2020). I encourage my students to think scientifically and continue making their own discoveries after class ends. My goal is to reach every single one of my students, regardless of their learning styles or abilities. I advocate for compassionate teaching by encouraging my colleagues to apply a growth mindset (Williams et al., 2021). Learning cannot progress if students cannot access it, so maximizing accessibility should be at the forefront of course design. I use and extoll Universal Design for Learning to benefit every student from a diversity of abilities (CAST, 2018). For my students to truly think scientifically, they need the confidence to ask

questions. I feel that approachability is key to truly connecting with students, and my friendly, welcoming demeanor lets students feel comfortable asking me questions and open up about any difficulties they may be having with my course. I progress through my lectures by constantly asking my student's questions, which both develops the scientific method and keeps them engaged. It's easy for students to get confused with so much complicated information, and they may have a hard time conceptualizing dynamic concepts. So, I used analogies to make my lecture topics more understandable.

My Goals for Students

I would rather my students develop a deeper understanding of the big picture, which is why I relate all course content to the broader Nature of Science (Abd-El-Khalick et al., 1998) including explicit-reflective instruction and assignments (Akerson et al., 2000). I want my students to broaden their perspective when they come to my class. I challenge their assumptions and combat long-standing misinformation while giving them the perspective to reflect on their values and realize what is important. I regularly strive to pave a culture of inclusion and diversity in every course I teach by incorporating Critical Race Theory and Feminism into my lectures. When studying biology, many people focus on differences; however, I want my students to develop the perspective to focus on what we have in common. Many of my students leave my class much more tolerant and open-minded, and I regularly hear that it is the best class they have ever taken.

My Teaching Methods

My passion for biology education is palpable, and my students come to class excited because I teach with unbridled enthusiasm and use several tools: analogies, storytelling,

compassion, and humor/approachability. I constantly update my courses to make them relevant to current events and relatable to my students' lives. I give my students examples of how to apply what they learn in the classroom into the real world. I use examples of how each topic affects us, expand upon the broader implications it has on our future, and invite students to come up with their own ways that they would have answered the scientific question. I encourage my students to learn from one another by interacting in discussion forums and studying with our class undergraduate Learning Assistants (LAs), which can improve student learning (Sellami et al., 2017). My class has made my students aware of how to lead a healthier and more fulfilling life and strengthen our communities. My students know that I care about each of them. I impress upon my students that we are all interconnected and a part of the same world.

I changed my face-to-face courses into an online asynchronous format, so that students can learn course material on their own time, regardless of other obligations or abilities, and feel comfortable engaging with sensitive content such as in my Human Sexuality class. My lectures are accessible, and they're broken down into numerous short segments, making them easy for students to view and reflect on what they learned.

Assessing Learning

I assess students in a wide variety of ways so that everyone has a chance to learn and grow, regardless of learning style. My students take selected-response exams, respond to essay prompts, reflect on documentaries, submit their reflective lecture notes, engage in discussion with their peers, and select assignments to complete from a variety of options for their "You-pick Assignments." By giving students options for them to select from,

students can step outside their comfort zone on their own terms. Offering students choices in their learning can increase their motivation and learning (Cordova & Lepper, 1996).

Conceptual Framework

Critical Theory

Science, and indeed all aspects of most societies, have historically, and arguably continue to be, andro-, European-, white-, cis-, hetero-centric. With the advent of modern feminism and the civil rights movement in the twentieth century, my foremothers called into question what influence do women have on science, and what influence does science have on women? When we study the history of science and technology, the contributions of men are predominant, so one might assume that women had no influence on science. However, as Harding (1991) emphasizes, women have always been involved in science, whether through their direct participation in contributions or in support of the men conducting (and receiving the credit for) the science. Just as society was built on the backs of the working class, women, too, have been the ones devoting their time to the service of men so that they might spend their time conducting science or other pursuits (Harding, 1991). Harding's assessment that the root of women's lack of equity in science is due to structural obstacles and not any biologically derived personality traits is something I have long purported.

The need for a feminist epistemology arose from the blatant androcentric philosophy we have relied upon for thousands of years. One only has to peruse the faces of the "great philosophers" to realize they are all white men. The concept of what knowledge is has been written by wealthy white men at the exclusion of everyone else since the

inception of philosophy. Feminist standpoint theory holds that both opinions and what we believe to be knowledge is socially situated (Harding, 1991), which is also an aspect of the Nature of Science. Standpoint Theory uniquely claims that social and political discourse can advance collective human knowledge, in contrast to the more common view that politics block scientific advancement (Harding, 2004). I agree with this sentiment, because science does not exist in a vacuum; it is, of course, social imbedded, as this is an aspect of the nature of science. Politics is everything and everything is politics. Those who attempt to separate politics from anything else, I have noticed, just want to maintain the status quo. The first aim Harding lists is that the aim of Standpoint Theory is to, what she calls, "study up," which means to attempt to explain how the social structure of *society* works and influences those at the "bottom" of the social hierarchy, instead of trying to explain the behaviors of underprivileged as if they were in a vacuum (2004). The goal is to uncover how the current and former power structure functions in its framework of oppressing certain groups while maintaining the power for other groups. The second feature she mentions, related to the first, is how it looks for insights in how the hierarchical social structure functions. The third, again, related, feature is how it attempts to uncover how insights of oppressed people have been manipulated through being a part of the oppressive social structure.

Limitations of Study

This action research study, by its very nature, is a study of my own students taking my classes. While action research has faced its share of criticism, as all research methodologies have, it can nevertheless be an incredibly powerful tool to improve the learning experiences of students. This action research study only examined my own

students taking my online biology classes, so the results may not be generalizable to students throughout the world. However, my student population is very diverse, so my results may thusly be more impactful than wider studies that are nonetheless more limited in diversity of students. Furthermore, this research revealed my students' individual experiences that may have been previously overlooked.

Definitions of Relevant Terms

Motivation

Student motivation is an expansive field of study. In this dissertation research project, I measured three aspects of student motivation: expectancy – whether students believe they are capable of successfully learning and succeeding in biology; value – whether students believe biology is worth learning; and cost – limitations (in time, energy, or other resources) that students feel they must expend to learn and succeed in biology (Barron et al., 2017; Getty et al., 2021).

Equity Gaps

Equity, or achievement, gaps are widely understood to be disparities in achievement, or academic performance, between different groups of students, such as those grouped by race or ethnicity (National Center for Education Statistics, 2022). As a Feminist and Critical Race Theorist, I hold that these disparities are perpetuated by the institutions themselves, and that educational reform is necessary to reevaluate how students are both taught and assessed. Furthermore, placing white performance as a goal for minorities to achieve perpetuates racism and white supremacy (Brown McNair, 2021). Nevertheless, these disparate measurements of performance can have long-lasting consequences, such as

completing degrees or when graduate schools or employers use them as measurements for admittance or hiring, adding further barriers and hindering certain students' chances of success and decreasing earning potential.

Active Learning

Active learning engages students in the learning process through activities and/or collaboration, as opposed to didactic lecturing that assumes students passively absorb knowledge. The Cornell University Center for Teaching Innovation summarizes a variety of active learning techniques, which they roughly break down into either in-class activities or collaborative tools for use outside of class. In-class activities include Think-Pair-Share/Write-Pair-Share, Minute paper, Catch up, Brainstorming, Problem solving/Case study, Making predictions, Concept mapping, Drawing/Diagramming, Worksheet, Close reading & Visual analysis, Writing prompts, Peer review, and Polling. Collaborative tools for use outside of class include Social annotation and Discussions (Center for Teaching Innovation, 2023). Study groups and Peer Learning Assistants are another form of student collaboration. Research has shown that interacting with one's peers can facilitate student learning (Tenenbaum et al., 2019), particularly with student understanding of science (Ford & Forman, 2006).

Organization of this Dissertation

In the next chapter (Chapter 2: Literature Review) I have shared studies by other researchers that have explored curriculum and instructional methods which may close equity gaps between students from historically underrepresented backgrounds (HUB) and students from non-historically underrepresented backgrounds (non-HUB) in classes

similar to mine that are large, undergraduate, introductory biology courses. The research largely points to active learning as effective ways to close these gaps. Through my review of the literature, I found that active learning were particularly effective in closing these equity gaps in large undergraduate introductory biology courses.

I appreciate the multiple perspectives a mixed method study offers. While my literature review resulted in few examples of mixed methodology research studies, I feel that it could be particularly insightful to the topic of closing equity gaps, due to the exploring of the unique experiences of each individual student that qualitative research affords, and the wider need for generalized quantitative research to make conclusions and recommendations for other classes. In Chapter 3: Methodology I outline how I conducted this action research dissertation project. I used quantitative methods to explore the research question "What effect does motivation have on equity gaps?" I used qualitative methods to explore the research question "What teaching practices influence my students' motivation?" I integrated these findings to gain a better understanding of the experiences of my students.

I share my findings of this research in Chapter 4: Results. There I present the results of my data collection and analysis, presented in order of research question. My dissertation concludes with Chapter 5: Discussion. There I synthesize the results of my data analysis, form conclusions based on the available data, and make suggestions for future instructors and researchers.

Chapter 2: Literature Review

Introduction

My goal as an educator is to give every student the opportunity to learn and succeed, regardless of their background. In fact, as a constructivist, I see my students' unique experiences as assets that they can bring to the classroom to help all of us learn. As a Critical Race Theorist, I believe that discrepancies in perceived academic performance between different groups of students (equity gaps) are perpetuated by the very institutions instructing and assessing them. To better myself as an educator, I have researched methods that better facilitate student learning and close equity gaps and implemented them in my own classes. I extrapolate on my theoretical framework in the next section of this chapter.

In this literature review chapter, I share my findings of the literature on curriculum and instructional methods that have been shown through peer-reviewed research to close equity gaps. I contextualize this issue within my own teaching environment in two California State University (CSU) campuses. The overwhelming majority of the literature credits active learning as means to close equity gaps. In this chapter I share research on active learning, including quantitative studies, qualitative studies, and mixed methods studies. The section on quantitative studies of active learning includes studies of student performance in class, meta-studies, and studies of learning assistants/peer support specifically.

Research suggests that the reason why active learning are beneficial to students is that they increase student motivation, which in turn helps them persist in science. I have extrapolated from this to suggest that the reason why active learning is effective at closing equity gaps is because it bolsters student confidence, thus increasing student motivation,

which in turn helps them identify as scientists in spite of being underrepresented within the field. Following the section on literature that explores how and whether curriculum and instruction strategies close equity gaps, I share my review of the literature on student motivation.

While the literature points towards active learning to close equity gaps, there is little exploration of specifically which of the many strategies are most effective. Because I rely on several different active learning interventions, for this dissertation research I asked my student themselves how each intervention impacted their motivation them to learn biology.

Theoretical Framework

Critical Theory

The lens with which I view my research is through Critical Theory (Graham et al., 2013; Horkheimer, 1976). I critique the assumptions and status quo of society that has placed burdens to science education on students of historically unrepresented backgrounds (HUBs), including women, people of color, first-generation college students, and the socioeconomically disadvantaged (Harding, 1991). In my research I aimed to explain how equity gaps exist and share practical ways to ameliorate these inequities among students (Horkheimer, 1972).

In the natural world, biology tells us that diversity is stability. While the academy delineates the natural and the social sciences, humans are a part of both realms. It's not difficult to extrapolate that diversity should incur benefits to a social situation as well as to the natural world. We are diverse in many wonderful ways, and yet historically and currently, some groups benefit from the arbitrary social order while others are alienated

from the benefits of society such as a quality science education. Research that explores this phenomenon is necessary so that changes may be made to encourage the entire spectrum of humanity to participate in the community of science. Not least of which so that science progresses towards benefiting all of humanity, not just certain groups at the expense of others.

For science to benefit a diverse society, we should constantly ask who benefits from science, who gets to define science, and who gets to be a scientist. Despite recent progress, there is still important work to be done on researching equity for diverse students in science education. As suggested by Buck, Cross Francis, and Wilkins-Yel, the future direction of this work needs to consider the contemporary research in equity interventions, the shift in how we define and understand diversity, and how society as a whole changes with time (Buck et al., 2020). I believe this will be a never-ending task considering the constantly changing and dynamic nature of humanity, but it is a labor we must undertake to create a peaceful society that benefits from science.

There are two schools of thought in the nature of knowledge in science education. Universalism is the belief in only one set of rules that govern science, in a vacuum devoid of culture; it is reminiscent of the science I learned when I was very young and is probably the way it has been taught for a long time. When people say culture has no place in something, they really mean culture that is "other," ignoring the fact that White, Eurocentric is a culture in itself, instead seeing it as the "norm" and everything else as "the other." This just sounds patently racist and ignorant in my opinion. In contrast with universalism, multiculturalism views science as socially and culturally constructed, in agreement with the aspects of the Nature of Science. This way of thinking recognizes the multiple alternative worldviews,

which I incorporate in my classes, particularly when teaching native ecology and farming practices. Drawing from postcolonial theory, cultural hybridity and third space blends school science with culture to create a new inclusive space, recognizing different knowledge that influence how we learn, allowing the new construction of knowledge (McKinley & Gan, 2014).

Who is a Scientist? In asking students to envision who a scientist is, can they envision themselves? Historically, science was conducted by and benefited wealthy, European, white, men. Students who are not part of this demographic of what society views as a stereotypical scientist may not see themselves as scientist, even if they have an interest. Buck, Cross Francis, and Wilkins-Yel (2020) explained this disconnect between science ability, interest, and career choice with girls as a result of the internalization of society's gender expectations (p. 6-7). This may be ameliorated by diversifying representation of scientists in both school and media. In the classroom, Buck, Chinn and Upadhyay found that science identities develop with engaging, meaningful experiences, that connect their home identities they have to their growing identities of competent learners of science (Buck et al., 2023). Furthermore, the contributions of diverse scientists have often been underplayed or ignored by society. However, women and minorities have always been involved in science, as Harding (1991) emphasizes, whether through their direct participation in contributions or in support of the men conducting (and receiving the credit for) the science. Our society was built on the backs of the working class, women, and minorities, and this extends to the field of science as well, where wealthy white men have had the time and money to pursue their education (pp. 25-28). Students should be made aware of the contributions of diverse people to science historically and presently. Not least

of which because credit should be given, but also so that students may see themselves as scientists.

Funds of Knowledge or the Cognitive Perspective of Constructivism. Science is the pursuit of knowledge. But who decides what knowledge is? The field of epistemology (the theory of knowledge) has been written by and for wealthy, white men for millennia. Harding (1991) describes new feminist epistemologies to diverge from the blatant androcentric philosophy we have relied upon for thousands of years (p. 150-137). Teachers of science may need to reframe their thinking of what kind of knowledge is valuable and consider that other types of knowledge exist outside the ubiquitous androcentric philosophy that has shaped society. Parsons posits that the erroneous belief that science is universal (when in truth it has been written by and for one particular group) has been used to marginalize and discredit scientific views from other cultures (Parsons, 2014). Teachers should see their students' wisdom or knowledge that they bring to the class from their own experiences and cultures as an asset that can further be used to help them relate to the course content. The theory of constructivism holds that students learn by constructing their own meaning by building upon what they already know. I am in agreement with many researchers, including Parsons (2014), that teachers should see their students' funds of knowledge and cultural understandings as assets, not something that they must break from in favor of a Western scientific understanding. Welcoming and embracing students' funds of knowledge helps students foster intimate and meaningful connections to each other and to science (Buck et al., 2023).

Why do Inequities Exist? Causes of Achievement Gaps. Achievement gaps exist. These discrepancies exist because of barriers put in place within the classroom, not due to

different demographics' innate affinity for STEM fields. The cause of these differences in performance between groups of students must be explored to close the gaps. Because no group is better or worse suited to learning science, the gaps must be due to barriers put in place in society, in the classroom, or on the assessment itself. Because these barriers are constructed, they can be dismantled. By employing instruction and curriculum strategies such as Universal Design for Learning (UDL), teachers can "teach to the margins" instead of to the average student, reaching a greater diversity of types of learners. Science classrooms especially could be improved with UDL, due to the ableism inherent in many laboratories and the ubiquitous equity gaps in science (McGinnis & Kahn, 2014). I share the same beliefs expressed by Harding (1991) that the lack of equity in science is due to structural obstacles and not any biologically derived personality traits. In fact, much of the research in diverse science education explores equity gaps between groups that have no biological differences, but instead are social constructs, particularly race, but also to an extent gender. Parsons (2014) found that many of these studies ignored the historical and generational experiences of BIPOC populations (pp. 179-180). Closing these gaps must be undertaken at the classroom level to remove obstacles to learning and create fair assessments, but also at the wider societal level to remove structures of oppression.

How Do We Influence One Another? Science Education as a Community Effort. Science education is not limited to the classroom. Inquiry and discovery, the hallmarks of science, begin in infancy, well before science is taught in school. Furthermore, students' perceptions of science are influenced by their families, friends, and communities. Researchers need to think outside the box (and outside the classroom) in their investigation. Buck, Cross Francis, and Wilkins-Yel (2020) looked beyond science education

in school and examined the dynamic connections between student achievement and choice, self-efficacy, stereotypes and STEM identity, support and resources, and sociocultural marginalization within communities (pp. 7-10). Science is a community effort, and it doesn't exist in a vacuum. Alienating certain groups is not only an injustice to the excluded but is a disservice to all. McGinnis and Kahn (2014) found that inclusion of students with disabilities in general education classes benefits all students (p. 229) and that to serve diverse learners general and special educators must collaborate to fairly teach heterogeneous groups of students (p. 228). Furthermore, we should question who science serves and who benefits from science. Harding (1991) argues that if science-as-we-know-it benefits certain members of society at the expense of others (or their outright exploitation), then instead of trying to diversify who is working in that industry, women should change the field of science itself. She argues that instead perhaps we should dismantle the bigoted field itself and replace it with a superior, inclusive institution that better serves humanity (pp. 57-60).

Active Learning to Close Equity Gaps

My exhaustive exploration of the literature on practices to close equity gaps in large, introductory college biology courses revealed an overwhelming consensus that active learning led to minimizing of gaps in achievement between historically underrepresented students and non-historically underrepresented students. I shared my findings on studies that examined active learning strategies as a means to close equity gaps, including quantitative studies of student performance in class, meta-studies, and learning

assistants/peer support; qualitative studies on instructor implementation; and mixed method studies.

Quantitative Studies

Closing achievement gaps between underrepresented minority (URM) and non-URM students, especially in STEM, as well as fostering a sense of belonging in our students are major goals of my diverse campus. Studies that explore the effect that a particular intervention, such as active leaning, had on student performance can offer insights in how to close achievement gaps at other campuses. The authors of a quantitative study examined the effect that the transition from traditional instruction to active learning had on URM and non-URM students in a large introductory STEM course at an elite campus (Ballen et al., 2017). They examined student academic performance, science self-efficacy, and sense of social belonging. When instruction utilized active learning, it closed the achievement gaps between URM and non-URM students, confirming the authors' hypothesis that active learning disproportionality benefits URM students, who also noted an increase in social belonging. However, all students, both URM and non-URM, showed an increase in science self-efficacy with active learning. The demographics of the students in the study were quite diverse, with a good representation from different races for both URM and non-URM groups. This study examined courses from one particular elite campus, where I would expect students to already be well-prepared, so their findings might not be as applicable to other campuses (Ballen et al., 2017).

The authors of another study sought to discover ways to close achievement gaps in STEM courses by utilizing teaching strategies that benefit students from disadvantaged backgrounds who are at higher risk of failing (Haak et al., 2011). While most studies I found

were published in education journals, this was published in *Science*, where I am glad scientists will be exposed to evidence-based teaching strategies, especially considering most science professors receive little to no training in pedagogy. The authors found that highly structured introductory biology classes that used active learning strategies such as regular problem-solving decreased the achievement gap between disadvantaged and non-disadvantaged students, but also increased the performance of all students (Haak et al., 2011). Active learning can help students succeed by closing the achievement gap while still benefiting all students. It may seem obvious, but it's important to see the big picture and not focus just on closing the equity gap, but closing it upwards, elevating the success of students. For example, an intervention that lowers the achievement of one group may technically close the gap, but not actually benefit anyone while hurting some, so quantitative measurements that simply focus on closing the gap may not actually indicate improvement.

Faculty or administrators may consider developing or adapting their own student-centered curriculum as a means to improve student learning outcomes. The authors of a study explored the effects of their Technology-Assisted Guided Learning (TAGL) which they designed to help undergraduate chemistry students at a community college (Lou & Jaeggi, 2020). This study would be useful to anyone considering developing or adapting their own student-centered curriculum. They compared their TAGL approach with other active control learning interventions, traditional instruction, and the Khan Academy learning platform. The authors found that students in the TAGL group scored higher than the other groups, and the TAGL intervention eliminated the achievement gap between students with low or high prior knowledge. Notably, they found that prior-knowledge activation was

especially helpful when students had low prior knowledge (Lou & Jaeggi, 2020). The other studies on the topic I have found all explore university students, whereas the authors of this paper explore community college students. I assume this is because instructors who are more likely to conduct research on the topic are more likely to work at universities, whereas community college professors have no research obligations. Community college students seem like a relatively unexplored group of participants I should explore in my own future research. I am not currently teaching at a community college, but I am still an employee of Mt. San Antonio College. I could definitely see myself working with community colleges to conduct research, particularly Mt. SAC from which many Cal Poly Pomona students transfer.

Peer learning has been shown to be a particular effective form of active learning in science classes. In a study of peer discussion during clicker questions, students increased their conceptual understanding even if their groups were not certain of the answer (Smith et al., 2009). Just by discussing the questions with their peers and working out the problems together increased understanding better than just having the correct answer explained to them.

Quantitative measures of student performance such as grades or graduation rates are an extremely rich source of data considering the shear multitude of students and immediate access of the information. While grades themselves do not paint the whole picture of student success, they are an easy measurement to make. Furthermore, grades are an indicator of student future success, due to the circular reasoning that people believe they are an indicator of success in of themselves. For this reason, likening student grades as a measurement of achievement is a fair assumption.

A meta study would be useful to know the effects of active learning on a multitude of different courses. The authors of a quantitative study conducted a meta-analysis of 225 studies comparing student performance in undergraduate STEM courses taught via traditional lecturing versus active learning (S. Freeman et al., 2014). This was the largest meta-analysis of undergraduate STEM education at the time of publication. Through statistical analysis, the authors concluded that students performed better under active learning and likewise were more likely to fail under traditional lecturing. This effect was seen in various class sizes, although the effect was greatest with smaller class sizes. I appreciate the work that goes into a meta study, and the authors analyzed an incredible amount of data. Although the authors had to generalize what active learning actually means, since they compared classes that used active learning strategies in a variety of ways, not one single way (S. Freeman et al., 2014). This was one of the few meta studies I found on the topic, which I was little surprised by. While most studies I found were published in education journals, this was published in *PNAS*, where I am glad scientists will be exposed to evidence-based teaching strategies, especially considering most science professors receive no training in pedagogy.

The authors of a more recent enormous quantitative meta-analysis study examined the achievement gaps between underrepresented and non-UR students in STEM classes that were conducted the traditional lecture model versus with active learning (E. J. Theobald et al., 2020). For data on exam scores, the authors used data from 15 studies on over 9 thousand students, and for data on failure rates, the authors used data from 26 studies of over 44 thousand students. Through statistical analysis of the compiled data, the authors found that the achievement and passing rate gaps between underrepresented and

non-UR students decreased with active learning, but only in classes that used high-intensity active learning activities during class (E. J. Theobald et al., 2020). This study is useful to myself and others interested in reducing achievement gaps between underrepresented and non-URM students through alternative modes of instruction, in this case active learning.

I do appreciate that meta studies give us a broader perspective, and compliment other, more focused research within the field. Whereas qualitative or quantitative action research studies on single classes is undoubtably important and add valuable insights to the field, meta studies such as these further add to the literature by taking a different perspective of multiple studies. I think it's important that a wide variety of research methodologies be used to examine the issue from multiple perspectives and give us a richer understanding of the dynamic situation.

Learning assistants/Peer Support

Cal Poly Pomona utilizes a Biology Learning Assistant (LA) program in which undergraduates are employed to provide peer support in courses, including my large introductory Life Science courses. LAs provide office hours for students to seek help and tutoring with class, create study guides, and offer peer encouragement to students. CSUDH, where I teach the same class, does not currently employ LAs.

Learning Assistants can have a positive impact on student success in STEM, irrespective of race (Alzen et al., 2018). A large, quantitative study of predominantly White students showed that incoming college students in any sort of STEM gateway course who received support from undergraduate LAs were less likely to fail in their subsequent STEM gateway courses than students who did not receive support from LAs (Alzen et al., 2018). The authors conducted a thorough literature review of the topics of Learning Assistants and

retention rates of gateway STEM courses. The authors were able to conduct a large, quantitative study using a large amount of data, and were able to compare with statistics the failure rates of students who had and had not been exposed to LAs. However, there were probably confounding variables that could have affected failure rates, such as class size. Furthermore, it may not be possible to say if the rates were affected by the LA exposure or the additional time students spent studying. The student demographics of the campus where the study was conducted is for the vast majority white, unlike my own campuses. This study adds to the literature on Learning Assistants by providing a large, quantitative study on incoming college students taking gateway STEM courses. This study is useful to teacher/researchers who are interested in implementing Learning Assistants for their STEM classes.

Peer-tutoring can be an effective intervention for students who underperform on the outset of class (Batz et al., 2015). The authors of a quantitative study examined the effectiveness of peer-tutoring to help undergraduate students who were struggling in an introductory biology course. These "struggling" students had received low scores on their first exam of this first semester course and were invited to participate in the peer tutoring services. Of the struggling students, about a third accepted the peer tutoring. The authors had three large, delineated groups to compare: non-struggling, struggling accepted peer tutoring, and struggling declined peer tutoring. The authors found that the students who regularly received peer tutoring demonstrated in improved exam scores, improved perceptions of biology, and were more likely to continue their studies than struggling students who did not receive tutoring (Batz et al., 2015). The study was well designed, but the demographics of the students were not very diverse and may not be generalizable to my

own campus. This 8-year-old study examined the effects of peer-tutoring, a precursor to the currently common Learning Assistants model employed in many introductory biology courses lately, including Cal Poly Pomona. The authors utilized quantitative methods as a nice compliment to other studies with similar goals but who use qualitative methods. This study could be useful to faculty planning to implement their own peer-tutoring/learning assistant services in their department specifically targeting students who are struggling in their introductory biology courses.

The authors of a study examined the effects of collaborative active learning among peers through Peer-Led Team Learning (PLTL), on the achievement of underrepresented minority (URM) students in an introductory undergraduate biology course (Snyder et al., 2016). The authors noted a decrease in the achievement gap, mostly due to the decrease in the number of URM students failing to pass or continue with the course (Snyder et al., 2016). This study would be beneficial to anyone interested in closing achievement gaps for the URM students on their campus.

Where authors attempted to eliminate confounding variables by comparing classes with and without LAs, while not simultaneously comparing active learning versus traditional teaching, LAs specifically appear to improve student learning (Sellami et al., 2017). The authors of this study compared student achievement in highly structured, flipped (HSF) large-enrollment introductory molecular biology course classes that were either supported by learning assistants (LAs) or not to determine the effects that LAs specifically had on the students, not just active learning in general. The authors found that students who were supported by LAs scored better on exam questions, particularly on questions requiring higher-order cognitive skills, the types of which LAs were specifically

trained to help with. Interestingly, underrepresented minority (URM) students received the most benefits from LAs, giving additional credence to the practice of using LAs at diverse campuses in particular as a means to close achievement gaps (Sellami et al., 2017). Like many recent studies, the authors of this paper focused on a Learning Assistant program on their campus. Unlike many papers, the authors tried to distinguish the influence of the LAs specifically with that of active learning. This study would be useful to anyone seeking support for a LA program on their campus and who need to show that the LA themselves improve student achievement, not just active learning alone. Since I teach three identical (online asynchronous) sections of Life Science at Cal Poly, I may be able to conduct a similar study where, for example, my LA is involved in two section but not the third.

An extensive quantitative study of over 2,000 undergraduate STEM students (half biology) used surveys to examine the effect that interacting with Learning Assistants had on two aspects of student learning: both the cognitive perspective of metacognitive awareness (MA) as a predictor of course performance and also the affective perspective of disciplinary identity (DI) as a predictor of persistence in the discipline (Kornreich-Leshem et al., 2022). The authors found that active and collaborative learning, such as interacting with their peers and LAs, increased student both metacognitive awareness and disciplinary identity. The survey used included interesting questions to paint a broader picture, such as high school GPA, last grade in high school math, and family support of their interest in science, which I thought added to a richer story of student experience. Three-fourths of the students in the study were Hispanic and half were students in biology classes, so this study was similar to my student population. A study of this kind could be beneficial to those

exploring the effect of active, collaborative, and/or social interactions on student learning, especially in STEM classes (Kornreich-Leshem et al., 2022).

Not only grades in the current course, but also long-term benefits may be conferred to students who have collaborated with peers to study course content (Kudish et al., 2016). In one study, the authors examined the performance and achievement outcomes on students in an introductory biology course after their participation in peer collaboration study group meetings, comparing the effects on underrepresented minorities (URM) with non-underrepresented minorities (URM). Interestingly, while the gap between URM and non-URMs only narrowed slightly, if at all, in terms of grades, URMs nevertheless persisted in their pursuit of biological studies, graduating with degrees in biology and enrolling in graduate degree programs at the same or higher rates than non-URM, demonstrating the difference in performance gap with achievement gap (Kudish et al., 2016). Researchers should take into consideration other measurements of success other than just grades in their study of the influence of interventions on student outcomes. However, there may be confounding variables in this study since the students in this study were already from an elite university and participated in numerous kinds of support. Whereas most studies I have read examine the immediate effects of the intervention, usually student grades in the particular class, the authors of this study collected data for years, giving a broader view of the effect of the study group intervention on student achievement and persistence in biology. This study would be useful to anyone researching the outcomes of student participation in active learning, or peer or Learning Assistant collaboration, particularly in students studying biology. However, this university is unlike my own, particularly in terms

of acceptance and graduation rates, and therefor while it's a quantitative study, may not be generalizable to my own student population.

The focus on closing achievement gaps should include both short-term outcomes, such as grades, but also long-term outcomes, such as student persistence in science. The authors of a study at UCLA compared the achievement and persistence rates in underrepresented minority students who participated or did not participate in an academic support program specifically for science majors from underrepresented backgrounds: the Program for Excellence in Education and Research in the Sciences (PEERS) (Toven-Lindsey et al., 2015). The authors found that students who participated in PEERS scored better on introductory courses, had higher GPAs, completed more science courses and where less likely to change out of their science majors compared to students who did not participate in PEERS. There exist confounding variables such as that students who are more likely to participate in PEERS may be more motivated to succeed anyways and may be more likely to seek out other resources and support that could result in better outcomes (Toven-Lindsey et al., 2015). There is also a conflict of interest because the authors also work for UCLA. Nevertheless, the study is thorough and well-designed, taking into consideration many factors. While many studies on the topic are action research where the authors examine student achievement in a particular class, the authors of this study examined students who participated in a particular program on the UCLA campus, following the students throughout their college careers. This study would be beneficial to anyone looking for ways to close achievement gaps for underrepresented minorities in science and increase their persistence in science majors. This study explores a campus-wide intervention that may be of interest to faculty looking to implement programs serving many students, such as I might

be involved with as a Faculty Fellow with Cal Poly's Center for Excellence in Math and Science Teaching (CEMaST).

There are a large number of studies examining the ways to close achievement gaps for historically underrepresented students in college science classes. That active learning can improve overall student performance, particularly among minority students, was a common finding. Considering the large portion of my students at my campuses who are underrepresented minorities, first-generation, and Pell eligible, I think implementing active learning has a positive effect on our students and could help close equity gaps.

Qualitative Studies on Instructor Implementation

One could assume that in order for students to experience active learning in their classrooms, the instructors would by necessity need pedagogical knowledge of active learning. However, many college STEM instructors receive little to no training in teaching. Fortunately, campuses often have ample opportunity for professional development and collaboration with departments dedicated to improving STEM education.

The authors of a large qualitative study investigated the pedagogical knowledge that 77 college biology instructors used in their large undergraduate classes (Auerbach & Andrews, 2018). The authors built a framework of knowledge for active learning instruction based on the collective thinking of their participants. The authors identified seven components of pedagogical knowledge in the biology instructor participants. Those instructors who reported using active learning displayed knowledge of educational principles such as how people learn, classroom management, and practical strategies (Auerbach & Andrews, 2018). Although this is a qualitative research study, the authors examined a large number of participants (77) an impressive feat. This study looked at

college instructors similar to myself, who teach large biology courses, but it could probably also apply to other instructors of other STEM courses. While some studies examined students, this one examined the instructors. This study would be useful to those interested in how instructor pedagogical knowledge influences how they teach and also whether instructors even have any pedagogical knowledge at all, perhaps assessing the effectiveness of professional development.

In an in-depth qualitative study, the authors sought to understand and describe how thirteen college biology instructors of large classes use both their pedagogical content knowledge and their pedagogical knowledge to design and implement active learning opportunities for their students (Andrews et al., 2019). Unlike many other studies, the authors of this paper explored the pedagogical knowledge of the instructors themselves, instead of the content knowledge of their students. The authors found that the instructors who utilized generative instruction drew from their pedagogical knowledge to create lessons focused on students generating on reasoning and integrated their pedagogical content knowledge with their pedagogical knowledge in order to plan lessons (Andrews et al., 2019). Typical of qualitative research, the authors did a deep dive, focusing on just thirteen instructors. This study was relevant to my research interests, as it explores active learning in large biology classes, such as what I teach. It would be helpful to anyone seeking a better understanding of the instructor's perspective and their understanding of what active learning actually entails.

Students and instructors are two sides of the issue of education. It would be unwise to study one at the expense of the other. While there are numerous quantitative studies examining student performance as a measurement of effective teaching, so too is it

important to consider the instructors themselves, who are the source of the education. This seems obvious, and yet studies focused on instructors were not nearly as common in my literature review. It would seem this is an under-studied area of this issue, and an opportunity for future research.

Mixed method Studies

Since instructors are the ones providing the education and administering the assessments, studies that examine instructors may offer deeper insights into how gaps can be closed. An important strategy may be to implement wide-scale change through supporting professors and providing instruction to them for how to teach effectively in ways that may impact diverse student populations. In a newly published quantitative research study, the authors examined the effects on students after science and math instructors participated in the Collaborative for Institutionalizing Scientific Learning (CISL) professional development program, which encouraged teacher/scholars to adopt evidence-based student-centered teaching practices at a large Hispanic-serving institution, similar to my own campus (Biswas et al., 2022). The authors compared student outcomes from those who took a class of a scholar of the program with those who did not. Passing rates were higher for students who enrolled in courses where their instructor participated in the CISL program. This was a huge effort on everyone involved and it appears to have made a positive impact on a large number of courses. The authors used a lot of quantitative data to make generalizations about the effect of the program on student outcomes. I appreciate that they also surveyed the teacher/scholars to dig deeper into their experience and provide even more meaningful data (Biswas et al., 2022).

The largest study of its kind that I found used data from 2,873 students across 73 introductory STEM courses from a diversity of colleges (Gasiewski et al., 2012). The authors of this enormous mixed method study sought to gain a deep understanding of how teaching methods in introductory science courses effect student engagement, with the assumption that lack of engagement leads to attrition. I appreciate the use of mixed methods to use multiple perspectives to create a dynamic picture. Unlike many studies, the authors sought insight directly from the students themselves. Through data from surveys and focus groups, the authors concluded that students were more engaged if their instructor was open to student question and took personal responsibility for student learning. Students were more likely to be engaged when they felt comfortable asking questions, attended tutoring and extra instruction, and worked with their classmates (Gasiewski et al., 2012).

There appears to be a dearth of research on equity gaps that employ mixed methods approaches. That I limited my literature review to research within science classes may explain the overwhelming reliance on quantitative methods, as many of the researchers work within the field of natural sciences and were conducting discipline-based education research. I think a mixed method study on science classes, employing both the quantitative methods of the natural science and the qualitative methods of the social sciences could uncover a great deal about students' experiences and provide insight to improve other classes in the future.

Motivation

Maslow's Theory of Human Motivation states that motivation is achieved through meeting five basic needs: psychological, safety, social, esteem, and self-actualization (Maslow, 1943). In an extrapolation of this theory, by ensuring that students feel supported, safe, included, capable, and able to see themselves as scientists, I can assume that they will feel motivated to learn and succeed in their science classes.

Student Motivation

The importance of motivation specifically in students' success is likewise well-documented. As cited by Getty, Barron, and Hulleman (2021) much research has shown the importance of motivation to students' achievement, engagement, and persistence in education (Elliot et al., 2017; Pintrich, 2003; Stipek, 2002). Researchers on student motivation recommend instructors adopt the Expectancy-Value-Cost framework of motivation for their students. This framework suggests that instructors can motivate their students in their classes by facilitating attitudes in their students that they can expect themselves to successfully complete a task, see value in that task, and have minimal costs that would prevent them from engaging in said task (S. Getty et al., 2021). By bolstering my students' confidence that they can succeed in their biology class, that learning biology is valuable to their lives, and removing obstacles to their learning and succeeding in my class, they should be highly motivated and excel in my class.

The Persistence Framework, based on social and cognitive psychology, cites confidence (belief in one's own ability) and motivation (deliberation in pursuing goals), in conjunction with active learning and learning communities as pathways for students to learn science; which leads to further confidence and motivation, nurturing students'

identity as scientists (Graham et al., 2013). Because active learning and a sense of belonging have likewise been shown to close equity gaps, I believe these two fields (equity gaps and motivation) should be explored together to examine the interactions they have on one another.

Motivation and Equity Gaps

Furthermore, interventions to bolster students' motivation have shown to be particularly beneficial for students from historically underrepresented backgrounds, including women, first-generation college students, and people of color (Harackiewicz et al., 2014; G. M. Walton & Cohen, 2011). As cited in Barron and Hulleman (2021), "targeted motivational planning can address educational inequity and greatly benefit historically marginalized and disadvantaged students (Harackiewicz & Priniski, 2018; Hulleman & Harackiewicz, 2021; Yeager et al., 2013)." I can extrapolate that if students receive instruction that is motivating, equity gaps may close.

Researchers have also studied how the motivational attitudes of instructors influence their students. Evidence was collected that suggested equity gaps among students in college math classes were correlated with their instructors' diminished expectations for their Black, Latinx and Indigenous (BLI) students. This was the case even when BLI and non-BLI students had the same levels of motivation. BLI students' math grades were 9% lower on average than their non-BLI peers, even when corrected for students' aptitude, effort, and prior academic achievement. This suggests inequity in the motivational "payoff" among underrepresented students (Silverman et al., 2023).

Students who drop out of college give various reasons for doing so. According to data from StraighterLine with the University Professional and Continuing Education

Association, 42% of dropouts cited financial pressure as a reason, 32% cited family, 30% that it wasn't the right fit, 24% lack of time, 15% health, 11% employment change, and 9% change in program venue. While attending and completing college undoubtably requires sacrifices, it would appear that for most dropouts, the *cost* of completing their degree – be it financial, time, or other sacrifices – is too great (Hanson, 2022). For this reason, it is important to consider the motivational impacts our classes have on our students and decrease the "cost" associated with completing their degrees as much as possible to deter dropping out.

Choice

The psychological theory of self-determination states that choice is crucial to feelings of autonomy, motivation, and well-being (Deci & Ryan, 1985; Ryan & Deci, 2000). This theory is supported by research by showing that having choice relates to both performance outcomes and adaptive motivation (Cordova & Lepper, 1996; Iyengar & Lepper, 2000; Patall et al., 2008; Swann & Pittman, 1977; Zuckerman et al., 1978). In the classroom, offering students choice has been a popular practice by teachers as a means to increase student motivation and learning for decades (Flowerday & Schraw, 2000). As early as the 70's, giving college students choices about which tasks to complete was shown to increased their intrinsic motivation more so than students who were assigned tasks (Zuckerman et al., 1978). Providing students choice of homework assignment has been shown to increase their intrinsic motivation to do their homework, that students felt more competent in regards to said homework, and furthermore led to higher performance on exams (Patall et al., 2010). Since intrinsic motivation can have a more profound impact on student learning, and choice can increase student intrinsic motivation, I believe that choice

can increase the impact on student learning and performance. Conversely, some research has shown that too much choice can sometimes be too much of a good thing; that people are more likely to undertake optional essay assignments when offered a more limited array of options (Iyengar & Lepper, 2000).

I divide my classes into four units and assign one You-pick Assignment due for every unit. I also give the option of completing a "bonus" You-pick Assignment for extra credit, allowing students to make up points they may be missing. With these assignments students have the option to pick from a list of about 30 different activities to experience, and also the choice with how to submit it (written response, video, or art.) The intent of my strategy of offering student a choice is to increase student motivation and interest in the subject of biology. The various activities students can choose to participate in enable them to actively learn biology by applying what they learn in my class into their own lives. I believe that by offering choices to students in my class it affirms their values, increasing their sense of belonging and motivation, benefiting their learning. My classes cover a wide breadth of the field, but students certainly find certain aspects more interesting than others. I would rather students remain highly motivated throughout the course by participating in activities that they value, rather than force them to complete something they have no interest in. I believe that by allowing students to engage with the class in a way that excites and interest them, they will be more likely to maintain long-term interest in the subject and persist in science classes.

Summary and Implications of Literature

In this review of literature, I conclude that a student-centered approach in which instructors use active learning techniques in their classes can help all students succeed, but particularly those who have been historically underrepresented in academia, closing equity gaps. However, this is limited research on *how* active learning interventions close equity gaps. Furthermore, the vast majority of studies on equity gaps use exclusively quantitative methods, neglecting the nuanced experiences of the diverse students. Including qualitative methods can amplify the voices of the students themselves, particularly the historically underrepresented students whose voices have for too long been ignored. While many types of improvements are slow to progress due to obstacles such as bureaucracy or vigilant opposition, teaching strategies such as active learning can be implemented in classrooms forthwith and can impart immediate action on creating equitable education. I recommend educators utilize active learning in their classrooms to close equity gaps among their students.

Chapter 3: Methodology

Research Questions

For this dissertation action research project, I explored the connection between how my curriculum and instruction in which I use active learning interventions influenced my students' motivation, as well as connections between their motivation and their grades, and how their motivation and grades differed among students of various demographics. I examined differences in motivation and grades between students of different backgrounds in which equity gaps have been noted by the California State University: Race/Ethnicity, Gender, Pell Grant status, and First-Generation college student status. To reiterate what I shared in Chapter One, I asked two research questions to explore the connections between active learning and motivation and their impacts on grades among my diverse population of online biology students.

Research questions I addressed through this dissertation project are:

1. In what ways do my various active learning practices impact my online biology students' motivation?
2. How does the impact of active learning on motivation and grades differ among my diverse biology student population?

I used a survey to measure student motivation of 131 participants both before and after taking my course, to measure any changes in their motivation over the course of the semester. The survey included both quantitate measurements via Likert scale questions specifically measuring their expectancy, value, and cost associated with learning biology, as

well as qualitative written responses asking them to share in their own words what specific things both increase and decrease their motivation to learn biology. To gain deeper insights into how specifically the active learning practices incorporated in my class impacted my students' motivation to learn biology, I conduct in-depth follow-up interviews with seven of my former students. Throughout my teaching career, I have incorporated many different interventions with the intent to make my class as engaging as possible, but until now I haven't been able to say with confidence which practices are actually impacting my students, specifically their motivation. By asking my students directly whether and how active learning interventions effected their motivation, I gained clarity and new insights.

I answered research question 1 by integrating my students' written survey responses and interviews with my own researcher journal, in which I reflected on how I, as their teacher, believed active learning was influencing their motivation. Incorporating the data together to answer the research question allowed me to consider both my students' and my own perspectives and helped me to contextualize the data.

I used quantitative methods to answer research question 2. I used statistical analysis to look for correlations between three variables in my students: the dependent variables of their motivation and class performance (grades), and the independent variables of their demographics. I used data from the quantitative portion of the motivation survey, their grades in my class, and their demographics, including Race/Ethnicity, Gender, Pell Grant status, and First-Generation college student status, to conduct a regression analysis. I uncovered what effect motivation has on student performance and patterns in motivation and grades among students of various demographics.

Research Design

The purpose of this study is to explore how active learning effects student motivation, and the interactions of student motivation and class performance (grades) between students of different backgrounds. I used a validated survey to collect data on my students' motivation as well as their demographic information, and I compared it to their grades to explore connections between the variables. Equity gaps (disparities in student achievement such as grades) exist for students of underrepresented backgrounds at my institutions, Cal Poly Pomona and CSUDH (Graduation Initiative 2025, 2023). Gaps have long-term consequences in terms of degree completion, salary, and employment, as detailed in Chapter 1. Active learning has been definitively shown to close equity gaps in large, undergraduate biology courses, as detailed in Chapter 2. I believe that the reason for the efficacy of active learning in supporting diverse learners is because the teaching practice increases their motivation. I believe that active learning increases student motivation and may likewise improve their grades, especially those of historically underrepresented backgrounds, closing any gaps.

This research protocol was approved by the Indiana University Institutional Review Board, review level Expedited/Full Board, protocol number 20595. A reliance agreement was made between Indiana University and both Cal Poly Pomona and CSU Dominguez Hills.

Action Research

Action research is the cyclical research process in which teachers continually improve their instruction through proposing changes, engaging in the action, observing the results, and reflecting on the action, and proposing new changes again (J. S. Lederman & Lederman, 2015). Action research rejects positivism (Clark et al., 2022), something that

ironically is associated with the natural sciences, and yet is a deeply flawed way to perceive science (Chalmers, 2013). As the Ledermans point out (2015) action research has a long history as a valuable research methodology to better society through improving curriculum and instruction. At a time when calls for social justice have led to many platitudes, action research is a powerful tool to facilitate real and immediate change.

The cyclical and reflective process of action research helps educators form a better understanding of their teaching, facilitating improvements in their classes (Reason & Bradbury, 2013). Using my own students to generate data helps me as a researcher to develop agency in my own knowledge, producing my own research artifacts instead of relying on what others have done. I think it aligns with the spirit of science to form our own inquiries and find answers to our own questions, instead of "being subservient to the knowledge enacted on their educational context" (Clark et al., 2022). Previous action research I have undertaken has led to improvements in my students understanding of the Nature of Science (Marin Rothman, 2022a), and reflecting on my teaching through a researcher lens led me to new insights as a scholar (Marin Rothman, 2022b).

Expectancy-Value-Cost Survey of Student Motivation

In my online asynchronous biology classes, I collected student data on their motivation with a survey shared on our Canvas class page. This survey collected data on student motivation via the validated instrument Expectancy-Value-Cost Survey of Student Motivation by Barron, Hulleman, Getty, and Taylor © The Motivate Lab (K. Barron et al., 2017), see Appendix A. This instrument includes both quantitative questions answered via Likert scale and qualitative open-response questions. Student responses to this survey were taken twice: at the very beginning of the semester as a pre-class survey placed in the

introductory module before the biology course curriculum began, and at the conclusion of the class as a post-class survey made available in the final unit of the class.

In addition to the motivation instrument, the post-class survey also collected student demographic information to be used to explore any patterns between and among groups. Demographic questions included gender, first-generation college student status, Race/ethnicity, and Pell Grant eligibility. These demographic questions were selected because the CSU has recognized equity gaps within these groups (Graduation Initiative 2025, 2023). To explore confounding variables, the survey also asked if students are or where enrolled in the corresponding laboratory class, and if they attended any sessions with a Learning Assistant (LA) or tutor.

Students were asked if they would consent to their responses and class grades being used for research purposes. Only students over 18 who consent to their responses and grades being used for this research were included in this dissertation action research project. 131 of my students consented to participate in this research.

Grades

Consenting students' survey responses were compared to their final grades in my online biology classes. Students' grades are the dependent variable that served as the measure of student performance in my class. I explored the relationships between motivation on grades, and compared the interaction between different independent variables, including race/ethnicity, gender, Pell Grant eligibility, and First-generation college student status.

Setting

My classes are online, asynchronous, general education biology classes for non-biology majors ran through the learning management system Canvas. I have been teaching this course since 2011, and my teaching methods have changed tremendously over the years as I constantly strive to improve the learning experiences of my students. While I had experience teaching active learning laboratory classes as a graduate student Teaching Associate, upon completing my master's degree I was hired as a Lecturer to teach lecture classes. When I first started teaching lecturers, I taught my classes in a similar manner that I had experienced as a student, that is lecturing at a large group of students without opportunity for other interactions and relying on several exams for their entire grade. As the "sage on the stage," I waxed on about biology for hours to a room of hundreds of students who passively listened to me, with their only measure of performance through a few exams. Since my lecturing was the only teaching tool I relied upon, in order to keep my students motivated I tried to lecture in an engaging way: telling stories, asking rhetorical questions of the audience, and telling jokes. While my teaching evaluations were very positive, I strived to continuously look for ways to improve by learning "newer" methods of teaching that had been shown through research to improve student learning. In my own literature review, which I shared in Chapter 2, I found overwhelming support through educational research for active learning to increase student learning for everyone, but especially students of historically underrepresented backgrounds. Naturally, I have incorporated many active learning teaching practices into my own lecture classes. Through this research, I aimed to gain a better understanding of how effective active learning is at

motivating students, and if there were any differences in how they can motivate different groups of students, particularly those of historically underrepresented backgrounds.

Teaching Interventions

In this action research dissertation project, I explored how my teaching intervention of utilizing active learning influenced my students, specifically how active learning influences student motivation and grades within my class. My extensive review of the literature on decreasing equity gaps in large introductory biology classes (see Chapter 2) revealed that active learning benefits all learners, but especially those of historically underrepresented backgrounds, and thus can effectively be used to decrease equity gaps. Wanting to provide an equitable learning environment for all of my students and in light of my literature review, I incorporated several active learning strategies into my online asynchronous biology classes. These active learning strategies should have hypothetically increased student learning and motivation, leading to better grades for students of various backgrounds among my diverse population of students.

When I first started teaching, the entirely of my students' grades came from their scores on three exams. Now, by adding a diverse assortment of fun, interesting, and engaging assignments that utilize active learning, their exam scores have subsequently had less impact on their overall grades. The three active learning strategies I use in my class and explored through this research are: Skeletal Notes assignments, offering choice through the You-pick Assignments, and peer interaction through discussion boards and Learning Assistants.

Skeletal Notes

Active learning engages students in the learning process. Instead of having my students passively listen to my pre-recorded lecture videos, I assign my students skeletal notes assignments for each of our four class units that they must complete while they watch my lectures. This assignment gives students the opportunity to pause the video lectures to answer questions I pose, write down their ideas and their questions, and find answers, engaging them in the lecture in a way they may not have had the opportunity to in a large in-person lecture where interruption is discouraged. I allow my students to use their notes on their exams, incentivizing them to fill out their Skeletal Notes assignment thoroughly for their own benefit. I encourage my students to apply the knowledge they have gained from my lectures into real-world situations. Furthermore, this assignment can help them develop note-taking skills they can use in other classes, which may help them persist as they work towards their degree.

You-pick Assignments

I assign my students active learning assignments in which they also have choice in both what activity they engage with and how to complete the assignment. For each of their four You-pick Assignments, students can choose from a variety of activities that suit their interests and accessibility. Examples of activities students can choose to participate in include exploring botanic gardens, zoos, aquariums, museums, state and national parks, boat and scuba tours, whale-watching, tide pools, and hiking trails. Further options include growing their own garden, California native plant species, a compost pile, and cycling an aquarium. They could set out a bird feeder and/or bird bath and identify species they observe. They could try meatless Monday six Mondays in a row or go vegan for one day.

They also have the option to watch one of the numerous documentaries on biology and nature. They may also with a child, watch an age-appropriate episode of a TV show or read a book about biology and talk with the child about what they learned. Students may also read a book or scientific article of their choosing about biology. Other options include attending a biology club meeting or seminar or visiting their campus Wellness Center and get tested for STIs.

Students also have choice in how they submit their assignments and share their experiences and what they learned. Depending on the activity type, students may choose to write about 500 words, create a video, author a website or blog. Students may also create an artistic rendering for one of their four You-pick Assignments, either illustrating and labeling the organs and cell types of an organ system or creating a representation of one of our class modules. I believe that allowing students to choose assignments that they personally find valuable should increase their motivation. By actively participating in biology in the real world, they should gain a deeper understanding of the class content, improving their grades. Likewise, having choice in what type of activity to participate in should increase their motivation by allowing them to learn biology and participate in class in a way they can expect themselves to be competent at, personally see as valuable, with minimal cost to other areas of their lives.

Peer Interaction

Instead of having students submit their You-pick Assignments through Assignments in Canvas where only I can view them, I switched to using the Discussion Board feature to foster student-student collaboration as a form of active learning. That way students can share their experiences with one another including photos they took participating in the

activities, they may ask one another questions, share comments, and receive feedback from their peers. This gives students the opportunity to learn from one another, while also fostering a sense of community and belonging. For their assignment, I ask students to share with one another how their experience related to our biology class, what they learned, and how it made them feel.

Cal Poly students have access to class Learning Assistants (LAs), whom they may visit in-person or via Zoom office hours to seek clarification on class concepts. The biology Learning Assistants (LAs) whom my Cal Poly students have access to may also foster feelings of inclusivity in my students when they see themselves in their LAs. This may be particularly beneficial if the LAs are similarly historically under-represented minorities, such as women, people of color, first-generation college students, or Pell Grant eligible.

Both campuses offer a corresponding laboratory class to my introductory biology lecture class. These laboratory classes are mostly active learning experiments with much peer collaboration. To account for this variable, I included a question in the survey whether students were currently enrolled or had ever taken the laboratory class.

Impact of Active Learning Interventions on Motivation

The instrument I used to measure student motivation specifically explores students' views of expectancy, value, and cost in learning biology (K. Barron et al., 2017). I predicted that actively engaging in the course content through completing the Skeletal Notes assignment, You-pick Assignments, and interacting with their peers would increase their **expectancy** that they could successfully learn biology, increase their **value** in learning biology, and decrease the **cost** associated with succeeding in my biology class. I predicted that active learning assignments that help students understand the course content would

increase their expectancy that they can learn biology and succeed in my course. I predicted that learning real-world issues that they can apply to their own lives through active learning would increase their value in learning biology and completing my class. I predicted that interesting active learning assignments they get to choose from would decrease the cost for students to complete my class.

Data Collection Procedures

This mixed methods dissertation research project integrates quantitative and qualitative data to gain a better understanding of the connections between active learning and student motivation among diverse biology students. Creswell and Creswell succinctly summarize the process of conducting a mixed methods study, where "the researcher draws a diagram of the design, integrates the two databases, presents the integration in a table or joint display for analysis, and draws insight or metainferences from the results of the integration" (2023). Using a convergent design, I collected and analyzed both quantitative and qualitative data concurrently.

Student Data

Student data I collected included my students' pre-class and post-class survey responses (including the motivation questions and demographic questions), their final grades they earned in my class, and follow-up interviews. My online asynchronous biology courses are hosted through a CAS-authenticated class Canvas site, from which I collected all student survey and grade data. Interviews were conducted and recorded via Zoom. All

electronic class data used for my research was collected and stored on a secure password-protected computer using IU Google/One Drive.

Survey. The pre-class and post-class surveys both included the instrument Expectancy-Value-Cost Survey of Student Motivation (K. Barron et al., 2017) to measure three aspects of student motivation. The motivation survey questions included both quantitative closed-ended Likert questions as well as qualitative open-ended questions. In the post-class survey, I also included questions on student demographics, and questions on whether they received other learning support from tutors or Learning Assistants (LAs) or were enrolled in the corresponding laboratory course. The pre-class survey was released at the very beginning of the semester, in the introductory module, before the course content was delivered. The post-class survey was released during the final Unit of the course and was due at the conclusion of the term. The survey invitation was included in the survey instructions via Canvas can is included in Appendix A. The survey questions are found in Appendix B.

Interviews. After the conclusion of the term, I emailed students who had consented to participate in my study through the post-class survey to invite them to participate in follow-up interviews in order so that I might gain a deeper understanding about how the active learning interventions impacted their motivation in my online biology class. At the conclusion of the term, after the post-class survey and after final grades were submitted, I emailed students asking them if they were available in the summer for follow-up interviews. Those seven who consented were interviewed via Zoom, which created a transcript automatically which I later checked and edited for accuracy while watching our

interviews. I explained to my interviewees the purpose of the interviews and the purpose of my research. In order to align with the research questions, I specifically asked how each of the three active learning interventions impacted their motivation. To gain deeper insights and relate their interview responses to their survey responses, I further asked how the assignments specifically effected their expectancy, value, and cost to learn biology in my class. The Interview Protocol I used can be found in Appendix D.

Grades. I compared student survey and interview response with the final grades they received in my biology class. Their final grades were based on their scores from the introductory module, four Unit exams, and the active learning assignments: four Skeletal Notes, and four You-pick Assignments, the later submitted and shared among other students via the Canvas Discussion Board.

Researcher Journal

For this action research, I also collected data in the form of my own logged reflections of my teaching practices. As a researcher-teacher, I regularly document any changes I make to my instruction along with my reflections on how I believed my practices would impact my students. This type of reflective journaling, or memoing, is a common practice in action research (Clark et al., 2022) and of qualitative research in general (Dey, 2003). Memo writing throughout the entire research process is important because just as different people have differing perspectives, our own perspectives and feelings can shift over time. Continuous memo writing can allow us to gain a more composite analysis of our thoughts instead of focusing on only one moment in time, especially when attitudes may

shift over time. All researchers are connected to their research, of course; "researcher, method, and data should be reflexively connected," (Mauthner & Doucet, 2003).

Throughout the term, I made weekly reflections in my teacher-researcher journal on my thoughts on how I believed my active learning practices were impacting my students' motivation. My reflections are based on my own perceptions of active learning practices and my ideas about how they relate to student motivation.. I considered how I believed the active learning assignments specifically impact students' feelings of expectancy, value, and cost to learn biology. I also reflected on my own motivation as a doctoral student and researcher, specifically thinking about expectancy, value, and cost.

Overall and Sample Populations

The population I studied are undergraduate students from the California State University (CSU). The CSU is the largest and most diverse four-year higher education system in the United States, comprised of 23 universities. The system currently serves nearly 460,000 students, awarding more than 125,000 degrees annually, and employs 56,000 faculty and staff. The CSU system aims to provide upward mobility to students and prepare a workforce for California's changing economy. (*California State University Office of the Chancellor*, 2023)

Students of the CSU system represent the diversity of California, and 40% of undergraduate students are transfers from California Community Colleges. Most CSU campuses are colloquially known as "commuter schools," and the vast majority (94%) of students are from California. More than half of CSU students are from historically

underrepresented backgrounds, nearly half receive the Pell Grant, and nearly a third are first-generation college students. (*California State University Office of the Chancellor*, 2023)

Participants

Participants for this action research dissertation project were my own students in my online asynchronous freshman-level undergraduate general biology classes through California State Polytechnic University, Pomona (Cal Poly Pomona or CPP) and California State University Dominguez Hills (CSUDH) via the learning management system Canvas. Students taking this class are non-biology majors, from a variety of different majors.

For my recruitment process, I included the surveys on our class Canvas class page within the course modules and also linked to on our Canvas Home Page. Students were asked to complete short surveys asking them questions on their motivation, and in the post-class survey, additional demographic questions as well, with 131 students consenting to participate in the post-class survey, out of a total of 155 students in my two classes (84.5%). Seven students consented to additional interviews after the course had concluded. I compared their survey and interview responses to their final grades in my class. Those eligible to be included in this study were adults (18 years of age or older) taking my class who consent to participate. Not being a student in my class, or being a student under 18 years of age, excluded anyone from this study. Students must have consented to patriciate in this research, electronically behind CAS authentication. In total, seven students consented to interviews, and 131 students consented to participate in this research via the survey, 82 (62.6%) from CPP and 49 (37.4%) from CSUDH, see figure 1.

Student demographics of both campuses combined. Of my 131 total student participants, 82 (62.6%) were Cal Poly Pomona students and 49 (37.4%) were CSU Dominguez Hills students (figure 1). 69 (52.7%) of my participants of were concurrently enrolled in the corresponding Laboratory class, 61 (46.6%) had never taken it, and 1 (0.8%) had taken it a previous semester (figure 2). Only four (3%) of my participants visited with a Learning Assistant or tutor, two only one time, and two more than one time (figure 3). 70 (53.4%) of my participants are women, 58 (44.3%) men, 3 (2.3%) non-binary (figure 4). 83 (63%) are first-generation college students and 48 (37%) are not first-generation college students (figure 5). Of race/ethnicity, 72 (55.0%) are Hispanic or Latino/a/x, 28 (21.4%) Asian, 6 (4.6%) Black/African American, 2 (1.5%) Native Hawaiian or Other Pacific Islander, 0 (0%) American Indian/Alaskan Native, 15 (11.5%) White, 8 (6.1%) Two or More Races, 0 (0%) unknown (figure 6). 78 (59.5%) are Pell Grant eligible, 53 (40.5%) are not Pell Grant eligible (figure 7).

CPP Demographics. Of my 82 consenting CPP participants, 45 (54.9%) were concurrently enrolled in Bio 1110L, Life Science Laboratory, 36 (43.9%) had never taken it, and 1 (1.2%) had taken it a previous semester (figure 2). Only four (4.9%) of my participants visited with a Learning Assistant or tutor, two (2.4%) only one time, and two (2.4%) more than one time (figure 3). 35 (42.7%) of CPP participants are women, 44 (53.7%) men, 3 (3.7%) non-binary (figure 4). 46 (56.1%) are first-generation college students and 36 (43.9%) are not first-generation college students (figure 5). Of race/ethnicity, 34 (41.5%) are Hispanic or Latino/a/x, 28 (34.1%) Asian, 3 (3.7%) Black/African American, 1 (1.2%) Native Hawaiian or Other Pacific Islander, 0 (0%) American Indian/Alaskan Native, 10 (12.2%) White, 6 (7.3%) Two or More Races, 0 (0%)

unknown (figure 6). 39 (47.6%) are Pell Grant eligible, 43 (52.4%) are not Pell Grant eligible (figure 7).

CSUDH Demographics. Of my 49 consenting CSUDH participants, 24 (49%) were concurrently enrolled in Bio 103, General Biology Laboratory, 25 (51%) had never taken it, and none had taken it a previous semester (figure 2). None of the CSUDH participants attended any live sessions with a Learning Assistant or tutor (figure 3). 35 (71%) of CSUDH participants are women, 14 (29%) are men, with no students reporting their gender as non-binary (figure 4). 37 (76%) are first-generation college students and 12 (24%) are not first-generation college students (figure 5). Of race/ethnicity, 38 (78%) are Hispanic or Latino/a/x, 0 (0%) Asian, 3 (6%) Black/African American, 1 (2%) Native Hawaiian or Other Pacific Islander, 0 (0%) American Indian/Alaskan Native, 5 (10%) White, 2 (4%) Two or More Races, 0 (0%) unknown (figure 6). 39 (80%) are Pell Grant eligible, 10 (20%) are not Pell Grant eligible (figure 7).

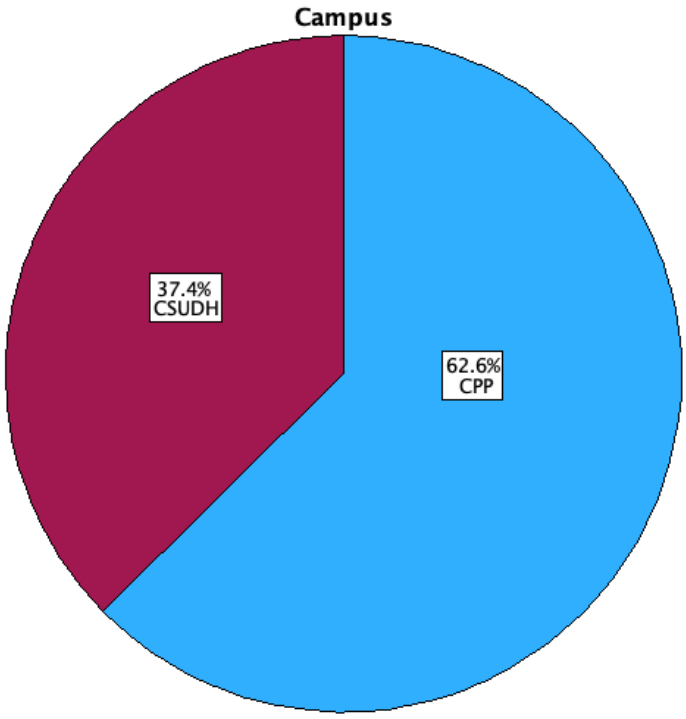

Figure 1. Campus of participants

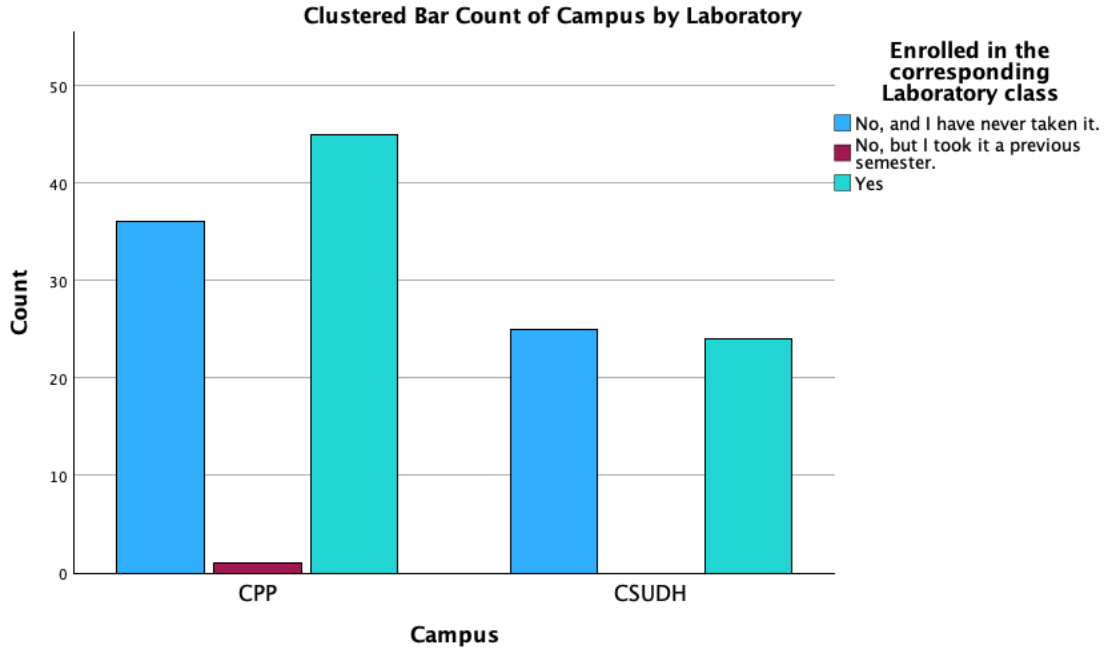

Figure 2. Participants who have taken the corresponding laboratory class

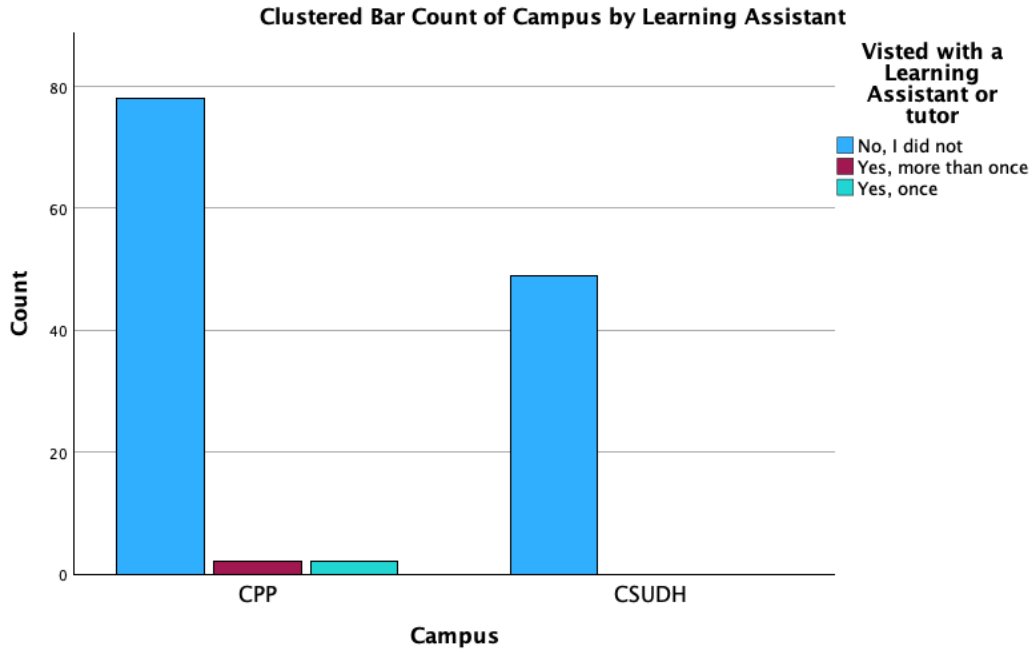

Figure 3. Participants who visited with a Learning Assistant or tutor

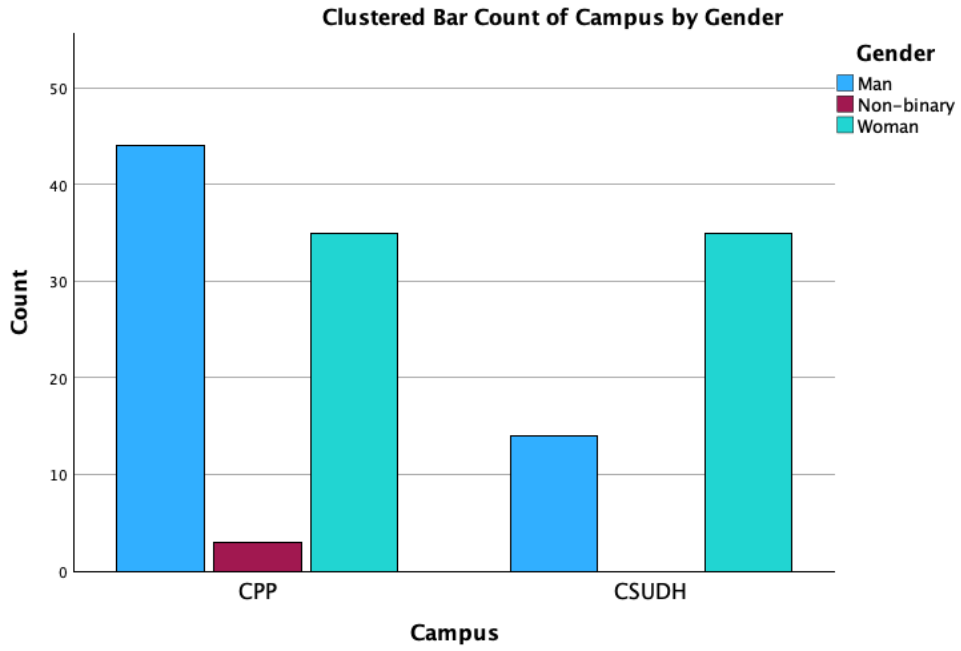

Figure 4. Gender of participants

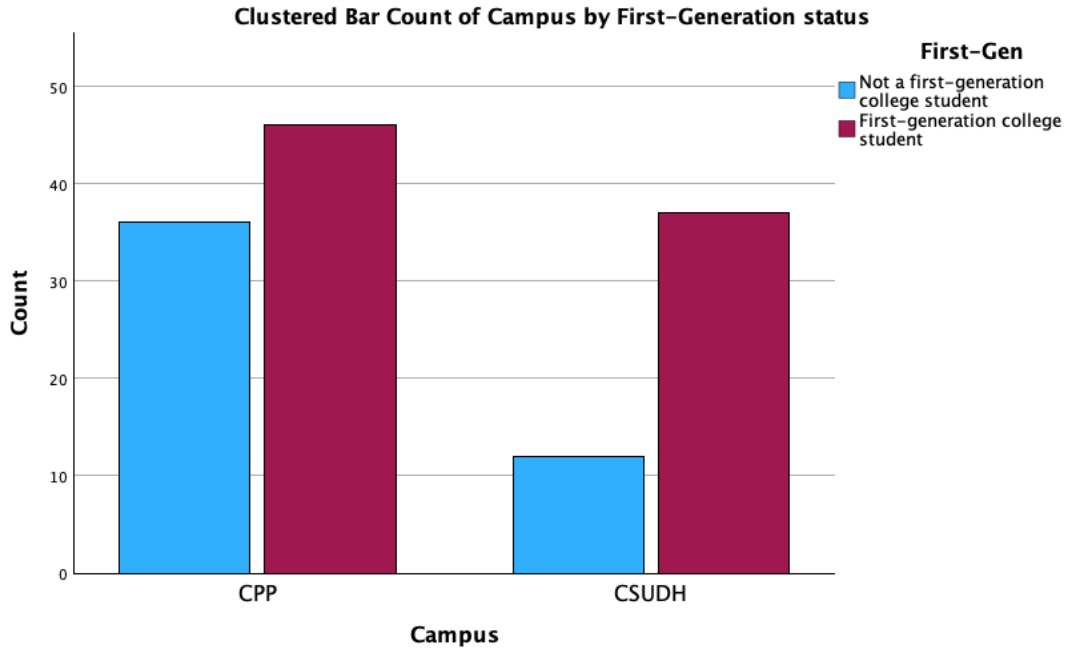

Figure 5. First-generation college student status of participants

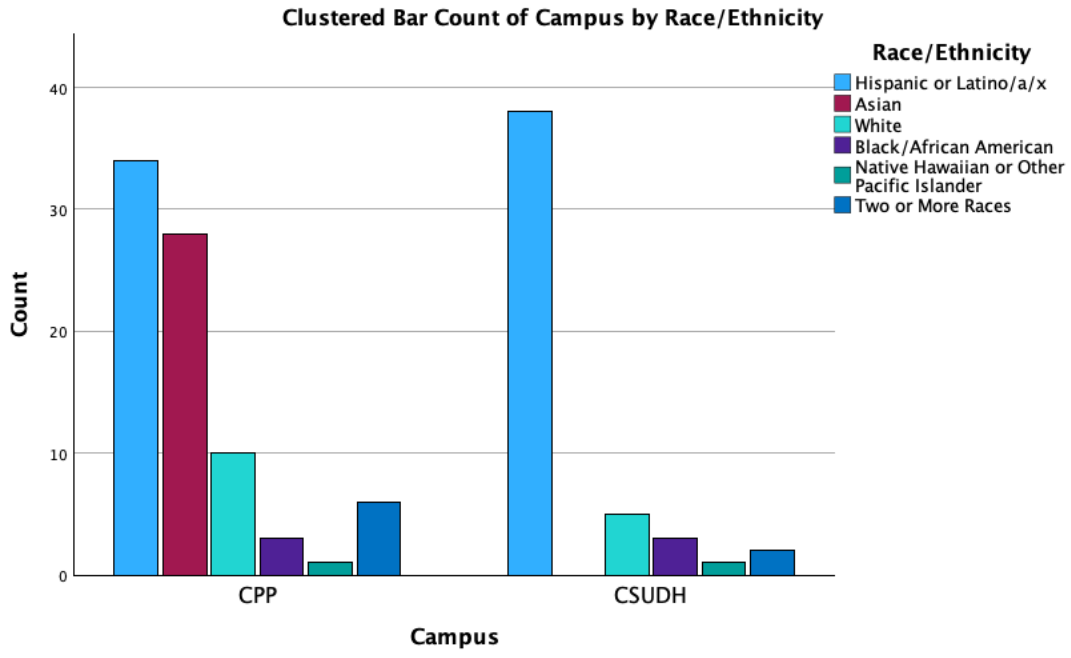

Figure 6. Race/ethnicity of participants

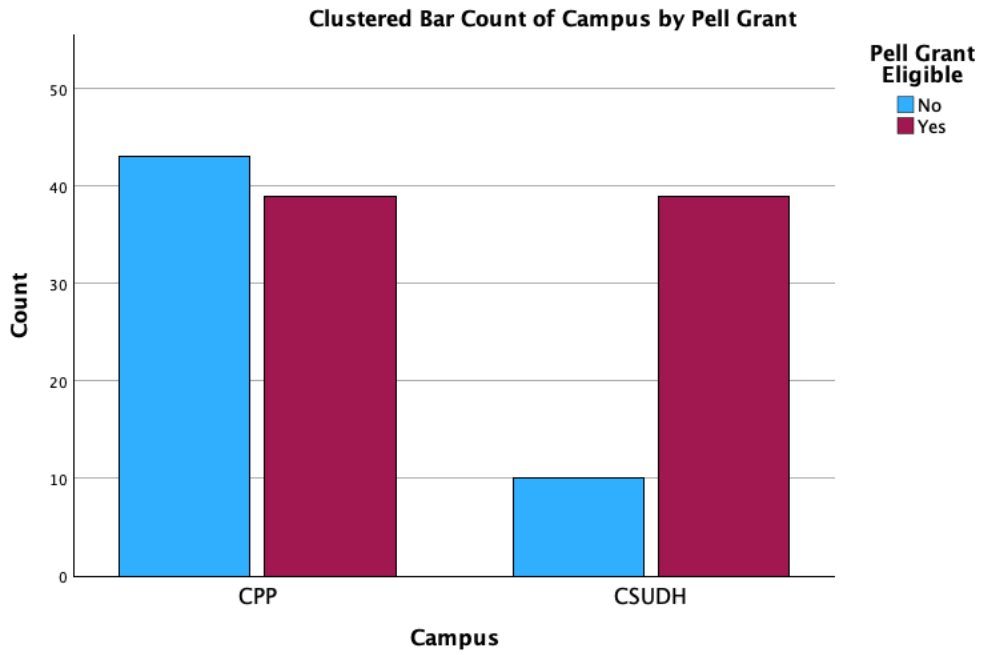

Figure 7. Participants who are eligible or not for a Pell Grant

Recruitment

For this action research, I recruited participants from my own online asynchronous biology classes from both campuses. In my classes I included a pre-class survey at the beginning of term and a post-class survey at the end of the term. The pre-class survey was worth no points and only included the motivation questions. The post-class survey was worth 10 extra credit points if completed. Student could also complete an alternative survey, not used for research, for 10 extra credit points. The post-class survey included a question asking for their consent, the motivation questions, and the demographic questions. The consent question was posed:

> I am asking for your consent for your participation in a research project for my doctoral dissertation. Data I wish to collect includes your responses to this post-class and the pre-class surveys, as well as your grades. Your information will be confidential, protected on a secure computer, and published with no identifiers. You can rescind your consent at any time. You

> are not required to consent, and your choice will have absolutely no influence on your grade or how you are treated in my class.
>
> This survey is being conducted under Indiana University IRB Protocol #: 20595

Students could select "Yes, I consent" or "No, I do not consent" to respond to the consent question. Students who completed the post-class survey were awarded 10 points of extra credit. In leu of participating in this research, students had the option to complete the alternative survey instead and likewise receive the 10 extra credit points. The alternate survey was a short, general open-ended feedback survey also worth 10 extra credit points, and was not to be used for research. This is a reasonable amount of credit considering time and effort expended in relation to the other class assignments. Students automatically received 10 extra credit points for taking either survey, regardless of their responses, including whether or not they consent to them being used for research. The consent-asking post-class survey and 10 extra credit points were added at the end of the term, after all other assignments had been graded, and so had zero effect on how students were treated by me or subjectively graded since the term was already completed. The survey invitation, displayed under instructions on the survey in Canvas, is in Appendix A. The survey itself is in Appendix B.

At the conclusion of the term, after survey data had been collected and grades submitted, I contacted all 131 consenting students via email thanking them for their participation and to request their further participation in a follow-up Zoom interview so that I may gain deeper insight into how active learning effects their motivation to learn biology. Descriptions of the seven consenting interviewees is in Table 1. The interview invitation is in Appendix C, and the interview protocol in Appendix D.

Table 1: Interviewee Descriptions

Student	Campus	Gender	1st gen college student status	Race/ethnicity	Pell Grant eligibility
Salvador	CPP	Man	1st gen	Hispanic/Latino	Eligible
Sofia	CSUDH	Woman	1st gen	Hispanic/Latina	Eligible
Catalina	CSUDH	Woman	1st gen	Hispanic/Latina	Eligible
Danielle	CPP	Woman	1st gen	Hispanic/Latina	Eligible
John	CPP	Man	Not 1st gen	Black/African American	Eligible
Ángel	CSUDH	Man	Not 1st gen	Hispanic/Latino	Not eligible
Rita	CPP	Woman	Not 1st gen	White and Asian	Not eligible

Value of Mixed Methods Research

Both qualitative and quantitative methodologies have their own value, with neither being superior to the other, but rather used to answer different types of research questions (Yin, R. K., 2016). Despite the opinions of some, particularly in the natural sciences, quantitative research is not the superior or sole way to conduct research. One major reason being so because empiricism and positivism is imperfect, in that facts are actually derived from the synthesis of prior knowledge, not solely observation and experience, and observations is up to individual interpretation (Chalmers, 2013). Indeed, it is a major aspect of the Nature of Science that all human observations and interpretations are subjective, with complete objectivity being unattainable (Ledderman, 2007). It can even be argued that all inquiry is a type of narrative because all researchers attempt to make

meaning from their data and share their findings in the story of their research (Hendry, 2009).

Research methodologies exist on a quantitative-qualitative continuum (Creswell & Guetterman, 2019; Newman & Benz, 1998), with mixed methods in the center, incorporating elements of both (Creswell & Creswell, 2023). Integrating the different types of quantitative and qualitative data can give us more insights than we would have if we had used only one method by itself. The goal of mixed methods research is to draw from the strengths of both quantitative and qualitative methods, while making up for their individual weaknesses (R. B. Johnson & Onwuegbuzie, 2004).

In this dissertation research project, the quantitative analysis has uncovered connections between student demographics and their motivation and performance in my class, while qualitative analysis amplifies the voices of my students as they have shared their own lived experiences, and shares with us new and deeper insights into teaching practices that affect their motivation to learn. Brought together, these combined data have helped me develop a deeper and more nuanced understanding of my diverse students' attitudes and experiences learning biology in my class. While the body of research on equity gaps is largely quantitative due to the types of research questions typically posed when researching equity gaps, including qualitative data gives students who have historically been underrepresented in the sciences and higher education the opportunity to share their valuable perspectives and experiences.

Mixed methods research designs are becoming more prevalent in educational research (Buck & Williamson, 2022). There are many examples of publications that have used a mixed method approach, and Buck and Williamson (2022) have recognized a

commonality between them in their purpose of measuring the effectiveness of programs or initiatives, finding that researchers used a quantitative approach to determine if initiatives or programs meet the goals and qualitative approaches to explore specific experiences within the programs' impacts. This aligns with my dissertation research because my quantitative data analysis was used to determine if there are differences in motivation and grades between different groups of students, while using qualitative methods allowed my students the opportunity to share their own experiences learning biology. Buck and Williamson (2022) found a variety of benefits researchers shared for using mixed methods such as triangulation, increased rigor and quality of study, minimize weakness in any one method, to enhance the understanding of phenomena, and to gain a more holistic perspective.

For this dissertation research, I collected quantitative data in the form of student grades and their closed-ended survey responses on motivation and demographics, which I analyzed using statistics to examine the relationships between the variables. I also collected open-ended responses to the survey and follow-up interviews, which I analyzed using thematic analysis to induce themes from my students' individual experiences. Through a convergent mixed methods design, during my data analysis I integrated these qualitative and quantitative data to gain insights about my students' experiences and make recommendations on improving the learning experience for all students. I believe that this rich collection of data and diverse methods of analysis paints a better picture of what is a dynamic issue that has often been over-simplified. A table summarizing of the types of data, including the collection and analysis, can be found in Table 1.

Instrumentation

Data for this study includes my students' final grades in my class, their pre-class and post-class motivation survey responses, follow-up interview responses, student demographics, and my researcher journal. The pre-class motivation survey included an instrument to measure aspects of student motivation, and the post-class survey included both the motivation survey as well as questions on their demographics including other learning support they received. The survey is found in Appendix B.

Motivation Survey

For data collection on student motivation, I used the validated instrument Expectancy-Value-Cost Survey of Student Motivation (K. Barron et al., 2017) which includes both quantitative and qualitative questions. The Expectancy-Value-Cost Survey of Student Motivation was validated at 15 different field sites from late elementary through college including 15,000 students (K. Barron et al., 2017; S. G. Getty et al., 2017). For the quantitative portion of the motivation survey, students answer ten Likert-scale questions relating to students' expectancy, value, and cost to taking their biology course. For the qualitative portion of the survey, students are asked to list specific things that either increase or decrease their motivation to learn in their biology class. Instrument is found in Appendix B.

Interview

To gain further insight into my students' sense of motivation, I conducted follow-up interviews with seven of my consenting students. I formed my questions based on my research questions, specifically asking how each active learning assignment impacted their

motivation, specifically their expectancy, value, and cost to learn biology. Interviewee descriptors are in Table 1. My interview protocol is in Appendix D.

Demographics

I chose questions on demographics based on those that the CSU has identified as having equity gaps across CSU campuses (Graduation Initiative 2025, 2023). Questions include students' gender, race/ethnicity, first-generation college student status, and Pell Grant eligibility. Survey is found in Appendix B.

Peer Learning

Some, but not all, of my students concurrently enroll in the corresponding laboratory to my lecture class. Also, some students may have sought outside help through tutoring or meeting with a class Learning Assistant (LA). Collaborative peer learning can increase student achievement in STEM class (Alzen et al., 2018; Batz et al., 2015; Kornreich-Leshem et al., 2022), especially for URM, which can close equity gaps (Sellami et al., 2017; Snyder et al., 2016; Toven-Lindsey et al., 2015) and increase in STEM persistence (Kornreich-Leshem et al., 2022) particularly with URM (Kudish et al., 2016). To control for these variables, I also asked students in the post-class survey if they enrolled in the corresponding laboratory course and if they received any outside help from class Learning Assistants (LAs) or tutors. Survey is found in Appendix B.

Grades

To measure student performance, I used the metric of the final grades that students received in my online asynchronous biology course. Their grades were calculated based on introductory assignments, exams, and the active learning assignments Skeletal Notes and You-pick Assignments.

Data Analysis Procedures

Data analysis occurred over the summer, after the completion of the courses and final grade submission, on my personal password-protected computer in my personal home office. I conducted both quantitative and qualitative analysis for this mixed method study. I used a mixed methods research design to integrate the two data sets and "mine" for a deeper understanding of the issue. I shared the side-by-side combination of the different data with a joint display in Chapter 4 (Table 6). Integrating the multiple types of data has allowed me to draw metainferences – insight into the complex issue gained from comparing and combining the different data sources. With this convergent design, I compared the different types of information and looked for instances where they are similar or different. My analysis is framed through my beliefs and values, while I form explanations based on the literature. (Creswell & Creswell, 2023)

Motivation Survey

The pre-class and post-class surveys provided both qualitative and quantitative data that I used to answer my research questions. I used the qualitative portion of the survey, Questions A and B to help answer research question 1. I used the quantitative portion of the survey, Questions 1-10, plus the included demographic questions, to answer research question 2.

Questions A and B. Two of the questions on the motivation instrument are open response, giving my students the opportunity to share in their own words what increases and decreases their motivation to learn biology, helping me to answer Research Question 1. To analyze these qualitative questions of the motivation survey, Questions A and B, I

employed thematic analysis using the software NVivo 14. I first read over all 131 students' four responses (A and B for pre- and post-) multiple times to gauge the type and scope of the dataset. After familiarizing myself with the dataset, I coded each students' response to each question of what increased (Question A) or decreased (Question B) their motivation to learn biology. I used a combination of *In vivo* and descriptive phrases to develop codes. Then after coding the entire dataset, I grouped related codes together to form categories. I used the categories to create themes from the dataset as a whole for each of the two survey questions. I included a code map adapted from (Anfara et al., 2002) in Chapter 4 (Table 3).

Questions 1-10. To answer Research Question 2, I compared the student surveys of their motivation and demographics and grades, in order to uncover how student motivation and grades differ among my diverse student population. To analyze the quantitative Likert scale questions of the motivation survey, Questions 1-10, I conducted statistical analysis using the software IBM SPSS Statistics Version 29.0.2.0 (20). To measure the change in student motivation over time I used a Paired sample T-test to compare the responses to the pre-class survey to the post-class survey. I used the data from Questions 1-10 to conduct a regression analysis comparing the motivation survey data to student demographics and grades.

Interviews

To gain a deeper understanding of students' perspectives, I conducted follow-up interviews with seven of my former students. I viewed and listened to their responses from the interview recording multiple times to create accurate transcripts from the ones automatically provided by Zoom.

I used a Thematic Analysis to analyze their verbal responses through the interview transcripts (Saldaña, 2009). Using the software NVivo 14, I developed codes and applied the codes to the text-based data. The first coding I did was to break up the transcripts by question. My first three codes were the three active learning interventions: Skeletal Notes, You-pick Assignments, and Peer Interaction. I then further coded each active learning intervention by measure of motivation: Expectancy, Value, and Cost. I then carefully analyzed my students' words as they discussed each assignment and measure of motivation. As I re-viewed the videos and transcripts, I looked for patterns in the data that I could use to develop codes. I used a combination of *In vivo* and descriptive phrases. I used *In vivo* codes when a particular word was used by the participants and succinctly summarized their description, such as Choice, Easy, Engage, New Experience, Organized, Perspectives. I used descriptive codes to summarize what the participants shared when they described it in a way that may not have made sense outside of the context of the interviews, including Community, Enjoyable, Funds of Knowledge, Good Investment, Mental Health, Not Impacted, Other Responsibilities, Quality of Life, Real World Application.

I used these codes to develop categories by looking for patterns in what codes were used for different active learning assignments and different measures of motivation. I then used the categories to derive themes that reflected the ideas and experiences my students shared. I included a code map adapted from (Anfara et al., 2002) in Chapter 4 (Table 4). I used the analysis of my interviews to help answer Research Question 1, gaining deep insight into how my three active learning interventions specifically impact my students' motivation to learn biology.

Researcher Journal

I also conducted a Thematic Analysis of my teacher-researcher reflections I included in my Researcher Journal using the software NVivo 14. Reflexivity is when the researcher reflects on how their own beliefs influence their research. Reflexivity is important throughout the entire cyclical research process, but I would think it's most pertinent at the analysis stage, because that is when you construct knowledge from the data. You can't just write a positionality statement at the beginning and call it a day, never to reflect on it again. Those differences in perspectives need to be unpacked at every stage. I think reflexivity is particularly important (and potentially uncomfortable) to me during data analysis because in action research I research my own students, and de facto my own teaching. Action researchers need to consider "the ways in which our emotional responses to respondents can shape our interpretation of their account" (Mauthner & Doucet, 2003). I included a code map adapted from (Anfara et al., 2002) in Chapter 4 (Table 5).

Motivation-Grades-Demographics

To answer Research Question 2 and analyze the influence of multiple data points on each other, I analyzed multiple data sources simultaneously using the statistical tool of a Linear Regression. By controlling for each variable, this type of test is used to determine which independent variables are significant in their influencing the dependent variable, as well as the level of any influence (Butin, 2010). This test allowed me to explore the relationships between the outcome of grade on the variables of both motivation and demographics, including race/ethnicity, gender, Pell Grant status, and First-generation college student status. Regression analysis has been used in other studies to untangle relationships between variables and student performance outcomes in college science

classes (Alzen et al., 2018; Batz et al., 2015; Biswas et al., 2022; Gasiewski et al., 2012; Kornreich-Leshem et al., 2022; Murphy et al., 2020; Sellami et al., 2017; E. J. Theobald et al., 2020; R. Theobald & Freeman, 2014; Toven-Lindsey et al., 2015; G. M. Walton & Cohen, 2007). Using a Pearson Correlation, I also compared the final grades students received in my class to their responses to the motivation surveys.

Using data from a pilot study, statistical power analysis was calculated using G*Power (Faul et al., 2009). A medium effect size was set to .15 (Kraft, 2020). For two (2) predictors, such as I would use to compare students of different genders (women and men), Pell-grant status, or First-generation college student status, I calculated a minimum sample size of 68. Because I had 155 students the Spring term, at least 44% of them would have needed to consent for a medium effect size analysis. For this study, 131 students, 84.5% of my class, consented to participate, giving me a nearly twice as large required sample size for this study.

Validity of Interpretation

The instrument I used to collect data on my students' motivation, The Expectancy-Value-Cost Survey of Student Motivation, was validated at 15 different field sites from late elementary through college including 15,000 students (K. Barron et al., 2017; S. G. Getty et al., 2017). The survey includes both open-ended and closed-ended questions, providing both qualitative and quantitative data on student motivation, suitable for this mixed method research project. To maintain validity, it is important when conducting mixed methods research that both data sources examine the same thing (Creswell & Creswell, 2023). Threats to validity in mixed methods research may arise when the datasets show

different conclusions. If this occurs, researchers can assuage this threat to validity through reanalysis and following up with participants.

Memo writing throughout the entire research process is important because just as different people have differing perspectives, our own perspectives and feelings can shift over time. Continuous memo writing can allow us to gain a more composite analysis of our thoughts instead of focusing on only one moment in time, especially when the data is so sensitive. My Researcher Journal provided context to my own thoughts throughout the process of simultaneously teaching my classes and conducting research on my students.

Limitations and Delimitations

Categorical thinking is one of several ways to examine your data in qualitative analysis and is what I employed as I conducted thematic analysis of my data. When we think categorically in qualitative data analysis, we examine the different components of our data and label and sort it based on its perceived meaning. As I describe to my biology students, it's part of human nature to name things and sort them based on their similarities and differences. This mode of thinking resonates with me with my background in the natural sciences. Classification of species (taxonomy) is a field that scientists use to create order and categorize different life forms. The goal is to determine how similar or different species are to one another and place them into a hierarchy of groups so that we can better understand their relation to one another. But as I tell my students, there are limitations to this mode of thinking. Firstly, scientists are in continuous disagreement about how to classify species; arguing and reclassification is interminable within the field. In what may be a more familiar example, a group of children can have different ideas about how to sort

toys based on their own perceptions, such as by color, type, or how much they like the toys (Galman, 2016). And as technology advances and we learn more, such as by comparing genomes among species, labels and categories can change. Secondly, putting things in boxes assumes order, but limits the complexity of what it is you're categorizing. The example I give my students is race, because those boxes could be arbitrary and could lead you to make unfair generalizations (M. Freeman, 2016). So, while categorical thinking appeals to my desire for logic with my natural science background, it's important to be aware of the pitfalls and limitations, and carefully consider what "boxes" you're creating.

While researchers can try to be distant observers of their subjects, it's not entirely possible, because we researchers are social beings (Usher, 1996). This concept is important for conducting research in both the natural sciences and the social sciences. Like with the Interpretivist epistemology, it's important for researchers to consider both the details and the big picture (Usher, 1996, p 19). Along this vein, I agree with the Postmodern approach that emphasizes the need to consider not just the methods, but also the implications of our research (Usher, 1996, p 28). Research should serve the people (Hostetler, 2005). As an education researcher my focus is on not just how I conduct my research, but how my research will impact the fields I am a part of (both the natural and social sciences) and my subjects: our students, who are all unique and complex individuals.

Ethical Considerations

Because I required a sample of my students to consent to participate in my research, one may assume that I had undue influence to pressure them to participate. Fortunately, I taught multiple large sections, with 155 students total, a huge excess of what I would

require for an adequate sample. Even if only half of my students consented to participate in my research, I would have collected adequate data. To assuage any feelings of coercion in my students, I was adamant in describing that they were under no pressure to consent and that they would be treated the same whether they chose to participate or not. Furthermore, data analysis occurred at the conclusion of the term, after I had submitted final grades, so I was able to ensure students that their responses and whether they choose to participate or not would have no impact on how they were treated in my class or on their final grades. Students had the option to complete either the post-class motivation survey for my research or an alternative non-research survey for 10 extra credit points, rewarding them whether they consented to participate in my research or not. I invited students to participate in interviews over the summer after I had submitted their final grades, so they could share with me freely how they truly felt about our class.

In the case that students were inclined to discuss problems, complaints, or concerns about a research study, or to obtain information or to offer input, they were given contact information for the researcher/their instructor, their instructor's advisor, and the Institutional Review Board (IRB). IRB acceptance letter can be found in Appendix D.

The research personnel involved in this study had no significant financial interest which could affect this research. Nor are the research personnel aware of an institutional conflict of interest which could affect or be affected by this research.

Summary

This mixed methods action research project used both statistical analysis and thematic analysis of various data sources including grades, demographics, motivation

survey questions, interviews, and researcher journal, to gain a better understanding of the impact of active learning teaching interventions on student motivation, and the differences in motivation and grades among students of various demographic backgrounds.

Table 1: Data Collection Matrix

Research Questions	Intervention	Data Source	Timeline for collection	Data Analysis
Q1: In what ways do my various active learning practices impact my online biology students' motivation?	Active Learning assignments: 1. Skeletal notes 2. You-pick assignments 3. Peer interaction	Motivation Survey Q's A & B	Pre-class Post-class	Thematic analysis
		Interviews	Post-class	Thematic analysis
		Researcher journal	Weekly through term	Thematic analysis
Q2: How does the impact of active learning on motivation and grades differ among my diverse biology student population?		Motivation Survey Q's 1-10	Pre-class Post-class	Regression analysis
		Demographic questions	Post-class	Regression analysis
		Grades	Post-class	Regression analysis

Chapter 4: Results

Aims of Data Collection and Analysis

Through this mixed method action research, I collected multiple data sources to answer my research questions. To answer Research Question 1, "In what ways do my various active learning practices impact my online biology students' motivation?" I used qualitative data sources including surveys, interviews, and my researcher journal. To answer Research Question 2, "How does the impact of active learning on motivation and grades differ among my diverse biology student population?" I used quantitative data sources including student grades, and surveys of motivation and demographics.

Data Descriptions

I collected diverse sources of both quantitative and qualitative data for this study to triangulate the data and paint a dynamic picture of a complex issue. This data has revealed new insights into how active learning impacts student motivation, and how, and in what ways, those impacts differ among my diverse group of students.

Motivation Survey

I administered both a pre-class and post-class survey to my online biology students at both Cal Poly Pomona (CPP) and CSU Dominguez Hills (CSUDH). Both surveys included the Expectancy-Value-Cost Survey of Student Motivation (K. Barron et al., 2017) to measure aspects of student motivation. The post-class survey also included demographic questions used to answer Research Question 2. In total, 131 students consented to participate in this research, 82 from CPP and 49 from CSUDH (figure 1).

Expectancy-Value-Cost Survey of Motivation. The motivation survey included quantitative and qualitative questions pertaining to students' motivation. In the qualitative portion of the survey, Questions A and B specifically asked students to list what things increase or decrease their motivation to learn in their biology class, which I used to answer Research Question 1. Questions 1 – 10 of the survey were quantitative Likert scale questions about students' perceived expectancy, value, and cost to learning biology, which I used to answer Research Question 2.

Demographic Questions. The post-class survey included additional questions about the students themselves that I used to answer Research Question 2. These Demographic questions included their gender, their race/ethnicity, first-generation college student status, and whether they were Pell Grant eligible. Additional questions asked whether students had taken the corresponding laboratory class or had visited with a tutor or Learning Assistant. Raw demographic information about my participants is listed in Chapter 3 under Participants (Figures 1-7).

Interviews

To gain deeper insights into how my active learning assignments impacted my students' motivation, I conducted follow-up interviews after the term had ended. I interviewed seven of my former students over the summer, after the class had concluded and I had submitted final grades. Interviews took place over Zoom, which auto created a transcript, which I edited myself for accuracy by listening to the interview recordings while making appropriate edits to the transcript.

Interview questions started with a jumping-off question about how our class impacted participants' motivation in general, then specifically their expectancy, value, and

cost associated with our class. This general first question served to prepare my interviewees to think about the three aspects of motivation I measured. In order to answer the research question and learn specifically how active learning impacted their motivation, we discussed each of the three active learning interventions (Skeletal Notes, You-pick Assignments, and Peer interaction), and I asked how each of those active learning assignments impacted their expectancy, value, and cost to learn biology. My interview participant descriptions are in Chapter 3 (Table 1).

Grades

I collected final grades at the end of the term from consenting students, so that I could compare their grades to their motivation survey and demographics to answer Research Question 2. Final grades were the culmination of their assignments in my online biology class. 25 points came from their orientation module, making up nearly 5% of their final grade. My class was broken down into four units, with each unit having three assignments: a Skeletal Notes Assignment worth 25 points each (19% of their final grade), a You-pick Assignment worth 50 points each (38% of their final grade), and a Unit Exam worth 50 points each (38% of their final grade).

CSUDH. Of my CSUDH participants, the average final grade was 94%, a letter grade of A. Two of my participants received Fs in the class, one received a C, three received B/B-s, and the remaining 43 received A/A-s. Looking at only the exam scores of these participants, their grades were slightly lower than their overall grades, at an average of 92%. Four participants earned an average of C+/C/C- on their exams, nine earned an average of B+/B/B- on their exams, with the remaining 36 earning an average of A/A- on their exams.

CPP. Of my CPP participants, the average final grade was 93%, a letter grade of A. Three of my participants received Fs in the class, one received a D-, five received C+/Cs, nine received B+/B/B-s, and the remaining 43 received A/A-s. The average exam score of these participants was likewise 93%. One participant earned an average of an F on their exams, one a D, three participants earned an average of C- on their exams, five earned an average of B+/B/B- on their exams, with the remaining 85 earning an average of A/A- on their exams.

Researcher Journal

Throughout the term, I regularly wrote in a Researcher Journal, making entries several times per week. I wrote my thoughts on being a teacher-researcher, looking at my teaching through a researcher lens, and my research through a teacher lens. I made note of my thoughts on how I believe active learning can be leveraged to increase motivation in online classes, thus leading to student success and closing equity gaps. I also wrote notes on my research process, including steps I had taken and plans I had formulated. I also included my stream of consciousness thoughts in general, including my attitude towards teaching and research, as well as my own motivation.

Data Analysis

I used Thematic Analysis to explore my qualitative data and answer Research Question 1, and Regression Analysis to explore my quantitative data and answer Research Question 2.

Research Question 1: In what ways do my various active learning practices impact my online biology students' motivation?

Using a mixed methodology for this research project, I conducted qualitative analysis on several data sources to answer Research Question 1. I analyzed students' responses to the survey questions asking what increased and decreased their motivation, and I augmented that data with follow-up interviews to gain deeper insight into how active learning specifically impacted their motivation. As my students' instructor who assigned them their active learning assignments with the intention of increasing their motivation, I also conducted an analysis of my own researcher journal in which I documented my perspectives and feelings of motivation.

Motivation Survey. I surveyed my students before class started with the pre-class survey and again at the conclusion of the term in the post-class survey using the Expectancy-Value-Cost Survey of Student Motivation (K. Barron et al., 2017) to measure aspects of student motivation.

Two questions on the Motivation Survey, questions A and B, are open-ended response questions asking students to list what increased (Question A) or decreased (Question B) their motivation. I analyzed their responses using Thematic Analysis and compared questions A and B.

Pre-class survey question A. Students were asked in Question A: "In the space below, please list specific things that INCREASE your motivation to learn in your biology class."

Like many students, Salvador was intrinsically motivated to learn:

> Learning anything regardless [of] if I need to know it or not is really fun to me. I personally feel that learning something regardless of what it is, is

> something I really like doing, so that is my motivation for this class. Learning for the love of learning!

Many students, like Ulysses, came to class already motivated even though biology wasn't their major.:

> My major isn't focused on any STEM programs or learning any science topics. I am simply an English Lit major. However, I love learning about everything, and my favorite science topics are anatomy, biology, environmental, and astronomy. So, I figured I take a class this semester that would essentially be my favorite topic class to look forward in my schedule.

Students overwhelmingly placed the source of their motivation to learn on the quality of their teacher. Muhamed shared "Great teacher with work that is taught to us well and in a way to enable us to understand it and not just memorize." Likewise, Joanna shared:

> Things that increase my motivation to learn is a positive and uplifting learning environment. When my professor is high energy and encourages interaction with classmates, it makes learning all the more enjoyable. Additionally, having a teacher that is patient and understanding increases my motivation, because it makes me want to do better in their class- it gives me another reason to do the work.

Cristina similarly shared that a good teacher is motivating:

> …my biggest motivation is a good professor; I enjoy when a professor makes class fun, and they value their work; with a subject like biology (something that I don't have much knowledge in) it would be great to know that I have a professor who is willing to help me with the extra mile if needed.

Brisa shared what makes a motivating instructor in general: "I believe when instructions are clear in assignments and the professor provides help and encouragement, I can succeed in this class."

As with my interviews, students were mixed on the motivating power of peer interaction. Some students explicitly listed peer discussion as a motivating factor, while others stated they would rather work on their own. Casandra: "Biology has been one of the classes I've struggled with since high school, but I've realized that when I work with a

partner instead of working alone, I understand the material way better!!" For Miguel, a class with peer interaction means someone's there to help: "I would like to work with others to make my learning experience much more hands on. It would be easier to ask for help as well." Emily noted the importance of peer interaction outside of our biology class, listing "[to] relate better to friends that are in a bio field" as a source of increased motivation.

Like other students, Teresa is motivated by classes that utilize multiple modes of learning: "Having a good mix of different methods of receiving information (i.e documentaries, textbook, other books or articles." Indeed, the format of the class itself, and the multiple modes of instruction an online asynchronous class affords was motivating for Loni:

> Having biology as a virtual course is a large motivation for me since it allows me to learn at my own pace in any environment. Additionally, having videos to follow along with structured notes attached makes learning easier for me and also allows me to retain information.

Several students mentioned that active learning was motivating because it was fun. Giana shared: "Hands-on activities and interactive sessions can enhance my understanding and make learning more enjoyable."

Joshua shared not only what would increase his motivation, but why:

> Engaging and Interactive Lessons: Incorporating hands-on activities, experiments, and interactive demonstrations in the class enhances my motivation by making the subject more interesting and applicable. Relevance to Real-World Applications: Connecting biological concepts to real-life situations and applications helps me see the practical implications of what they are learning, increasing motivation to understand and apply the knowledge. Clear Learning Objectives: Clearly defined learning objectives and goals provide me with a sense of purpose, making it easier to stay motivated as I work towards specific outcomes.

Like many of his peers, Aidan was motivated by real-world application: “Things that increase my motivation to learn biology are when I can see the topics I'm learning about in real life or real-world applications of it. When I can see how previous biologists have made breakthroughs and changed our understanding of our world.” Michelle likewise was motivated by learning things that applied to her own life: “As I start this class, something that I think can increase my motivation to learn in my biology class is to have the lectures apply to my daily life and demonstrate how valuable knowledge in Biology can be.”

The overwhelmingly most common code was “real world-relevant,” which was coded in 40 of the 131 responses. The next most common code, used 32 times, was “active learning,” which was often paired with good teacher, multiple modes of learning, peer interaction, notes-study aides, fun-enjoyable, interesting, passionate teacher, and understanding teacher-positive. Of my active learning assignments explored in this research, which my students had yet to experience as they took their pre-class test, 15 mentioned peer interaction, 6 mentioned notes-study aides, 12 mentioned hands-on activities, and 10 mentioned fun-enjoyable assignments. The third most commonly used code, used 26 times, was “good teacher,” followed by, and frequently coded with, “multiple modes of instruction” 25 times. A good number (eighteen) spoke of their own intrinsic desire to learn-gain knowledge. Like myself, some students (7) mentioned prompt feedback-validation as motivating. Seventeen mentioned achieving their grade goals, and eleven mentioned earning their degree-graduating as a motivator.

Post-class survey question A. As our course concluded, students were given the same motivation survey again, asking the same questions they were posed in the pre-class survey. Question A again asked: “In the space below, please list specific things that

INCREASE your motivation to learn in your biology class." Students shared both things that they would consider motivating in any class and things specifically from our class that they found motivating.

Kaitlin held biology in high value: "It helps with literally everything… Biology is so important." The content of the course itself and how it's presented was also a major motivator for Leilani: "I think that when the content we are learning is presented in a way that is both informative and interesting, it allows for the students to retain information better. I also think that it increases the motivation we have because we look forward to learning new information." Like many of his peers, Cillian enjoyed learning biology with real world application "Understanding how our anatomy works has helped me understand how to better take care of my body in order to live a healthier lifestyle." José was motivated by learning about biological concepts that he thought were relevant to his own life: "I believe that since I am an athlete, the parts where I learn about nutrition and how our bodies function when we consume food is a very important factor for me. It helps me stay motivated and want to learn about the lecture even more." Matilda saw the relevance of biology not just to her own personal life, but to the entire world around her:

> Specific things that increase my motivation to learn in this biology class is not only learning about how different organisms function but ultimately understanding how it affects our world and humans. It is eye opening to see how much of my life is actively affected by biology even if I may not be totally aware of it all the time.

Likewise, Ryan shared: "Being able to connect it to what is going on around me in my life and connecting it to major world events in the present time." Daniel was also motivated by learning relevant biology:

> When it's all about MEEEEEEEEEE! Well, not directly me, but how the things we learn affect "me," ("me" being students in this current time and place.)

> Local geographic area-specific examples, "Fossil fuels create air pollution that used to cause smog alerts throughout Southern California until regulations were implemented. That air pollution possibly cause you or your parents to..."
> "The melting polar ice caps are causing the mass extinction in the polar biome, and also negatively affecting your local beach cities by threatening the Los Cerritos Wetlands.."
> "The foods you eat won't just affect you today; they will affect you later in life by impacting your overall health and well-being by..." (This was covered in class.)

That our class was interesting further fueled Bridget's curiosity: "Things that increase my motivation to learn in my biology class is the content and interest I have for the environment and learning why and how things happen the way they do. It's fascinating how everything works, and it makes me want to keep learning."

Salvador expressed his appreciation for having choice in our class with the You-pick Assignments: "The fact that we can pick our own assignments is what I really enjoyed and makes the class feel more about learning and less about getting good grades."

Many students looked to their instructor to motivate them, like Ruth: "Motivation is all based on the professor. Since the professor I had was a great professor who explained everything really well which made me motivated to complete my assignments since I was able to learn everything on lectures." Attitude of the teacher was likewise motivating to Victor: "A teacher who genuinely loves teaching is a motivation because it shows through how they teach and how they explain concepts. I genuinely enjoyed the lectures in this class."

The accessibility of asynchronous online lectures allowed Jiaoxian to study when her motivation was higher: "The lectures being online and easily accessible at any time made it good to learn when I actually felt like learning and not just being forced to listen to a lecture

when I didn't feel like it." Tiffany shared a way she was able to take notes more efficiently in order to reduce her cost of time and thus increasing her motivation:

> "I struggled with focusing and finding the motivation to watch the lectures in the first 2 units. By the third and fourth units I figured out that by speeding up the play back speed I did better (1.5 and then 2). I am also not a fast typer so screenshotting the slides and adding comments worked better for me and once I figured that out it also became a bit easier."

Providing multiple modes of learning helped students like Luca: "Seeing visual representations along with diagrams provide the most motivation to learn more. I am not the type of person that enjoys reading a biology textbook. However, I could spend hours watching a documentary on different species." Adriana was also motivated by having lecture videos: "I think assignments with videos and easy broken-down explanations motivates me to learn because it makes me feel confident and like I'm learning since it's easy to understand." Ines cited a combination of active learning with flexible asynchronous lectures: "Doing assignments at my own pace and having a lab to go with it."

While my students were not biology majors, there were some who entered my class already interested. That they learned more about their prior interest was motivating for Mei: "I love animals and nature so taking biology class helps me to understand them more."

Daniela: "One of the things that increased my motivation to learn in my biology class is simply that [it] is fascinating. Sometimes it can be difficult to remember certain processes and terms like the difference between mitosis and meiosis, but it was all so interesting. Other things that increased my motivation were simply seeing that my work was complete, and I had one less thing to worry about, and reading my peer's discussion posts and seeing what fun ways they were applying new knowledge."

Like many of his peers, Michael was motivated by organized teaching of real world-relevant concepts, active learning, and peer interaction:

> 1. Engaging and interactive teaching methods, such as hands-on experiments, demonstrations, or group discussions.
> 2. Relevant and interesting topics that connect to real-world applications or current events.
> 3. Clear learning objectives and expectations, providing a sense of purpose and direction.

Even for students with a prior interest, such as Marie, active learning is important for motivation: “I have always found Biology really interesting so for me I never really lack the motivation. I think something that increases my motivation is when there is activities explaining concepts rather than just lecture notes.” Similarly, Lilly shared the importance of active learning even for those with prior interest:

> I honestly love science in general so do not need much to motivate me to learn in my biology class. Although sometimes it is just scary to not fully understand because I doubt myself too much and think I won’t understand everything. I think things that can increase one's motivation to learn in my biology class is due more "hands-on" interesting lectures. This gets others involved and want to learn more regarding the topic. I also love learning about animals because I love animals.

Several students like Daisy were specifically motivated by the Skeletal Notes and You-pick Assignments: “The note template is provided for me to take notes. I am able to pick the assignment I want to work on. The grading scale is not too tough or each assignment in the course weighs too much on my grade.” Having choice in the You-pick Assignments motivated Jesús: “Biology is very interesting and important to learn. As each week goes by, I became more excited to work on the assignments for this course. Also, we were able to choose what assignment to do or what to read, which made it more exciting to learn.” Huang shared that specifically the active learning aspect of the You-pick Assignments were motivating: “To increase my motivation of learning in biology, there

should be more outside learning, learning from the real world, which the u-pick (sic) assignments have."

I frequently noted in my researcher journal when I would send reminder announcements and my belief in their importance to student success. However, only one student noted their influence on increasing their motivation in our class.

Pre-class survey question B. Students were asked in Question B: "In the space below, please list specific things that DECREASE your motivation to learn in your biology class."

Like others, Carlos found the field of science intimidating because of the perceived difficulty: "Science in general has never been a strong area for me. I find the information too difficult to be motivated to know more than what I am assigned to do."

Thomas linked poor teaching with passive learning: "Monotone lectures, no interactive activities, and unclear instructions would decrease my motivation to learn in biology class." Hua cited poor teaching as well:

> Some things that decrease your motivation to learn is if the material was not explained well, the information being taught was unnecessary, and if the information was presented in boring way in general. If the quizzes and assignments also ask for miniscule details, it would decrease my motivation as well.

Lauren was succinct in what makes a demotivating class: "Excess work, a bad professor, busy work or too much reading that is uninteresting, material not being the same as on the test, no current world connections." I coded her response bad teaching-confusing, boring, too much work, busy work, unfair grading, and irrelevance.

Muhammed shared how busy work was demotivating: “Too much unnecessary work and assignments just to keep busy.” Likewise, Daniel cited work with a high cost with little reward: “Exhausting workloads, lots of lectures/notes to read and process, and harsh grading criteria not focused on the effort made by student.” Similarly, Raul described how busy work increases cost while decreasing value and expectancy: “ ‘Busy work’ can also feel demotivating, as in assignments that do not necessarily feel like they further comprehension of the material but still consume time.” Soledad shared: “Overwhelming amounts of information to remember.” Leilani succinctly shared what makes a demotivating class, coded irrelevant, too difficult, and too much work: “I am less motivated to learn biology when the concepts are hard to understand, take too much time and effort, or are hard to enjoy or relate to.” The attitude of the instructor was important for many students, Akira shared: “professor sounds bored, monotoned, or lack of energy when teaching.”

Bonita felt that clear communication was an expectation in an online class: “Negativity, confusing material with unclear instructions can decrease my level of comprehension and motivation. Since it is an internet class, I expect my professor to be able to answer any lingering questions about assignments, videos, essays, and readings.”

Whereas many students shared that learning through multiple modes of instruction was motivating, many expressed the demotivating effect of exclusively receiving instruction through readings. Leila: “My motivation will be decreased if the majority of learning is all through the textbook, as well as if the quizzes and midterms are more tricky and not as similar to the information provided.” Similarly, Victor explained why relying solely on reading decreases his potential to learn: “The big thing that decreases my motivation for

biology is an intense amount of reading. I normally need a picture or video of what I am learning in biology to understand it."

With students juggling other responsibilities, their motivation could decrease: Linda: "Specific things that will decrease my motivation to learn is other classes getting in the way. Work will also be a factor in decreasing my motivation since it will take time away to do assignments and study.

Students are dealing with challenged beyond the classroom: Joanna:

> I am a student athlete… With that being said I try my best to navigate our busy… schedule and my classes, however I would be lying if I said it didn't get in the way occasionally. Especially considering travel unfortunately sometimes requires us to miss class. Although I can guarantee that I will put forth utmost effort in BIO and will do the best that I can. Another factor that may get in the way with my motivation is my mental health. With recent personal events of which I prefer to not disclose, my mental health has been a battle over winter break. I fell into a depression over break and am working to navigate that, however I cannot speak to whether it will carry on into the school year or not. This is essentially new grounds for me. However similarly, I plan to do my best and will work towards success all that I can.

Daniel listed several demotivating factors that were also commonly shared by his peers:

> 1. Lack of Relevance. (When I cannot see a connection between biology concepts being taught and their relevance to the broader world or everyday life, it makes it hard to engage.) 2. Overwhelming Jargon. (Excessive use of complex scientific terminology without adequate explanations or context can make it inaccessible. We need the terminology, but we also need it restated in plain language.) 3. Monotonous Methods. (Repetitive lectures without interactive elements, hands-on activities, or real-world applications.) 4. Heavy Workload. (When a class requires an excessive amount of coursework, and¬† assignments, and exams without clear educational benefits, it can be demotivating, especially when trying to balance coursework across 12 to 16 units.) 5. Lack of feedback. (Professors who are unapproachable, unresponsive to questions.)

Some students cited a poor study environment, outside the classroom, as demotivating. Megan:

> Socializing with those who plainly deny well-supported theories in evolutionary biology could potentially decrease my motivation to learn in this Biology class. Not receiving an adequate amount of sleep and not eating in as healthy of a manner as I should could potentially decrease my motivation to learn in this Biology class. Consuming excessive amounts of alcohol and other drugs could potentially decrease my motivation to learn in this Biology class.

A concerning trend was that several students cited their mental health as demotivating to learn. Fatema: "I have severe depression, and I struggle to even do daily activities due to fatigue and lack of motivation."

A large portion of students cited excessive reading as demotivating, Miguel explained why: "Long amounts of readings just because of my level of understanding, I sometime do not comprehend everything."

Carlos shared what makes a demotivating lecture:

> Monotonous Teaching Style: A consistently monotonous or uninspiring teaching style can lead to boredom and decrease my motivation. Lack of Clear Organization: Poorly organized lessons, unclear instructions, and a lack of structure can make it challenging for me to follow along and stay motivated. Irrelevant or Outdated Material: Presenting outdated or seemingly irrelevant information without connecting it to real-world applications can diminish the perceived value of the content, reducing motivation to engage with the material.

For students who mentioned their other responsibilities outside of class, they often cited this as their own problem they needed to overcome themselves: Lilly: "Biology is not always easy and can be a bit tricky. It requires times and to put one's full attention. Although I have work and more classes, I need to learn to manage my time properly."

Post-class survey question B. As our course concluded, students were given the same motivation survey again, asking the same questions they were posed in the pre-class survey. Question B again asked: "In the space below, please list specific things that DECREASE your motivation to learn in your biology class."

Most students shared things that are generally demotivating in any class, which I coded similarly to the pre-class survey. However, some shared instances of their demotivation specific to our class.

As mentioned in my Researcher Journal, I messaged students who had yet to submit their work shortly before the due date, in an effort to minimize zero grades for those students. While my intention was to help improve student grades by reminding them to submit their work and avoid a zero, the impact on one student was surprising:

> On unit one you send me a direct message about you pick 1, and that decreased my motivation me and felt a bit passive aggressive. As I had already submitted the notes for the unit, showing that I had already watched the lecture content, I do not feel that should have been sent that early (maybe if I hadn't even started the lectures it would have had a better response). If the message had been a general announcement or even the night before/the morning of the due date I would have responded better. But a direct message over 24 hours before the due date, when I had already shown that I had started the Unit did not make me want to complete the unit.

In contrast, Alfredo shared "The main thing that decreases my motivation to learn in my biology class would be doing bad on a test or assignment." Which is what I was trying to avoid by sending extra reminders to submit work.

Several students mentioned that learning evolution was demotivating as it conflicted with their personal beliefs. Joseph shared his discomfort learning other sensitive topics: "Sometimes we learn some inappropriate things in Biology such as the food cycle, our body parts etc. It makes me feel uncomfortable but it's anatomy, so I have to deal with it." Daniel

also shared an interesting instance where the field itself was demotivating: “The only thing that decreases my motivation to learn in my biology class is when we use weird words such as Eukaryote.” This is obviously something no teacher could change. Jacob shared how learning the content itself was difficult, although mentioned how the open-note format of the exams assuaged this challenge: “Some things that decrease my motivation to learn in my biology class is just the sheer amount of memorizing needed for certain topics. At least in this class, it is open notes and open internet which is amazing but if it were an in person, memorizing is something that I do not enjoy very much.”

Cillian cited his lack of confidence in the sciences stemming from his prior experiences: “I have failed science classes before, so I always second guess myself when it comes to certain assignments.”

Cristiano described the toll that classes can put on students: “Being pressured to do good on exams and having to study most of the day just to pass. Classes like those are very draining and depressing to be in.” Estafania similarly shared the struggles students face balancing their health and school: “The things that decrease my motivation I can say is just the lack of time, or not getting enough sleep. I think that sleep is something I have valued finishing college, and the work will get done, but I will be getting sleep before or after it.”

Interesting, while many students from my interviews praised the benefit of the skeletal notes, some found them to be too much work. Isabella: “Having too much work assigned that requires a lot of notetaking can take away my motivation from diving into the work in general, this may also be because several other classes make notetaking optional rather than required. I personally think the lectures should be enough.” Interestingly, I

never specify how detailed their notes have to be and emphasize that they are to be used for their own benefit.

There was a wide range of prior experience with biology, with some, such as Noah stating their “limited previous knowledge about biology” was demotivating, while others like Dai Lu stated, “there are some things that I have already learned in middle/high school that I keep relearning and that makes it boring.”

Like the pre-class survey, students again mentioned excessive reading as demotivating, in contrast with our own class: Victor: “Reading textbooks decreases my motivation to learn biology. However, the approach to learning in this class's model is a lot more favorable.”

Several students compared our class to other classes when asked what was demotivating. Nevaan: “Busy work and way to long notes. Luckily my bio class doesn't have these, unfortunately my chem class does :(“ Daniel similarly compared our class:

> Jargon, highly esoteric knowledge. Please don't focus on the Zonule of Zinn for a serious length of time or make it a test question in a General Biology class. If it is required for a person's degree, they'll take human anatomy to cover it. This class did not in any way do that, this class was great. I've had this happen. it was awful for all involved.

The importance of teaching course content in a relevant way was demonstrated well by Trung:

> When I know I’m learning biology for the sake of learning biology and will not have a use for it in the future after the class. an example form classes (not from college) in the past is when we learn about the anatomy of an earth worm (which is understandable if we was [sic] learning about the anatomy of different species, but we was [sic] not) and student know that they won’t really use that knowledge again.

Ulysses opened up with his mental health struggles and lack of confidence in his own aptitude:

> As much as I adore learning about science, I do struggle with math a lot and I am a more creative mind such as painting, writing and set design. I've grown up thinking I was going to be an artist, so that does not only discourage me with "My mathematical research might be wrong" but also the idea that I won't truly fit in and like the medical field I'm pursuing. They do say to get a job you love doing and that you're good at. On top of that, memorizing has never been my strong suit as I do struggle with ADHD so this often really discourages me from doing well in most learning environments. I would apply for accommodations, but it seems like a waste of time for me, personally.

Motivation survey thematic analysis. As I coded all four survey responses (questions A and B for each of the pre-class and post-class surveys) of my 131 participants, I developed 49 codes. Active learning was mentioned numerous times (72) as a motivating factor. In contrast, passive learning was mentioned 9 times as a demotivating factor. Relevance was mentioned 80 times as motivating, and irrelevance was mentioned 24 times as demotivating. Organized was mentioned twelve times as motivating, and disorganized was mentioned 5 times as demotivating. Having sufficient time-cost was mentioned twenty times as motivating, in contrast with too difficult mentioned twenty times and too much work forty times as demotivating.

There was largely a consensus among my students, with nearly all codes either entirely motivating or demotivating. However, there were several codes that increases motivation for some, but decreased motivation for others. An asynchronous course format was mentioned 18 times as motivating, and 2 times as demotivating. Peer interaction was mentioned 24 times as motivating, but our discussion posts were demotivating to one person and group work was mentioned seven times as demotivating. Notes-study aides were mentioned six times as motivating, but nine times as demotivating.

Students more often stated in the pre-class survey that excessive reading was demotivating. In the post-class survey, they more often stated that long lectures were demotivating. They have to get the information somehow. That they gain information through multiple modes of learning was mentioned 33 times as a motivating factor.

Table 3. Code Mapping for Motivation Survey Questions A & B
(to be read from bottom up)

Third Iteration: Themes
Active learning is motivating, and passive learning is demotivating. A desire to learn combined with a good teacher maintains student motivation. Some practices are overwhelmingly better than others, but students are still unique. Teachers must balance course work to maximize benefits to students.
Second Iteration: Categories
Students want diverse and hands on learning, not just reading and listening. Engaging teachers and enjoyable classes increase motivation. Learning relevant information that is interesting increases motivation. Students come to class with multiple sources of motivation. Students face many different challenges that decrease their motivation. Too much difficult, confusing, boring, monotonous work is demotivating. Students have responsibilities and challenges outside of class that effect their motivation. Online courses work best of some, but not others.

Notes assignments are beneficial to some, but not others.

Peer interaction is beneficial to some, but not others.

Some students come to class interested in the subject, others do not care.

First Iteration: Initial Codes/Surface Content Analysis

Increase motivation

Choice, earn degree-graduate, engaging, family pride, fun-enjoyable, good study environment, good teacher, grade goals, hands-on, interesting, intrinsic desire to learn, laboratory, low cost-effort, multiple modes of learning, notes-study aides, organized, passionate teacher, peer interaction, prior interest, prompt feedback-validation, real world-relevant, sufficient time-cost, understanding teacher-positive

Decrease motivation

Bad teaching-confusing, boring, busy work, disinterest, disorganized, excessive reading, excessive writing, group work, incompatible with beliefs, irrelevance, lack of confidence, long lectures, memorization, mental health, neglectful teacher, notes-study aides, nothing, other responsibilities, passive learning, peer interaction, poor study environment, too difficult, too much work, unfair grading, vocabulary

Interviews. To gain deep insight and paint a richer picture of student experiences, I conducted follow-up interviews after the term had ended with seven former students. (See Table 4 for interviewees' demographics.) Interview questions started with a jumping-off

question about how our class impacted their motivation in general, then specifically their expectancy, value, and cost associated with our class in order to prepare my interviewees to think about the three aspects of motivation I measured. In order to answer the research question and learn how specifically active learning impacted their motivation, we discussed each of my three active learning interventions, and I asked how each of those active learning assignments impacted their expectancy, value, and cost to learn biology.

I shared significant quotes from interviewees below, organized by each active learning intervention and then each of the three measures of motivation, alongside my contextualization and interpretation of their meaning. I analyzed the interview transcripts using Thematic Analysis. I assigned codes to segments of the transcripts, then used those codes to form categories, and finally used those categories to derive themes from my interview data.

Skeletal Notes. Students appreciated the Skeletal Notes assignment, and the consensus was that they were worth the extra effort it took to complete them because they facilitated learning and prepared students for the exams.

Expectancy

For student **Salvador**, the Skeletal Notes assignment was an easy way to prepare for the exams. They increased his expectancy that he would learn and remember the course content for the class exams, as he shared, "If it's something I wrote down, I usually remembered it… and actually in most of the exams, if I wrote it down on the Skeletal Notes, I remembered what the answer was." While Skeletal Notes are a more active learning assignment than merely passively listening to lectures, he still found them less taxing to complete than the assignments from his other classes for his engineering major. Starting an

hours-long session of grueling homework with our Skeletal Notes assignment gave his "brain a warm-up."

Having an organized structure with clear instructions helped **Sofia** manage her time in our biology class. She shared that the organization and flexibility of our well-organized online class kept her motivated and helped her succeed, in contrast with negative experiences she's had with previous online classes, she stated "by the end, I was actually like really surprised that I actually did really good." **Sofia** found the Skeletal Notes assignment very beneficial to helping her understand biology and succeed in our class:

> The videos actually tell you more if you pay attention to them. It's taking the time to, like, listen carefully, because just by watching the videos, you know what you're supposed to do. So, doing that assignment actually was not as hard as I expected it to be. Because I actually took the time and listen to the videos, watch the lectures and everything that was related to that. And on my own side I was like, okay, well, I don't know what this exactly is, so let me do my own research. And actually, researching stuff that I didn't know… helped me more with the assignment. So, I was really proud when I got my grade back.

Catalina has struggled with taking helpful notes in previous classes, "I still don't know how to take notes to this day. Like, it's either I just make a bullet point and then I bold what I'm supposed to be learning about, and I call it a day, but other than that I don't know how to take proper notes that will save my life." But **Catalina** found the Skeletal Notes assignment helpful to her success in our class, which served as a very active assignment for her**,** in contrast with typical notes that are more passive:

> It was really, really different from the usual notes I take but it was… really helpful to me, a lot, to just sit down and listen to the lecture and then write down the notes… that were going to be helpful for me for the test. Before we started the notes… we had the objectives that we had to write down and then, without looking up the answers, the little questions that you would have for us, that was also very engaging because it made my mind think. Like, it really made my mind think, and then like without looking at the answers and then just thinking about it.

Danielle likewise benefited from the organization the Skeletal Notes provided in keeping her engaged and motivated in our class and gave her study skills she will take with her in her future education.

> I really like the structure of the Skeletal Notes since it was really organized, so since we just had to put in our own notes, and then I really liked how there was the section where you would ask… 'how would this relate to the… Nature of Science,' and then I also liked how you made us write the components 1st, to know what we're going to learn about. So that really amped up my motivation too, and then that helped me structure my notes through each lecture. But… most of all the organization is what made me have… a greater expectation to get through the notes, to… be more motivated as well.

John felt that the excellent organization of the class with clear structure gave him a high expectancy to succeed: "Definitely… after that 1st unit I was very, very confident. I had a high expectancy to succeed just because everything was so straightforward. The format for the class was very easy, easy to follow. I knew what I needed to do. I knew when I needed to do it. And so, I had a high expectancy to succeed." Furthermore, the structure of the skeletal notes assignment itself helped him succeed in our class:

> This is my 4th year in college, and I still don't know how to take notes (laughs) in a way that, like, is effective, that I can go back and study, and the skeletal notes were super helpful for that because it was like, it was structure. I didn't have to come up with a structure myself, it was there for me, telling me where, if I had questions, where to put them, if I find answers, like, I know where to put them. Each unit is broken down and so it was it was very helpful for me personally.

Like many students, **Ángel** didn't come into our class with the best note-taking strategies, but he found that the Skeletal Notes assignment facilitated deep engagement with the lectures and helped keep him on-task, especially in an online course where one could easily get distracted:

> I feel like they actually help me a lot. I mean, to be honest with you, I'm very bad at notetaking individually, so, kind of having that guide. And to be honest with you, online classes, I can have 4 tabs open to be honest with you, and working on different classes, but it kind of made me sit down and focus on your class *only*, because I had to watch the videos and kind of take what information I found important and transfer it over to my notes. So, you made it in a way – which kind of is frustrating to a student – but overall looking back as really good because you can't just copy and paste what you want. You actually have to type it out. So, it kept me engaged and it just made me focus on one thing at a time.

Furthermore, having the class content outlined and filled in with his own notes from the lectures gave **Ángel** confidence that he knew and understood the material:

> I mean, having the skeletal notes. Me, I really just try to take everything honestly with school, so I won't have my notes out or anything, so being able to just study those notes and have a good guide out. I really just want to get a good basis on my grade and how much I understand of it. So, the end of the day, I'm going to need it later on down the road. Even if it's just a biology class, it's still something that's going to pop up that I may need, and just being able to keep myself honest and have that structure and have that outline that I need to follow to be successful in the class is very good.

For recent graduate **Rita**, she found her motivation generally decreasing through the semester from a combination of factors, including "senioritis" and the stress of taking 18 units. However, she knew what to expect in our class due to the organization and framework of the notes:

> So, it was kind of kind of a lot at once, so I feel like I had a tendency to put more energy into my in-person classes, however I did find that it was helpful that it was a similar structure throughout the semester, and it was good in that I knew what to expect every time, and I felt like I knew what I was doing and it was easier as I went on because it got into a little bit more of a routine, and I knew exactly how I wanted to take notes, exactly how much notes I should be taking.

Her confidence that she could produce work which I would grade highly was bolstered by the organization of the Skeletal Notes assignment themselves, which provided

clear instructions on how to complete them, a rarity in her prior experiences with online classes:

> I think that it actually helped quite a bit. I really enjoyed the structure of the Skeletal Notes because it really clarified things, and make things a lot easier to understand, and that is hard in an asynchronous class, often because … expectations are a little bit more blurred because you're not as in close contact with the teacher, maybe. So, I think it really helped brake things down, and it allowed me to focus on each section individually as opposed to blindly taking notes on an hour and a half of content and not knowing what's important and what to prioritize. So, I think the Skeletal Notes were really helpful honestly. And they definitely confirmed that I would be able to succeed in the class. And that I could meet your expectations.

After years of college, **Rita** knew from experience that each professor has their own idea of what constitutes good work, so she initially didn't know what to expect from her grades going into our class, but was assuaged after earning good marks on the first Unit:

> I feel like throughout I was expecting to be able to succeed. I think for the first module I was a little bit more concerned because I wasn't sure how detailed things needed to be, how thorough my notes needed to be, just because I feel like every professor kind of has different things they want you to take from their lectures, so I wasn't exactly sure what the initial expectations were, but, after seeing my grade on the first one, I decided what I was doing was okay and that I could continue doing that throughout [the course].

Like all my students, **Rita** was not a biology major and was taking my class because of general education requirements to graduate. As a senior taking my freshman-level class, she was not expecting our Gen Ed class to cause any setbacks for her goals:

> But I was pretty firm throughout that I would be able to get a good grade in the class, and then I could put enough effort in to get a good grade in the class without it taking away from my other studies either. And I would say the motivation portion is definitely a little bit harder when it's asynchronous and a Gen Ed. that isn't major-related, which, it's kind of understandable. So, for me, it was definitely an expectation that, like, this would be a little bit easier and maybe a little bit – I know this is not what you want to hear – but like definitely a little bit, like, less of a priority because of that. But I think that's generally how I feel with gen-eds.

Nevertheless, while completing her Skeletal Notes assignment, **Rita** found the lectures engaging and interesting, despite her experiences to the contrary with other online and general education classes:

> I actually liked your lectures a lot more than a lot of other asynchronous classes I've taken and other gen-eds that I've taken. So, I did appreciate the way you explained everything, and you sounded more relatable in your examples, and just your tone generally, and it was definitely more engaging than other ones I've taken. So, I did appreciate that. It's hard when you are teaching a topic that a lot of people don't expect to enjoy as much, but you did a very good job.

Value

The Skeletal Notes assignment helped **Danielle** prepare for the exams, increasing her expectancy to succeed in this and future classes, while simultaneously inspiring her to value biology more:

> The Skeletal Notes also impacted the value, since, like, in other classes, they just tell you, 'Oh, just watch a lecture and do your own notes,' but I feel like this made it more valuable, like learning biology. Since I wouldn't really, like, pay attention to biology, but after like using these skeleton notes and going through it, it made me more aware, and it prepared me for the exams better. So, it was like more valuable for me to be better in bio and study, have better study habits as well.

In the Skeletal Notes Assignment, students are tasked with connecting their current lecture topics to the aspects of the Nature of Science, which I taught at the beginning of the term. **Salvador** felt this reinforcing of the NOS aspects through the lecture content helped him better understand science and prepared him for discourse with colleagues outside of academia. Furthermore, the lectures themselves allowed him to connect his funds of knowledge to the course content, reflecting on how his upbringing on a country homestead related to the study of ecology, with diverse ecosystem of plants and animals connected to one another.

Sofia found considerable value in connecting the skeletal notes assignment to our lectures, especially in how the assignment encouraged her to formulate her own questions:

> Well, it made me value biology a little more, given that at first, I was like, okay, well, it's just bio, like, what's really interesting about it? But going into details and looking at the notes, being able to look at videos and take notes about what we're looking, creating our own work regarding what we saw or anything that we had seen before actually, like, okay, well, maybe there is more to biology than I thought there was. So, it just opened a lot of questions for me regarding biology and I'm like, now I could actually look into it and research on my own or ask more questions about it.

Furthermore, **Sofia** shared that by more deeply engaging with the lectures she developed a new appreciation for biology as a whole, whereas before she did not care for the subject:

> It gave me a different understanding and it showed me that it's not just one thing regarding biology, but it's everything around it that makes it interesting and more able to like, oh yeah, I want to learn more about this because, well, this assignment just like opened my eyes to this big thing, but it's not just that one big thing, it has like a lot of other things around it that are connected. In high school never had a good biology teacher. So, I was like, okay, well, if I didn't have a good one, like what's going to change? But then I had this class, and I was like, wait, so maybe it's not everybody. I was like, okay, I actually like this now, like the concept of biology is different from what I had like expected it to be.

By engaging with the lecture through the Skeletal Notes assignment, **Catalina** experienced a new appreciation for the field of biology as a whole:

> It was really helpful. It was good. It made me value biology more and made me appreciate why biology is such an important topic to learn about, and you know, what it brings to the world itself because biology is practically pretty much everywhere. It's not just, oh, like, your DNA and everything like that … it's practically everywhere you look, everywhere you turn, you'll see something regarding biology. So, I feel like that really helped me appreciate more, and you know, just value little things that biology has to offer.

John saw value in engaging deeply with the lectures as the content was relevant to his job and interests:

> I am a personal trainer and so there was a lot of high value in the content of the lectures. A lot of stuff that I was watching over and over again taking notes on just so I could be like, 'This is this is good information,' not just from, like, an exercise perspective, but from a scientific perspective, so there was high value as well.

In the Skeletal Notes Assignment, I ask students to reflect on how the lecture content relates to the wider Nature of Science. This allowed **John** to gain a broader perspective of biology and science without solely focusing on the details of the lecture:

> How every chapter was asking about the Nature of Science, and how the lecture that I just watch connects to the Nature of Science, I think it helped me kind of scale through, like, broader biology concepts, you know, not just these are like the small things that we're learning, but like from beginning to end for all of biology: this is how what we're learning is connected. Something in that aspect helped for sure.

Ángel felt that the Skeletal Notes had a big impact on how he values biology, and that what he learned and what he wrote in the notes he could keep using even after the class has ended:

> I could see myself going back and having those all saved on my computer. Something pops up, I know the answer to it. Or being out just knowing that I have that stuff in the back of my head, or just kind of remember it in the slightest bit, I feel like is beneficial in the long run.

By providing my students an outline of our lectures, **Rita** could engage more deeply with the content of the lectures, making her own connections and priorities:

> I think they definitely increased [my value of biology], just because I could focus in more concentrated bits on each subject and pick out what I thought was important and what I thought was relevant. And I will remember lots of the things that I did write because … I think it being in a condensed format and breaking down each section was really helpful because when you're listening to an hour and a half lecture, sometimes it's hard to pick out exactly, like, what's important in there. So, I think it did increase the value for me.

<u>Cost</u>

Salvador agreed with other students that the Skeletal Notes were a good investment of his time:

> I would say it saved time in the back end, not necessarily the front end. Because every time I had to pause the video in order to like, right down… what you said, but definitely on the back end it saved me a lot of time on the exams because like I said, if I wrote it down, I most likely remembered it. But if I didn't write it down, I would have to go, you know, skim through notes… That's how I'd say the cost broke down for me. Pay it off in the back end. Not necessarily in the front end when I was taking notes. In fact, they probably took a little longer, but I definitely prepared it that way, because if I wrote it down, like I said, I remembered it for the exam.

Sofia likewise shared that the skeletal notes prepared her for the rest of the class, as she stated, "Well, it definitely made sure that I was ready for like the rest of the assignments that were coming up." And while completing the notes was a time commitment, having the flexibility to complete them on her own schedule as part of an asynchronous online class made it easier to manage this class in addition to the rest of her course load.

While the Skeletal Notes assignment was a "time-consuming" task, **Catalina** felt that the organization they provided made for a more streamlined and engaging task, than if she had to take notes herself:

> Yeah, it definitely helped more since they were already structured out … it was very helpful because you also made it engaging for us … Like the questions that we had to ask at the end and then the answers that we had to find ourselves from that lecture, made it more engaging to us.

Having me provide the Skeletal Notes as a template instead of creating notes herself from scratch as is typically done in other classes was a time-saver for **Danielle**:

> It would give me… more energy, like more motivation… I've never like done this type… this is my first class that I did Skeletal Notes, and I feel like I would do this kind of structure for any other class. I just feel like it's more motivating… it saved me a lot of time. A lot. I feel like it's a more faster and structured way to complete your notes.

John felt that the cost to succeed was low in our class, and was time well-spent: "it wasn't too high of a cost either. I think, the lectures and the notes, both together prepare you very well for the exams." He felt that the time and effort it took to complete the Skeletal Notes Assignment was worth it because they facilitated his learning, preparing him for the exams:

> I think they affected the cost in a way that like, on one hand, like, it was a greater cost because they took more time. But on the other hand, that cost is kind of accounted for because I actually learned taking the notes. And the exams, they were open internet open books, so I could have very easily just used Quizlet and taken the exams and not really learned anything. But because I could take the notes and they were there, like, the time was worth it because I actually learned the material.

Like many others, **Ángel** felt the time spent on the Skeletal Notes was time well-spent: "It cost more time, but it was a hundred percent worth it."

Recent graduate **Rita** felt that the Skeletal Notes made watching the lectures and taking notes easier, because I had already done the work of the first step of organizing how she should structure her notes before she even began:

> I think it actually lowered the costs in terms of the class… There was less opportunity cost involved because I did not spend quite as much time picking things apart; you kind of did it for me, if that makes sense. And I think it made the overall structure of the class better, so I think it lowered the cost of taking the class… Streamline the process… Just much more consumable, if that makes sense.

You-pick Assignments. Students felt hugely positive about their You-pick Assignments.

<u>Expectancy</u>

Salvador shared that the You-pick Assignments were a welcome break for his mental health during an otherwise stressful semester. The act of watching a biology

documentary and reflecting on it calmed him down after a disappointing result on a physics exam. Salvador described how for one assignment he watched a Biology Department Seminar, and while the topic described cutting-edge advanced cellular biology beyond the scope of our course, being privy to science-in-action gave him a new appreciation for the field. And while the You-pick Assignments didn't necessarily change how he expected to do on the exams, he nonetheless felt they were a meaningful and worthwhile learning experience:

> For me, the You-pick Assignments didn't really help on the exams, but…I wouldn't say it was a waste of time doing them, because it kind of still put me in to a learning mode. And isn't that kind of the goal, to Learn? You know, not be so focused on… like because a lot of professors they really want kids to learn instead of just chase the grade. And I guess they kind of did that, where it didn't really like help the grade, but it was good to learn.

Sofia expressed that the You-pick Assignments were manageable to complete, so long as students managed their time well. While she was at first confused about how to start and create a unique assignment, because the course was organized with flexible due dates, she was able to manage her time with her other class commitments:

> So, it's not as hard as it looks, but it is time-consuming. So, knowing that I was going to have to maybe take a good hour to do my research or like, I don't know, a day to do the stuff if I needed to go out for it, it was more of like, okay, so I need to like clear a certain day that I'm going to be doing this assignment... So, knowing that I had enough time to where I could work on one assignment itself was like, okay, well, maybe I do expect to do better by the end and then when I got my grade I was like, okay, yeah, I did good.

The You-pick Assignments inspired **Catalina** to try new experiences that she never would have expected to do before, whether for a class or otherwise:

> Because you don't really see that for other classes. Like, other classes wouldn't ask you [to do] that. So definitely once in a lifetime experience, which I really enjoy.

For one assignment, she visited Planned Parenthood, something she never would have considered doing if not for our class, as she stated "Honestly, I never really saw myself as going… to Plant Parenthood just for a class and being like, 'hey, you know, like, can I go and get myself an STI test?'"

After visiting the San Diego Zoo for her first time in order to complete a You-pick Assignment, **Danielle** changed her expectations about biology:

> Taking this class, I really learned many things. …For one of my assignments, I… actually went to the San Diego Zoo and like, I didn't even think like a zoo would make me change my perspective about biology. But after visiting it, it changed my expectations and I really learned a lot about like, the animal lifestyle, the plants, everything, like the whole environment. And since that zoo's really big, I really enjoyed looking at the small details since I wouldn't really look at details that much, but after that experience they changed my expectations of my learning. And it also implemented all the everything like in the lectures that you would teach us too.

The unique and varied opportunities for the You-pick Assignment allowed **Danielle** to try different experiences that increased her expectancy to succeed in our biology class. She found herself more engaged with the activity than if she had done it passively, outside of class, and the assignment inspired her to continue learning about biology:

> I feel like they bettered my expectancy since there was a wide variety of things you could do. So, for like one of them, I watched the episode of the biology of animals, and that made me look more about biology and it also made my expectations higher about biology. And it made me learn even more, like I would read out articles about that episode after, and I wouldn't do that before. Before, I would just, like, watch. And then after, when I would write about it, I would even learn even more. So yeah, it made my expectancies higher.

For **John**, while he would have enjoyed completing the more involved options for activities for his You-pick Assignments, knowing he had a simpler option such as watching a documentary to fall back on had a big impact on his expectancy to succeed in our class:

> Grade-wise success, I think it was just like, 'yeah, okay, I can do this. I can do this for sure,' and if I don't get the chance to do something cool, I have something to fall back on which was, like, huge. I'm sure it was huge for a lot of people.

Ángel appreciated the option to create a picture for a You-pick Assignment, as he described himself as "a very visual person." Furthermore, the drawings he created for the assignment helped prepare him for the exams. Not only that, but the experiences opened his eyes to the biology all around him:

> It kind of opened my eyes to look around my surroundings when I go somewhere new or when I go out in general, kind of take in what's around me, because everything has its own unique purpose. And honestly, day to day, a lot of people just go by and yeah, they see the same thing, but that one same thing has larger purpose than we think it does.

Rita initially wasn't sure what to expect in terms of how she would be graded on her You-pick Assignments. My rubric is quite general to allow students room for creativity. But as the semester progressed, her expectancy that she could produce work with high grades increased:

> Initially I was a little bit worried, because a lot of professors expect different things from something that's 500 words. I think initially I wasn't sure how hard it would be graded, how eloquent I needed to speak, because this felt like more… clearly it's something from my experience versus a hard-hitting educational piece, you know? So again, I wasn't really sure what the expectation was for my writing style and my eloquence. So initially I think it lowered my expectation to succeed in the class, but after again receiving my grade for the first one, I realized that they were manageable and that you were open to different writing styles, and after looking through everybody's it varied quite a bit. So I think [expectancy] just increased as this semester went on.

<u>Value</u>

Salvador expressed his appreciation for having a diverse array of interesting options for the You-pick Assignments, and extolled the value in giving students the opportunity to try something they hadn't before, such as observing nature in-person:

> I grew up outdoors, you know, I'm kind of a country boy, I'm from Texas in the south, so I grew up outside. But for someone who grew up in, you know, the city, you know maybe that was their first time going out to hike, and I think that's cool that you had stuff like that … It's good for people to get out of their comfort zone.

Sofia found great value in researching topics from our class that had real-world applications for her assignment: "I definitely made me value biology more when I started doing my research". Not only did the assignments increase her own understanding of biology, they gave her the confidence to share her new knowledge with others, including ways to improve their health. When friends asked her where she learned her information, she told them: "my biology class… you get to pick your own assignment, which is where I got most of my information from."

Catalina found value in the You-pick Assignments as they allowed her to connect the lecture content to the activity she chose to experience. Furthermore, the experiences helped her appreciate the biology in herself and value her own body more:

> I definitely, like I said, along with the Skeletal Notes, I also really valued it more, biology helping me understand 'why' more. I think what really made me value it was definitely going to Planned Parenthood, like the whole experience of going to Planned Parenthood, and you know, them asking me if I wanted to get blood taken out or if I wanted to do the urine sample, like those, knowing that biology, again, runs in our system, runs in our body, like that makes me value it and value myself more as well.

The You-pick Assignments piqued **Danielle's** interest and curiosity in biology, whereas she had not been very interested in the subject before:

> It made me want to learn more, like, be aware of biology. Like, I wouldn't be that motivated before I took this class, I wasn't really interested in it, so it made my interest go higher. And then it made me like biology more valuable since it's our whole environment, you know, like the whole world. Biology is in our lives daily. So yeah, it just made me see it as more valuable.

While **John** shared that he would have enjoyed doing some of the more involved, time-consuming activities available, he usually ended up completing the You-pick Assignment at the last minute, necessitating the choosing of a simpler option. Even so, from simply watching a nature documentary he was able to draw connections to the lecture material and gain a deeper insight into relevant real-world issues:

> I'm a very last-minute student and so, every time I was going to do the You-pick Assignments I was upset because… it was like 10:30 at night before it was due, so I was like… the only thing that I can do is watch a nature documentary and write 500 words about it. So, like, I was looking through the other options and I wish like I, like, went on a hike and did the sourdough thing, all that stuff sounded really cool. So I think that if I were to take advantage of it, then it would have been more impactful. But even still, like watching the nature documentary, I think I saw a lot of different aspects. I watched like the basic ones, so one Morgan Freeman voiced and stuff like that, which were really cool watching: birth throughout different periods of time; and deep-sea stuff, but I think the most interesting one was about how [snow leopards] in the Himalayas are affecting the livelihood of the people who live there and … it was just like a whole lot. I think I got to see it from a different perspective of how … the people were trying to kill the [snow leopards], but then preservers came and they're like, 'don't kill them you're destroying the ecosystem.' And so it's like, watching how that process took place like killing one species really dismantled the entire ecosystem. And I think it was something that we talked about, how everything has its place. And so just like they were helpful in saying in the real world like how 'does this stuff actually play out?'

Ángel did not come to class with much interest in biology. However, his opinions changed after taking our class and discovering the relevancy the course content had to the real world: "I feel like it just helped me relate it to my own real life." Furthermore, our class inspired him to explore the natural world more closely than ever before: Despite his previous lack of interest, "I'm not a big outdoors person and I hate camping," he finally acquiesced to a camping trip in a National Park with his family: "They've had it planned, and I always told them no, and then one day my mind was just like 'why not go experience

it?' so I'm going… I'm excited now. It kind of just opened my eyes and gave me a different perspective."

Rita likewise gained a broader perspective through her experience with the You-pick Assignment, particularly with her choice to go hiking:

> For the hiking it kind of forced me to evaluate things a little bit differently while I was hiking, which is something I hadn't done before. I was noticing new things and, like, making a concerted effort to notice those things. So, I think it increased [my value of biology] and kind of opened … my perspective a little bit more. So, I appreciated that.

Cost

While completing the You-pick Assignments required time and energy, students nevertheless felt they were worth the cost. **Salvador** shared that the cost of either spending or saving basically equaled out:

> I would say about the middle, because while it wasn't like timesaving because it didn't really help on the exams, I wouldn't say it was time-consuming, because I was still able to learn something, and kind of see a different facet of science.

Similarly, **Danielle** admitted the assignments were time-consuming, but since she got to choose how to complete the assignment, and thusly chose activities that interested her, it was time well-spent: "They did take more time, like doing the write-up, but I didn't mind it because I like the You-pick Assignments. You could pick whatever you wanted, you know?" she emphasized this point when she shared: "It impacted like your energy, like you needed energy to do all these activities, but you wanted to, you know? Like when you want to do something not just because you have to." Having the option to choose an assignment that is enjoyable made the task of completing the assignment likewise more enjoyable.

Catalina agreed that having the flexibility of having different ways to submit her assignments made them less stressful. Having choice in how to complete the assignments

gave her the option to study the lecture material in a cognitively new way, which decreased the cost of completing it. For one of the four You-pick Assignment, she created an illustration instead of the typical written response:

> Definitely for the drawings it, it was also very engaging because, you know, again, you're drawing… It kind of helped my mind, like, relaxed knowing that all I had to do was at that point was just draw. And I didn't have to, like, write an essay or you know write a whole empirical review study or anything like that. It was just drawing that kind of just helped me make my mind more relaxed.

Like the other assignments, **Ángel** felt that the cost associated with the You-pick Assignments was worth it, that they "costs a little bit more time, but was ultimately beneficial in the end." As someone who has taken many online courses, he felt that ours "was a larger cost than a lot of online classes, a cost of time, but it was a hundred percent worth it." Ángel actually admitted that while he could have reduced the time it took to complete the class, he chose not to because it was an interesting class: "I made it more time-consuming. I could have skimmed out on it and just got my grade, but I kind of put a little bit more effort into it because I found it more interesting than my other classes."

Like her classmates, **Rita** felt that the time it took to complete the You-pick Assignments was worth it:

> Maybe from a time perspective they raised the costs slightly. But I have an expectation to write in whatever class I take, so I really don't think it impacted it much at all. I think it was pretty even with the amount that I gained from it versus the time that I had to spend writing and researching.

Peer Interaction. While students agreed that peer interaction can be beneficial, reactions were mixed in terms of how students were impacted by the interactions in the class discussion boards.

<u>Expectancy</u>

Salvador, an older student who attended a low-tech, "old school" high school before COVID and started college after the ubiquitous online learning of the COVID pandemic, did not feel very impacted by the online discussion boards.

In contrast, **Sofia** was greatly influenced by her peers in the discussion board, whom she helped and was helped by in return:

> So, talking about like … 'I could help you understand how to figure that out if you just watch like a certain part of lectures,' or like 'watch this certain video and then it'll give you a better understanding.' And then knowing that if I had a question or something and it was late I could just message somebody from the class and be like 'Hey, I have a question, do you know what exactly…?' or like 'where I could find information for this assignment?' or like 'what video is it?' And knowing that they were like, 'oh yeah, it's that video, like you can find it here,' or like 'in this week lecture.'

Helping each other with the class notwithstanding, having the opportunity to interact with one another gave students a sense of community. Whereas an online asynchronous class could be isolating, interacting with peers gave **Sofia** the chance to see that they are not alone in their challenges: "Interacting with them actually like made me realize that everybody was struggling with something, at least the assignment in the class."

Furthermore, by interacting with one another, students could share their newfound appreciation for the field of biology. Seeing her classmates' perspectives in the discussion boards gave **Catalina** ideas for what choices to make for future assignments as well as new insights for activities she was planning on doing:

> It was really nice to see … what other people did for their You-pick Assignments, especially because I know that that's kind of like the topic that's there. It was definitely really nice to see how others, for example since I wanted to do going vegetarian, I know that another student did that and their experience with it, how it made them feel, like that was really cool to see. It was really cool to … see their thinking as well, like how it made them feel, how it impacted them too. So, it wasn't just more… 'oh, yeah, I'm going to submit this and it's pretty much it.' But I know that there are other people that did different things. It was cool to know too. So, it was really cool, to just

> see and read other people's experiences. …I felt like we were all in the same boat … like, oh, okay, maybe this person's going to do this, this other person isn't into that, and then kind of bouncing off of each other's feedback and thinking like, 'okay, you know what, I also want to do this next time.' I can come back to this person and see how they did it.

Danielle was grateful that I made the change away from simply having students submit their You-pick Assignments directly to me, as she enjoyed seeing what activities her classmates chose to participate it in. This gave her a sense of community within the class as her peers who participated in similar activities could relate with one another and communicate with each other about their shared experiences:

> Interacting with other peers it actually made me more motivated since I got to see… what they did, and I just liked reading their write-ups about what they did and then responding to their discussion posts. Because I would also do some the same activities that they would do, so I would just relate to the post and then just add on to what they did. And just reading about what they learned also motivated me more. …If we just submitted to you, we wouldn't have seen what other people have done, or like, relate to them.

By allowing **John** to see the multitude of perspectives from his classmates, he was able to increase his expectancy in our class, by understanding that there's not just one way to look at something:

> I think definitely … I was like 'So many different perspectives, so many different ways that you can look at the lectures' or ways that, because of the multiple different options for the you pick assignments, like there's just so many different takes on what we're learning in the course and what we're getting out of it. …Yeah, I think that was helpful because it helped me see a lot of different perspectives and I opened up my mind for, like, the next unit that we were going into like … I was looking at it solely from like, *this* sort of biological perspective, but I can look at it from *this* perspective because of the ways that my classmates were looking at them. So that was helpful.

Prior to our class, **Ángel** hadn't seen much benefit to discussion boards as they hadn't been a huge source of interaction. But for this class, he found the interactions very beneficial. He and his peers had even joined a group chat where they gave each other ideas

on what activities and topics to do for their You-pick Assignments. He found these interactions helpful in "a lot of different ways," for example in building a sense of community and mutual support: "if you don't know someone in the class, it can be really daunting, but being able to kinda compare with your peers and kind of give them ideas was really beneficial." The impact of the community was pronounced since the students had the common goal of succeeding in a class that was new to them:

> I know a lot of people were taking these classes for the first time and being able to kind of, not piggyback, but being able to give, like, ideas to other people and kind of help them along the road. At the end of the day, we're all trying to pass the class and we're all trying to be successful… It was a good connection. Like, I also met people that I didn't know that go to school and kind of realize that 'hey, you seem kind of cool,' and go from there.

Ángel and his peers kept each other accountable, encouraging one another to put in the effort to succeed in our class. This community was a give-and-take where advice and encouragement were given and shared by most of the students:

> When you talk to peers, you're kind of expecting yourself to stay engaged with them as well and not just kind of take their information and run with it. You also want to help them; you want to provide something back to them because they've provided something to you. And I feel like it just kept everyone engaged because we were all helping each other and that's ultimately the big thing. And if some people aren't comfortable with that but seemed like about 90% of them were. And just kind of kept everyone in check in a way. That 'hey guys make sure to do this, we're all here for the same reason, let's make sure we get our class done in a timely manner and get a good grade, so we don't have to take it again.'

Rita saw a small benefit in comparing her work to her peers in the discussion boards, but she did not have as meaningful connections with her peers as others did: "I don't think the interactions were substantial enough to change my expectations for the class."

<u>Value</u>

Salvador saw little meaningful interaction in an online discussion board, and as an extrovert prefers interacting face-to-face, but he did see value in having the opportunity to see what his classmates were doing for their You-pick Assignments:

> But like I said, it was good that maybe someone who's never gone hiking or gone to a museum went to one and they might have hated it, or they might have loved it and that's good, you know, it's good for people to get out of their comfort zone and know what they like and don't like.

In contrast, **Sofia** found tremendous value in interacting with her classmates on the discussion boards, which she felt served as a platform to share various perspectives and learn from one another:

> It actually helped me see things differently, cause I was like, okay, so we're all doing a different You-pick Assignment, like we can submit it, not only do we get to give feedback, but we also get feedback regarding our work … So, I'm like, okay, this is fun. Like, I actually love interacting with other people which makes it even better, like not only are we just doing our own assignment or the class assignments, but we also get to interact with our classmates who are probably people that we have in other classes.

Furthermore, having the chance to interact in the discussion boards facilitated a sense of community within and beyond our class, according to **Sofia**:

> When having this class, I realized that I had five people in my actual lab class and in my other two classes. I was like, oh, okay, I didn't know that. So, it was like putting ourselves out there because not only are we like, 'what's up?' Like, 'how are you?' Like, we could actually talk about the other assignments together, like get to know where we are and all of that. So, it helped a lot knowing that we have a community within the class.

Engaging with her classmates in the discussion boards caused **Catalina** to see more value in both biology and her peers, whom she saw more as fellow biologists:

> We did have to comment under them under their post. It was really nice … it made me value their opinions as well, because I know that they would also write their opinions on my stuff, same way I would do with theirs. So, it made me just value them as well and how they are as biologists, like, their feedback, how it made me feel like, 'okay, like this is what I can do better,' or you know,

> what I can do better as the class progresses. So definitely … it was a very fun, engaging class which made me value biology itself more.

Through viewing her peer's experiences for their You-pick Assignments, **Danielle** was inspired by them to participate in more biology-related activities outside of class such as hiking, and to formulate the goal of continuing those types of activities over the summer, after class has ended.

> It made me value it more, just to see it, all the activities that people did, like hiking. I actually started hiking where I wouldn't hike that much, but I just found the beauty of nature and … it just made me value it more, and I would see that people, would like in our class they would go on hikes and seeing the pictures that they would upload, it made me value bio more.

John would have enjoyed interacting with his peers in-person, but he was glad they had the opportunity to interact in an online asynchronous class:

> I think that even that little bit of interaction was helpful; and connecting with other people. It's easy to just, like, isolate and be like 'I'm going to get my work done and I'm going to get out of here,' but even that little bit of human interaction, it increases the value, and it increased the camaraderie… You're not by yourself doing this work, like, you have other people … so I find value in that for sure.

Ángel felt that the benefits of peer interaction didn't stop at helping to improve one another's grades, but that the sense of community itself has significant impacts on the lives of students:

> Everyone's just trying to help each other and ultimately the goal is just to help other students, and it's just being able to get through the college experience knowing that someone else is kind of having the same struggle as you and being able to help you is good.

Ángel was also inspired by his classmates' experiences that they shared. Their experiences gave him ideas as well as inspired his curiosity in wondering how his perspective of the same experience would differ from his peers:

> Seeing how some people were posting about their trips and kind of made me realize, 'hey, I want to go visit that place someday.' Kinda just brought a lot more value to it because if I didn't see that stuff, I would kind of just push it off to the side but seeing that someone else experienced it and they valued it. Kind of just how the human mind works, you also want to go do something like that or you want to do similar. Then you want to kind of just follow along and see how it is for yourself and see how you would interpret it.

Rita began our class without holding much value in online discussion boards, and her opinions were mostly unchanged through our course:

> I've been someone that's never really valued the replying to others on discussion boards. I feel like most of the time you just get generic responses, and what you're putting on the other person's post is also sort of generic, and you're trying to quickly do it. I feel like that's the case for most people. So, I felt like aside from being able to see the substance of what other people wrote, I don't think it impacted [how I value biology] very much.

Rita made the interesting connection that perhaps online discussion interactions lack substance because the sort of people who enroll in online courses are not interested in socializing anyways. As a social person, she has had more substantial experiences interacting with her peers in person, such as with her lab partner in her corresponding laboratory class:

> I think that's just the nature of a lot of asynchronous classes. I feel like people are taking it more so [that] they don't need to. They're either taking it because it's easier or they don't need to interact with as many people. And I'm a very social person so that's not my reasoning, but I think genuinely people aren't looking to have heavy interactions with other people when they're taking async.

<u>Cost</u>

Interacting with peers was a great use of **Sophia's** time that impacted her greatly. It was also a quick way to get answers about the class while also knowing she could approach her instructor for clarification if her classmates didn't know the answer:

> Knowing that I had that support was very helpful and knowing that… I'm going to succeed because I'm not alone taking this class, I have people

> helping me if I need it. Like, I could turn to my teacher and be like, 'Hey, I have a question,' or a student, and knowing that if they don't know the answer, then I could just go through my teacher again and be like, 'hey, so I have another question about this.' Knowing that the help was still there was actually very reassuring and helpful.

While participating with peers was a commitment, **Catalina** didn't feel that it took much time or effort because it was such an engaging assignment, basically like the old saying time flies when you're having fun, "It was more fun rather than time-consuming and being so dreaded about it, you know?" Likewise, **Danielle** shared: "My classes were overwhelming, but once I got into the semester, I got more motivated, so the cost didn't really impact [me] since I was enjoying the class."

Danielle further shared that the opportunity to share and interact with one another created a positive vibe for the class, negating the effort required to complete the assignments by spreading positive energy: "I feel like it did in a positive way, like just, spreading the energy to like everyone and just interacting with others. So, the cost impacted everyone in the end like in a positive way not in a negative way."

Ángel didn't see a large cost to interacting with peers, as it is a normal part of most people's days as is, and most people interact through technology regularly anyways: "I feel like it didn't really cost a lot to reach out to someone because you're always on your phone. You can take the 20 seconds of the day to reply back to someone and share your ideas."

As with expectancy and value, the cost that **Rita** associated with interacting with her peers on the discussion boards was largely unchanged.

Interview coding. I read each of the seven interview transcripts multiple times, as I edited the transcripts, pulled quotes, and assigned codes. After coding all seven transcripts, patters started to emerge. As I asked each student about the three active learning

interventions, certain codes were more common for various assignments. Likewise, certain codes were more likely to coincide with the same segment of transcripts. I developed categories based on codes that were prevalent for each of the active learning assignments: Skeletal Notes, You-pick Assignments, and Peer Interaction, and for each of the three measures of motivation: Expectancy, Value, and Cost. From these categories, I derived Themes.

Table 4: Code Mapping for Student Interviews
(to be read from bottom up)

Third Iteration: Themes
The organization of Skeletal Notes coupled with engaging lectures increase student expectancy and value and are a good investment. You-pick Assignments give students options for enjoyable real-world learning that can impact them beyond the class. Peer Interaction can show students other perspectives and can offer a sense of community in an online class.
Second Iteration: Categories
Skeletal Notes, **Expectancy,** easy, learning, engage, organized, other responsibilities, enjoyable, real-world application **Skeletal Notes**, **Value,** funds of knowledge, real-world application, other responsibilities, learning, perspectives, engage, enjoyable

Skeletal Notes, **Cost,** good investment, other responsibilities, engage, organized, organized, real-world application, learning, easy

You-pick Assignments, **Expectancy,** choice, enjoyable, easy, mental health, real-world application, quality of life, new experiences, engage, learning, individual

You-pick Assignments, **Value,** new experiences, real-world application, mental health, choice, perspectives, engage, inspire

You-pick Assignments, **Cost,** enjoyable, good investment, choice, engage

Peer Interaction, Expectancy, not impacted, perspectives, community, engage

Peer Interaction, Value, enjoyable, engage, community, real-world application, inspire, mental health, other responsibilities, flexible, learning, perspectives

Peer Interaction, Cost, not impacted, enjoyable, community, choice, engage, easy

First Iteration: Initial Codes/Surface Content Analysis

Choice, community, Cost, easy, engage, enjoyable, Expectancy, flexible, funds of knowledge, good investment, individual, inspire, mental health, new experience, not impacted, organized, other responsibilities, Peer Interaction, perspectives, learning, quality of life, real-world application, Skeletal Notes, Value, You-pick Assignments

Researcher Journal. I studied my own teaching and research experiences by conducting a Thematic Analysis of my own researcher journal. At the conclusion of the semester, as I analyzed the entries I had made in my researcher journal, I initially devised thirteen codes: inequality, conditions, disruptions, accessibility, assumptions, check-ins,

validation, motivation, demotivation, reminders, outside circumstances, research-teaching, and welcoming. I used these codes to develop categories to answer my research question of how I believed my teaching practices, particularly active learning, impacted my students' motivation. I contextualized my analysis by analyzing references I made to my own motivation throughout the term. I used the codes to then derive categories and themes from my researcher journal.

Student motivation. Throughout the term and before I finished my data collection, I reflected on how I assumed my students – and the generation of current students as a whole – were motivated. Not yet having motivation data to analyze at the time, I mostly noted my musings based on my prior teaching experience, the news, the literature, and social media:

> Been reading a lot on social media this week, because of the strike and TA and everything with [the union California Faculty Association]. Professors and teachers online sure like to complain about their students and Gen-Z in general. Apparently "student apathy" is a thing since COVID. Would be interesting if my spring data, like my fall preliminary data, shows that my students come to class highly motivated, totally unlike all the people online talking shit. Would be better for my ego if my students came in poorly motivated and left my class highly motivated. Reeks of white savior complex though. Although I'm sure we all would like to think we have an impact on my students. I'm sure we do, but it's probably not as much as we would like to think. There are so many other factors outside the classroom. Class doesn't exist in a vacuum. I think both students and teachers forget that. The joke about students not realizing their teachers have a life outside school. But so many professors don't realize students have a life outside class too. Work, family, so much stuff; and that all impacts how they come to class. What professors perceive as poor performance in class due to low motivation could actually be obstacles to student learning that the instructors put there themselves. It's not that the students lack motivation. They're trying, they want to succeed, but classes are obstacles to their goals. I want my class to be a springboard [to their goals].

With contemplations such as this I used codes including motivation, assumptions, disruptions, outside circumstances, and accessibility. My course is a general education

course, and so I assume my students come into my courses not particularly caring about the subject of biology. I think it's probably fair to assume that if they didn't major in it, it must not be their favorite subject. However, I was teaching under the assumption that my students were already motivated to *succeed* in my biology class. After all, it is a college class that they need for their degree, which they are already investing their time and money to take, so I assumed they were already motivated to learn and earn a passing grade at the very least.

I also pondered what particular things my students could find demotivating. While I acknowledged the multitude of potential barriers to educational goals students face outside the classroom, I also contemplated barriers deliberately placed within the classroom.

> Posted an announcement for CPP about bio seminar. It looked like complicated cell bio, which even I find difficult and boring. But maybe it will give my students an appreciation for the complexity of bio research, even if they don't actually enjoy it. I think they should be able to master what their instructors give them in class, without thinking the entire field is easy. Most of my science professors insisted on making us feel how difficult it was by making us struggle. This is also what I've heard from adults who said they "weren't good" at science. Science should be for everyone. Children are scientists. I don't like that exclusionary attitude, that if you fail at the task that they set then you are bad at the entire field. That's why I let my students pick their assignments based on their interest. The fields of science and biology are so diverse no one can be "bad" at all of it. Even professors aren't good at everything within science. So, they should have the opportunity to find what interests them and what they're good at within the field. Otherwise, you just make people think they aren't good enough to learn science and they give up on the whole thing. This can bring distrust. Exclusionary science teachers are grooming people to distrust science. It's hard to blame people for scientific illiteracy when that contempt has been carefully cultivated.

From these coded journal entries, I derived the category "**Students' motivation to succeed is weighed against other obstacles**."

As my dissertation research aimed to explore discrepancies between demographic groups, I also pondered on inequities in education, particularly in online learning environments, and the role active learning can take in creating enriching online courses:

> I was reading about learning loss during the switch to remote learning for K-12 during COVID. There are big inequities between race and income… You can't just sit kids in front of a screen. But online learning isn't the problem. Learning needs to take place actively, beyond the screen as well. Those children should have been working with their parents to actively learn the class content through discussion, worksheets, activities, etc. Children don't have the discipline or motivation that adult learners have to succeed in an unsupported online learning environment. Online learning PLUS active learning outside of the virtual classroom is ideal.

Because of my robust literature review, I believed wholeheartedly that active learning could close equity gaps. As a huge supporter for online classes, which I know have the potential to make learning more accessible, I believe that combining active learning with online classes are the most accessible and equitable way to teach the most people. Within journal entries such as these, I used codes inequality, disruptions, outside circumstances, and accessibility together to form the category "**active learning can increase achievement for all in accessible online classes**." With this category paired with "**students' motivation to succeed is weighed against other obstacles**," I derived the theme "**Accessibility removes barriers and active learning is a springboard. Both provide a clear path to learning**."

Inequality between campuses. As I recorded the actions I took throughout the research process, I regularly noted ways in which students from my two campuses were treated differently, which I coded "inequality." However, the bulk of the courses were in fact largely identical, and the only real difference in how students from each campus was treated were the dates that they were populated into the Canvas course, CPP students had

access to the Biology Resource Center where they could meet with Biology Learning Assistants, and I invited CPP students to Biology Department seminars almost every week that they could use as an option for a You-pick Assignment, which I coded "check-ins." The Biology Department at CSUDH did not offer the same weekly seminars as CPP nor Learning Assistants, so they received fewer "check-ins." This allowed me to derive the category "**Students from different campuses received different announcements from me**." Any difference in treatment at all was a huge concern for me that I noted in detail:

> My CPP students will have more opportunities to do active things outside of our class and will probably have a deeper connection with me since I will send them more announcements about LAs and seminars, which may increase their motivation.

Because I was so concerned about the potentially unequal treatment my students were receiving, I looked for ways to equalize their treatment, and incidentally formed a new practice that could benefit all, from which I derived the category "**Concern for equality can improve teaching**":

> Sent another announcement to CPP about a seminar this Friday, but since the due date for Unit 1 is tomorrow, I also reminded them of that. Since it didn't seem fair that CSUDH didn't get an extra reminder, I sent a reminder message to those who hadn't yet submitted You-pick [Assignment] 1 for both CPP and CSUDH. I had never done this before, but it was so simple I don't know why I never bothered, and it could have a huge impact on some students' grades, the difference between a 0 and full credit. I wonder if it will have a big impact on equity gaps. Reflecting as a researcher and wanting to make a valid study by treating my groups the same has made me a better teacher.

I was so concerned that CPP students would have a huge advantage; however, because the seminars were just one of many options students could use for their You-pick Assignments, the difference was not as pronounced as I had originally feared: only four students from CPP actually visited with a Learning Assistant and few CPP students actually attended the seminars, meanwhile CSUDH students participated in a wide variety of

enriching activities for their You-pick Assignments. So, I derived the theme "**Unequal treatment can be remedied by offering many choices**."

My own sense of motivation. My own sense of motivation oscillated considerably throughout the term. At times I felt my teaching-research was considerably valuable, and other times I doubted the value of my project and impact on my students. Sometimes I fully expected to achieve my graduation goals within the timeline I had proposed, other times I felt inadequate as a researcher. At times I felt the considerable cost I had expended was a worthy use of my time and energy, other times I felt I had made a mistake.

A particularly low, unmotivated point came after I'd had a difficult trip to present at a conference on the heels of my family and I having been sick for a month:

> April 13, 2024
> I'm feeling extremely unmotivated to work on my dissertation. I don't expect that I will succeed. The criticism I got at the conference really bothered me... I imagine I will not do an adequate job to complete my doctorate. That's been bothering me for months. More recently though, I feel that the cost of this entire endeavor of my doctorate has been too much. It has caused an exorbitant amount of stress that I don't think has been worth it and has taken time away that I could have spent with my family, especially my young daughter. I have had no time for myself between my job, family, and school. Also, I've recently felt that my doctorate doesn't have enough value. My family is my highest priority. Even the most perfect job, the highest degree, doesn't come close to the value of my family.

In a whiplash turn-of-events, I went from the lowest I had felt to the highest in a matter of days, and sustained that high motivation after a series of wins:

> April 16, 2024
> Got a fat grant woo! Well, that is certainly motivating! Apparently, others expect me to succeed, value my ideas, and are willing to give me lots of money! Things are turning around! I am very extrinsically motivated… I need to see tangible results for my efforts to be satisfied and continue pursing my goals. My students get the extrinsic reward of a grade for completing my class. I hope that my class is also intrinsically motivating because I relate it to their lives and interests. I know I've read somewhere that intrinsic motivation is better. I wonder if that's why I'm never satisfied? I get a win and

> feel high for a little while, then I wonder what the next thing will be. I wonder if intrinsic motivation lasts longer? I crave validation…
>
> April 24, 2024
> OMG I got the CDIP Dissertation Fellowship!! I feel so validated and motivated. Even if I believe that my work is important, I still rely on the validation of those to fully believe that and motivate me to continue my work. I think my students need to be validated to be motivated. I wonder how much impact the attitude of instructors has on their students? The [Motivating Learners Course] people have shown that students of professors who took the class score better, so apparently it does.
>
> May 1, 2024
> I presented my dissertation to CAFE's Equity in Practice Symposium. It was extremely well-received, which was a nice change from the NARST conference. I work at a very nice place with congenial colleagues. I've only ever heard supportive comments about my work and they're looking forward to hearing my results…

The codes motivation and validation were often paired together, and likewise, the codes demotivation and outside circumstances were often paired together, so I derived the category "**I am extrinsically motivated**."

While my extrinsic motivation oscillated concerningly, the one constant was my motivation to improve my students' learning. I documented how this research project made me a better teacher because it made me more aware of and sensitive to my students' participation:

> Canvas has a nifty tool where I can message students who either have or haven't completed an assignment. I sent a message to everyone who hasn't taken the Orientation Quiz. This could help keep students engaged, or else remind them to drop. This is a good practice to use going forward for all my classes. So, I went ahead and did the same thing for my Human Sexuality class too. Being a researcher has made me more aware of and engaged with my online asynchronous classes, even ones I'm not actively researching. Probably because the nature of action research makes me reflect on my own teaching and ways that I can improve.

Throughout the term, I constantly wrote in my journal, documenting my many concerns and brainstorming ideas to improve my class. Interesting in hindsight, but

frustrating at the time, my union called a strike the first week of the term. Although the strike only lasted one day, the months leading up to it, the day of, and the days after were very stressful. It was my first experience with withholding work, and as someone who checks their emails all hours of the day every day of the week no matter where I am, it was a jarring disruption to my routine:

> It's extremely tempting to check my emails. I know some detox will be good for me though. But I feel very unconnected from my students, whom I am conducting research on this term. Online asynchronous already can feel hard to connect with, but email was really our only thread to live connection, and that's been cut. I can only hope that my engaging lecture videos and active learning assignments will maintain that feeling of connectivity for my students. After all, most of my students DON'T ever email me; maybe the frequent emailing helps me connect with them, but it has less of an impact on helping them connect to me.

Throughout the term, I frequently documented my concerns about accessibility, disruptions to my class, and pondering the outside circumstances my students may be dealing with. I also contemplated how my own actions and attitudes influenced my students, coding together check-ins, strike, and disruptions. From these codes, I derived the category "**concern with student learning**." Which, paired with the category "**I am extrinsically motivated,"** I derived the theme "**Caring is critical, but validation is nice**."

Table 5: Code Mapping for Researcher Journal

(to be read from bottom up)

Third Iteration: Themes
Accessibility removes barriers and active learning is a springboard. Both provide a clear path to learning.

Unequal treatment can be remedied by offering many choices. Caring is critical, but validation is nice.
Second Iteration: Categories Students' motivation to succeed is weighed against other obstacles. Active learning can increase achievement for all in accessible online classes. Students from different campuses received different announcements from me. Concern for equality can improve teaching. I am extrinsically motivated. Concern with student learning.
First Iteration: Initial Codes/Surface Content Analysis Accessibility, assumptions, check-ins, demotivation, disruptions, inequality, motivation, outside circumstances, reminders, research-teaching, strike, and validation, welcoming

Research Question 2: How does the impact of active learning on motivation and grades differ among my diverse biology student population?

Because active learning has been ubiquitously shown to close equity gaps in large, undergraduate biology classes such as my own, I chose to explore how my active learning

interventions specifically impact my diverse students' motivation and their grades in my class. To further explore this dynamic issue, I used quantitative analysis to explore the relationships between three types of variables: demographics, motivation, and grades.

Using a regression analysis, I measured the influence of one variable on another variable. Independent variables are students' demographics: gender, race/ethnicity, First-generation college student status, and Pell Grant eligibility, as well as whether or not they were enrolled in the corresponding laboratory course. The dependent variables are grades in my course and students' motivation to learn biology (expectancy, value, and cost).

Change in motivation over time. The first 10 questions of the Motivation Survey are Likert scale questions. Scores were calculated such that 6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree.

I compared the pre-class and post-class surveys responses using a paired sample t-test to explore any changes in motivation that had occurred over the time of my course (Figure 8).

Expectancy. The average score for expectancy in the pre-class survey was 4.76, and 5.03 in the post-class survey. A score of 4 corresponds to slightly agreeing that one can expect to learn biology, and a score of 5 corresponds to agreeing that one can expect to learn biology. Expectancy increased significantly in the post-class survey (fig.8, t=-.4.31, p<.001).

Value. The average score for value in the pre-class survey was 4.88, and 5.20 in the post-class survey. A score of 4 corresponds to slightly agreeing that one values biology, a score of 5 corresponds to agreeing that one value biology, and a score of 6 corresponds to

strongly agreeing that one values biology. Value likewise increased significantly in the post-class survey (fig.8, t=-6.14, p<.001).

Cost. The average score for cost in the pre-class survey was 2.95, and 2.79 in the post-class survey. A score of 3 corresponds to slightly disagreeing that the cost is high to learn biology, and a score of 2 corresponds to disagreeing that one can expect to learn biology. Cost significantly decreased in the post-class survey (fig.8, t=2.08, p=.039).

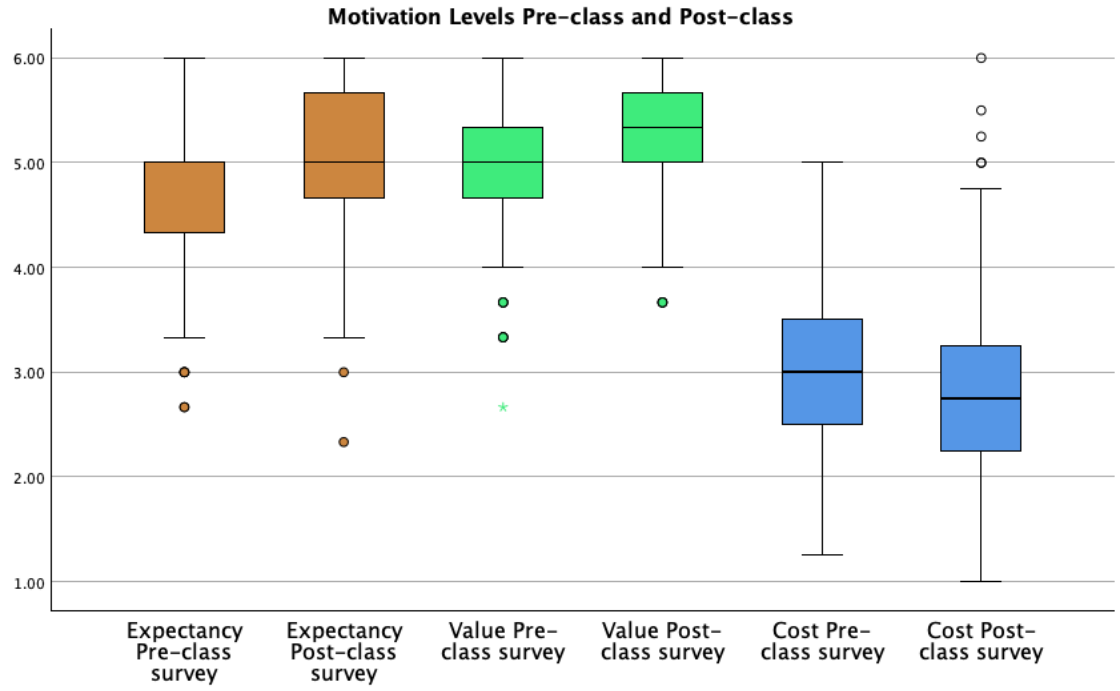

Figure 8. Expectancy, Value, and Cost pre-class and post-class.

6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree

Relationship between Demographics and Motivation. I conducted a multiple linear regression analysis using a generalized linear model (GLM) to explore connections between various demographic backgrounds and motivation.

Expectancy. The change in expectancy between pre-class and post-class surveys was not significantly different between the two campuses (F=0.04, df=1, p=0.85), between students who were or were not enrolled in the corresponding laboratory class (F=0.42, df=1, p=0.52), or who differed by Pell Grant eligibility (F=0.83, df=1, p=0.37).

The change in expectancy between pre-class and post-class surveys was not significantly different between genders (F=0.30, df=2, P=0.74), however, post-hoc testing showed that men and women differed significantly (post-hoc LSD, p=0.03), see figure 9. While the differences between men and women were significant, the differences were minor. Partial Eta Squared .009, almost a small effect.

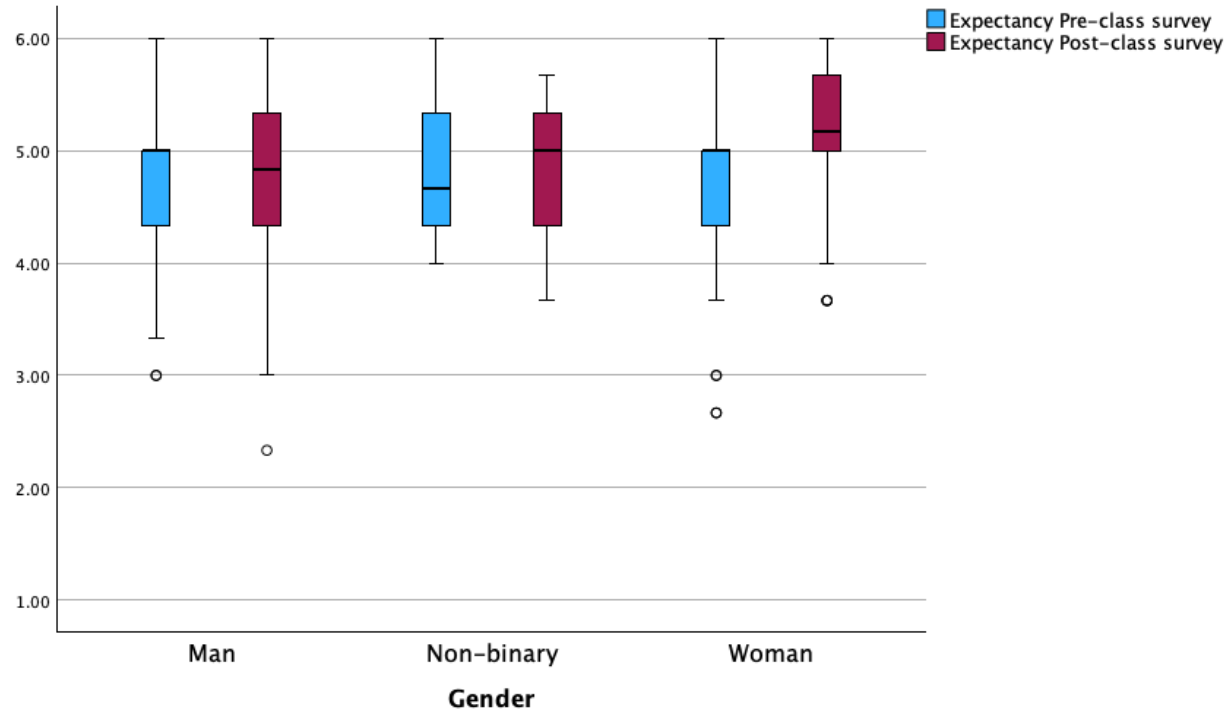

Figure 9. Pre-class and post-class expectancy between genders.

6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree

The change in expectancy between pre-class and post-class surveys was not significantly different between race/ethnicity (F=1.09, df=5, p=0.37). By pairwise

comparisons, students differed significantly in their change in expectancy between those who identified as Asian and those who identified as Hispanic/Latino/a/x (P < 0.03, all other comparisons P > 0.05), see figure 10. The differences were minor.

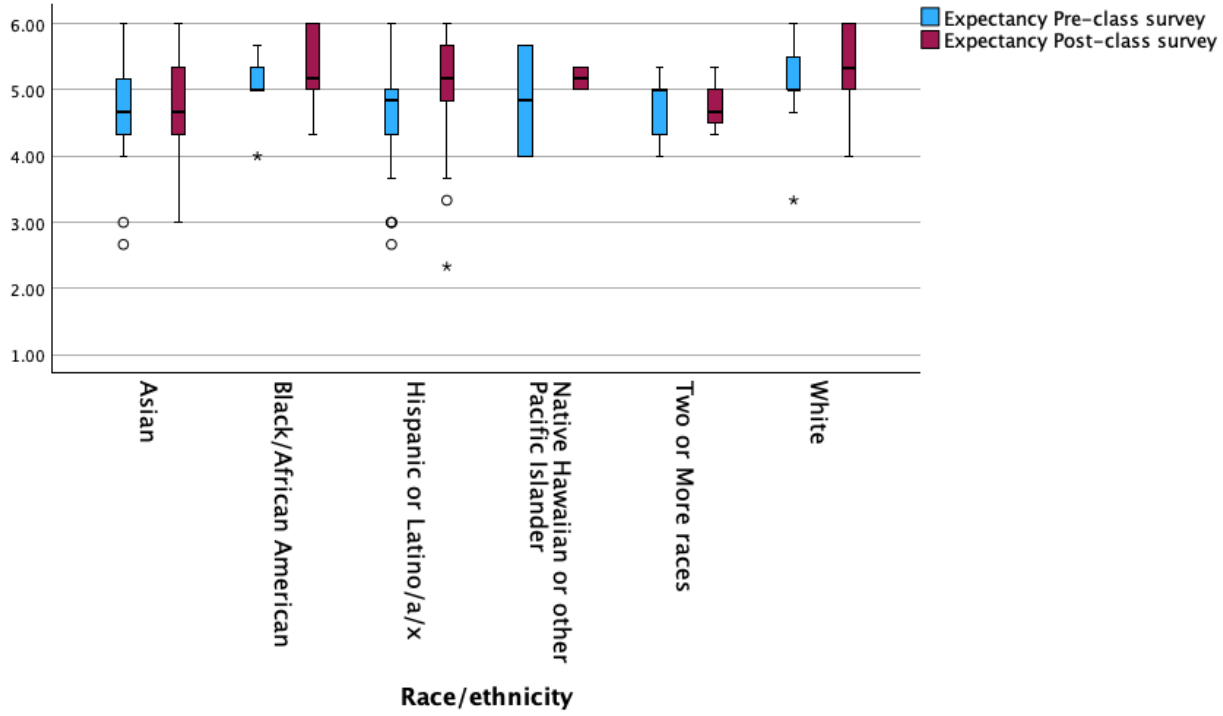

Figure 10. Pre-class and post-class expectancy between race/ethnicity.

6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree

The change in expectancy between pre-class and post-class surveys was significantly different between First-generation college students and non-First-generation college students (F=6.85, df=1, p=0.01), see figure 11. Partial Eta Squared .09, moderate.

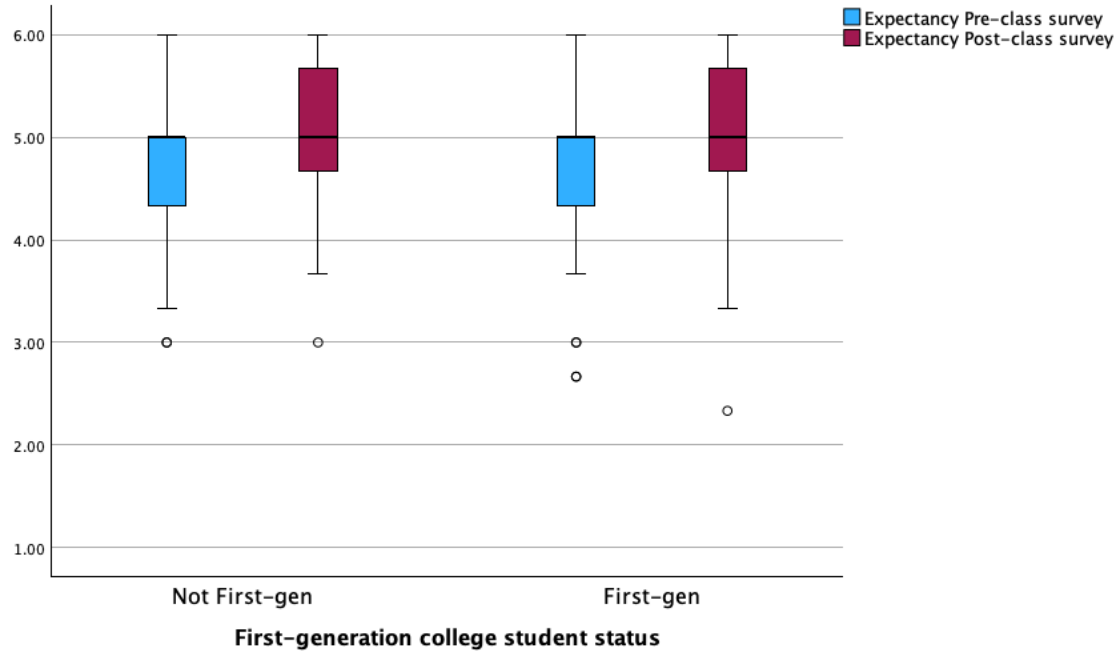

Figure 11. Pre-class and post-class expectancy between First-generation college student status.

6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree

Value. The change in value between pre-class and post-class surveys was not significantly different between the two campuses (F=0.04, df=1, p=0.84), between students who were or were not enrolled in the corresponding laboratory class (F=1.04, df=1, p=0.31), between different genders (F=0.12, df=2, p=0.89), or among those who differed by Pell Grant eligibility (F=0.62, df=1, p=0.43).

The change in value between pre-class and post-class surveys was not significantly different among students of different races/ethnicities (F=0.53, df=5, p=0.75). By pairwise comparisons, students differed significantly in their change in value between those who identified as Asian and those who identified as Hispanic/Latino/a/x ($P < 0.03$, all other comparisons $P > 0.05$), see figure 12.

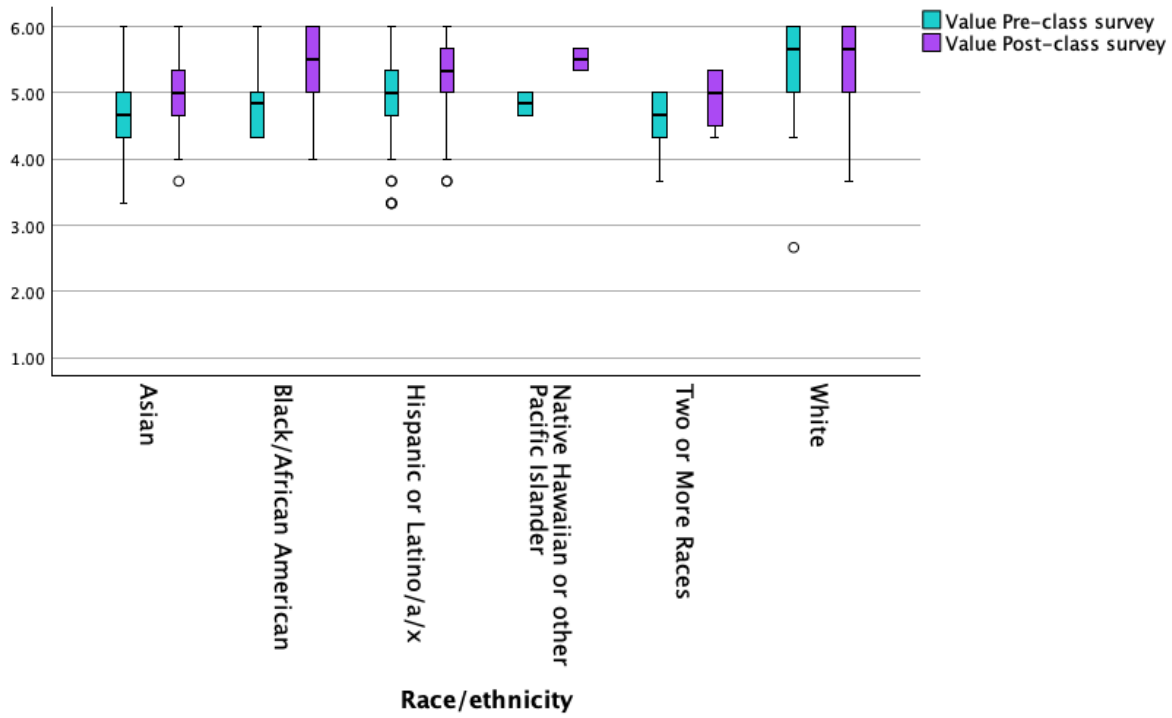

Figure 12. Pre-class and post-class value between Race/ethnicity.

6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree

The change in value between pre-class and post-class surveys was significantly different between First-generation college students and non-First-generation students

(F=3.97, df=1, p=0.05).

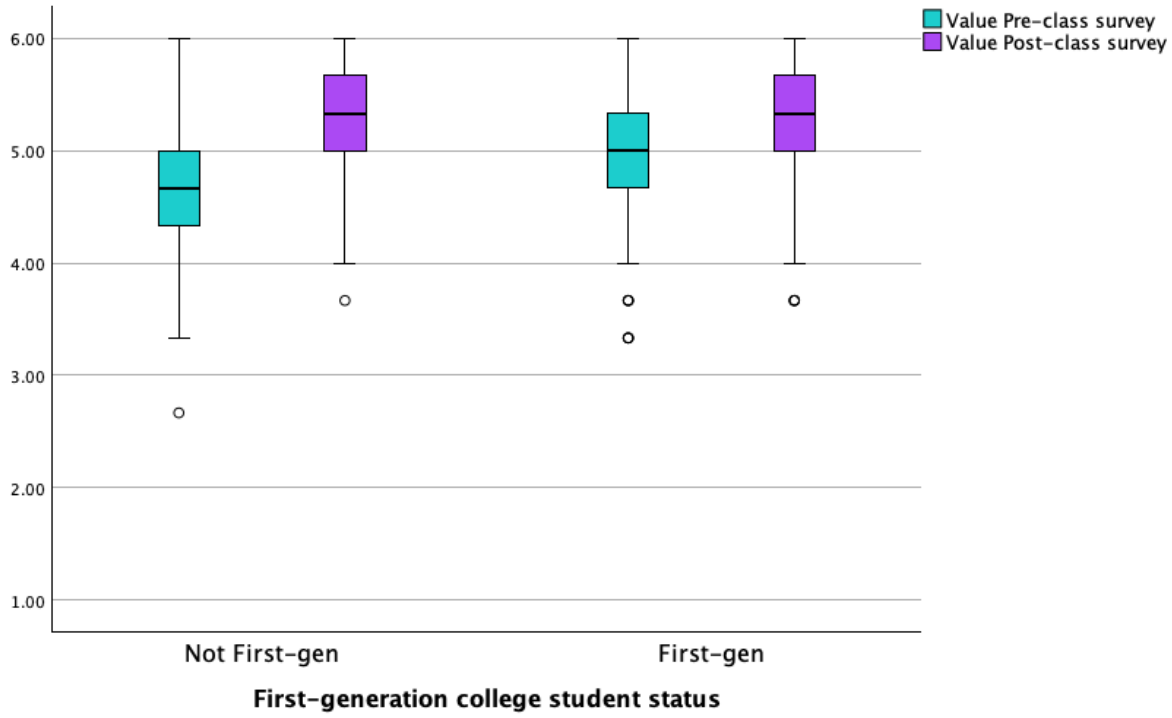

Figure 13. Pre-class and post-class value between First-generation college student status.

6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree

Cost. The change in cost between pre-class and post-class surveys was not significantly different among any demographics: between the two campuses (F<0.01, df=1, p=0.99), between students who were or were not enrolled in the corresponding laboratory class (F<0.01, df=1, p=0.96), between different genders (F=0.24, df=2, p=0.79), between First-generation college students and non-First-generation students (F=0.33, df=1, p=0.57), and among those who differed by Pell Grant eligibility (F=0.67, df=1, p=0.42).

The change in cost between pre-class and post-class surveys was not significantly different among students of different races/ethnicities (F=0.85, df=5, p=0.52). By pairwise comparisons, students significantly differed in their change in cost between those who

identified as Asian and those who identified as Hispanic/Latino/a/x ($P < 0.01$, all other comparisons $P > 0.05$), see figure 14.

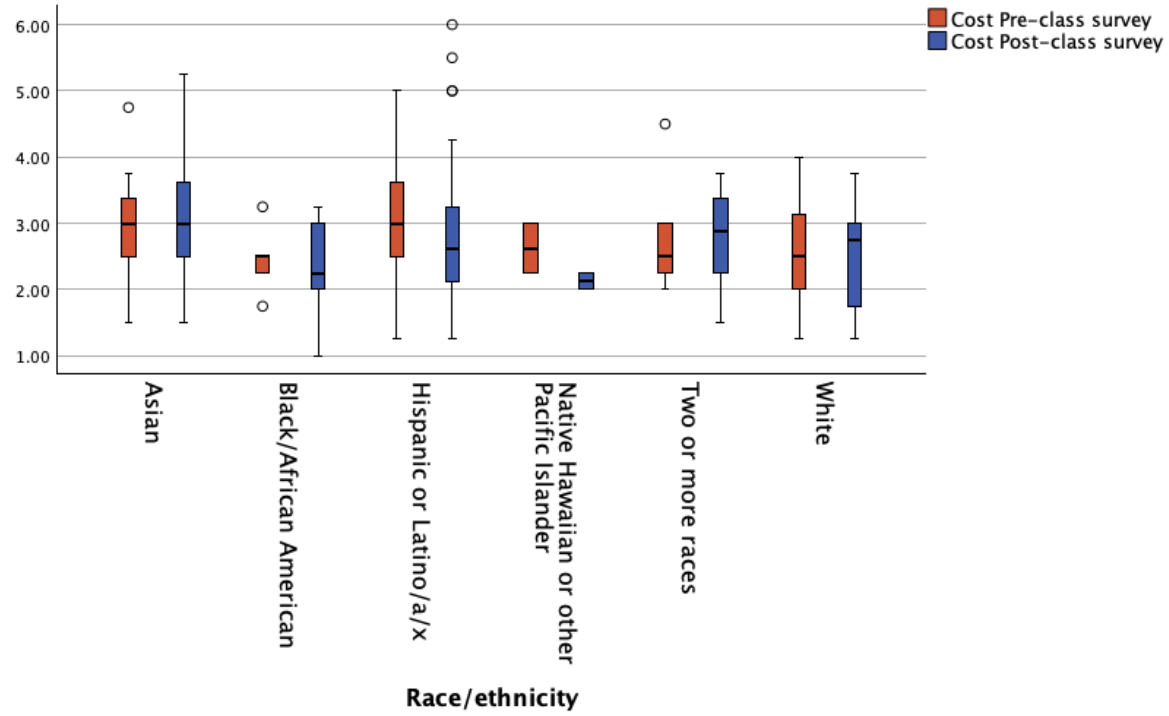

Figure 14. Pre-class and post-class cost between Race/ethnicity.

6=Strongly agree, 5=Agree, 4=Slightly agree, 3=Slightly disagree, 2=disagree, and 1=Strongly disagree

Relationship between Demographics and Grades. Using a generalized linear model (GLM) I explored the influence students' demographics had on their grades. Students' final grades were not significantly different between any demographics, including their campus ($F<0.01$, $df=1$, $p=0.99$), whether or not a student was enrolled in the corresponding Laboratory course ($F=0.05$, $df=1$, $p=0.83$), gender ($F=1.23$, $df=2$, $p=0.30$), race/ethnicity ($F=0.04$, $df=5$, $p>0.99$), Pell Grant eligibility ($F=0.32$, $df=1$, $p=0.58$), and First-generation college student status ($F=0.07$, $df=1$, $p=0.79$).

Relationship between Grades and Motivation. Using a Pearson Correlation, I compared the final grades students received in my class to their responses to the motivation surveys. There was not a significant correlation between students' final grades and their change in expectancy (Pearson Correlation=0.16, $p=0.06$). However, there was a significant correlation between students' final grades and their change in Value (Pearson Correlation=0.19, $p=0.03$) and Cost (Pearson Correlation= -0.26, $p<0.01$).

Summary of Results

This mixed methods study generated a multitude of data from each of my student participants. Moreover, the diversity of data has allowed me to explore the phenomenon from a plurality of angles, enabling me to gain a better understanding of the effects of active learning on student motivation and their classroom performance among a diverse group of students. See figure 6 for a Joint Display showing the impact of active learning on the three measurements of student motivation (Creswell & Creswell, 2023). In the next chapter, I make meaning from my results, create a dynamic picture of this complex issue, as well as offering suggestions for future classroom practices and research.

Research Question 1: In what ways do my various active learning practices impact my online biology students' motivation?

Through Thematic Analysis of Questions A and B from the Motivation survey, I arrived at four themes:

1. Active learning is motivating, and passive learning is demotivating.
2. A desire to learn combined with a good teacher maintains student motivation.
3. Some practices are overwhelmingly better than others, but students are still unique.
4. Teachers must balance course work to maximize benefits to students.

Through Thematic Analysis of my seven interviews, I arrived at three themes:

1. The organization of Skeletal Notes coupled with engaging lectures increase student expectancy and value and are a good investment.
2. You-pick Assignments give students options for enjoyable real-world learning that can impact them beyond the class.
3. Peer Interaction can show students other perspectives and can offer a sense of community in an online class.

Through Thematic Analysis of my researcher journal, I arrived at three themes:

1. Accessibility removes barriers and active learning is a springboard. Both provide a clear path to learning.
2. Unequal treatment can be remedied by offering many choices.
3. Caring is critical, but validation is nice.

Research Question 2: How does the impact of active learning on motivation and grades differ among my diverse biology student population?

In the class as a whole, expectancy and value significantly increased, and cost significantly decreased. Among most demographic groups there was little to no significant difference in motivation or grades. There was a significant correlation between students' final grades and their change in value and cost.

Table 6. Joint Display of the impact of active learning interventions on student expectancy, value and cost associated with learning biology.

Active Learning Interventions:	**Expectancy**	**Value**	**Cost**
Skeletal Notes	Increased	Increased	Worthy investment
You-pick Assignments	Increased	Increased	Worthy investment
Peer Interaction	Increased or neutral	Increased or neutral	Decreased

Chapter 5: Discussion

Research Aims

Equity gaps, disparate measurements of scholastic achievement between different demographic groups, are a persistent problem in education. As a Critical Theorists, I hold that these inequities are due to barriers put in place throughout society and within academia itself. Within educational contexts, these inequities can thusly be ameliorated through conscientious practice within the classroom. The wider literature points to active learning as an effective way to close equity gaps in large undergraduate biology courses such as my own. Similarly, theorists suggest that active learning increases student motivation. In this mixed methods action research study, I explored how active learning in my class impacts my own students' motivation, and how their motivation and grades differ between various demographic groups.

Making Meaning of the Results

In this concluding chapter, I discuss the findings of my study and make meaning of the results. I highlight important findings that I interpreted from the data that I used to answer my research questions. By using a variety of quantitative and qualitative data sources, I was able to create a dynamic understanding of the complex interactions between active learning on motivation among a diverse population of students. This greater understanding can be used to leverage active learning to close equity gaps.

By analyzing the survey questions asking students what increases or decreases their motivation and enriching that data with my students' interviews, I will share how the active learning strategies that I assigned in my online asynchronous biology classes influenced my

students' motivation, thus answering research question 1. To answer research question 2, I will explicate how active learning simultaneously impacts both motivation and student performance among students of various backgrounds. I will do so by interpreting the interactions of various data sources, including the independent variables of student demographics with the dependent variables of their motivation and grades.

After interpreting my data, in this chapter I will also offer my suggestions for other educators for how to use active learning to increase student motivation and performance as a way to close equity gaps. I will disclose the limitations of my study as well as the benefits to the field of education and research. I will also discuss the implications of my research and share my suggestions for future researchers who wish to continue furthering knowledge based off of my findings.

Research Question 1: In what ways do my various active learning practices impact my online biology students' motivation?

Survey. Through thematic analysis of the qualitative portion of the Motivation survey (Questions A and B), I derived four themes:

1. Active learning is motivating, and passive learning is demotivating.
2. A desire to learn combined with a good teacher maintains student motivation.
3. Some practices are overwhelmingly better than others, but students are still unique.
4. Teachers must balance course work to maximize benefits to students.

Students overwhelmingly shared that active learning increased their motivation to learn. Many of my students cited our active learning interventions specifically from our lecture class as increasing their motivation. Conversely, students find passive learning styles to be demotivating, especially when the instructor is not engaging. In contrast with

concerns that students today are apathetic towards learning, my students come to a new class motivated and ready to learn. A good teacher maintains this momentum, whereas a poor teacher reduces students' inherent motivation. Nevertheless, no teaching practice will work perfectly for every student, with some interventions, especially peer interaction or group work motivating to some but demotivating to others. Instructors should utilize meaningful teaching interventions that make learning worthwhile.

Interviews. Through thematic analysis of my students' interviews I derived three themes:

1. The organization of Skeletal Notes coupled with engaging lectures increase student expectancy and value and are a good investment.
2. You-pick Assignments give students options for enjoyable real-world learning that can impact them beyond the class.
3. Peer Interaction can show students other perspectives and can offer a sense of community in an online class.

In spite of being students for most of their lives, many young adults come to college not knowing how to take effective notes. Although the Skeletal Notes assignment took more time than typical notes might have taken, the effort students put into them paid off as they were better prepared for their exams, which increased their expectancy. Coupled with completing them by watching interesting lecture videos, students increased the value they hold for biology as well. I suspect that Skeletal Notes Assignments may discourage cheating in online, un-proctored exams by facilitating student learning and negate perceived necessity of looking up answers elsewhere.

As we learned from the Motivation survey, students hold hands-on active learning assignments that are relevant to the real world as very motivating. As such, it is unsurprising that students were highly motivated by the You-pick Assignment, where they chose hands-on activities that they found interesting and important. Having the chance to

apply class content into the real world and areas where students might continue to learn from and engage with may motivate students for years to come. I suspect that asking students to create unique assignments they find valuable may discourage them from relying on AI in completing their assignments.

Opinions were mixed on peer learning, although at worst some students were ambivalent towards it while it was a savior for other students. This is especially interesting because my classes are online asynchronous, a format that most would not consider conductive to fostering a sense of community. Nevertheless, my students had the opportunity to engage with one another in meaningful ways, providing them an important source of motivation. Although they may not have met in the real world, students could feel less like they're doing it alone. Furthermore, seeing the interesting activities their peers completed for their assignments could inspire them to try something new. This "fear of missing out" phenomenon is already seen in social media.

Researcher Journal. Through thematic analysis of my researcher journal, I derived three themes:

1. Accessibility removes barriers and active learning is a springboard. Both provide a clear path to learning.
2. Unequal treatment can be remedied by offering many choices.
3. Caring is critical, but validation is nice.

In designing their courses, instructors have the power to create either obstacles or springboards to student learning. Removing obstacles to learning can be accomplished through making learning accessible and providing assessments where students have the chance to succeed and attain their goals. Springboards to learning include hands-on, active learning assignments, making the course relevant to the real world, and giving students choice. Because every student is unique, offering them choice enables a customized

learning experience tailored to their interests and abilities, making courses a valuable effort. By removing these barriers and incorporating these springboards, instructors can create classes that facilitate learning for all students. As seen in the survey data, students come to class motivated. It's up to the instructor to validate their students and give them the opportunity to succeed.

Research Question 2: How does the impact of active learning on motivation and grades differ among my diverse biology student population?

As a whole, my students started class pretty highly motivated, ergo there was not a ton of room for improvement between the pre-class and post-class surveys. Nevertheless, by the end of our course, as a whole, my class was more likely to expect that they could succeed in biology, placed higher value in biology, and felt a lower cost associated with learning biology. I conclude that my course, in which I heavily utilize active learning, increases student motivation. Among genders, women saw a greater increase in expectancy from the pre-class to the post-class surveys. Among first-generation students, there was a wider spread of expectancy in the post-class survey.

Students' final grades were not significantly different between any demographic groups, meaning there were no equity gaps in my course. Each demographic measured, including gender, race/ethnicity, First-generation college student status, and Pell Grant eligibility was not a predictor of student success in my course. As the instructor, I was very relieved that my class is not an obstacle to success for students of historically underrepresented backgrounds.

I was very surprised that there were no significant differences in either motivation or grades between students who were enrolled in the corresponding laboratory course or not. Since laboratory classes are assumed to include more hands-on active learning done in collaboration with peers, I assumed there would have been a big difference in motivation and grades between those who were taking the laboratory class or not. Apparently, the experiences students have in their laboratory courses do not influence their motivation or academic success in my lecture course. I suspect this is due to the laboratory courses being taught by a wide variety of Teaching Associates with minimal to no teaching experience or training. I would be interested in replicating this study in the future at a community college in which I teach and where I am the instructor for both the online asynchronous lecture and the corresponding in-person laboratory for the same class of students. This will add more validity to my claims about the impact of laboratory courses since there would be fewer variables, vis a vis students will have the same instructor for both lecture and lab.

There was a significant correlation between higher grades and increase in value and decrease in cost of the class. Causation would imply that making classes a valuable experience with manageable work for students will increase their grades.

Relationship of Findings to Previous Literature

This study is unique in that I explored the interaction of three variables: active learning, motivation, and study performance (grades). My data suggests that active learning closes equity gaps by increasing student motivation.

Active Learning

My diverse group of students ubiquitously shared the importance of active learning in creating a motivating class, which aligns with the literature that active learning benefits all STEM students (S. Freeman et al., 2014). Through my classes in which I incorporated several active learning interventions, equity gaps among students of various demographics were not present. Therefore this study adds to the wider literature citing active learning as a means to close equity gaps (Ballen et al., 2017; Biswas et al., 2022; Haak et al., 2011; E. J. Theobald et al., 2020). Likewise, as I predicted, over the course of the semester students became more motivated. Coupled with the closed equity gaps in my classes, this adds to the literature that supports interventions used to bolster student motivation are particularly beneficial for students of historically underrepresented backgrounds, including women, first generation college students, and people of color (Harackiewicz et al., 2014; G. M. Walton & Cohen, 2011).

I believe that active learning motivated students because the active learning interventions were engaging. Previous studies have found that students are more engaged when they have the opportunity to work with their classmates (Gasiewski et al., 2012). My students were mixed on the importance of collaborative peer learning in their education. While some students found peer interaction extremely helpful and motivating, others found it unimportant. Of my students who I interviewed, the one student who found little value in our class discussion boards identified as non-first-generation, non-Pell Grant eligible, and racially/ethnically as White and Asian. In contrast, student interviewees who were of historically underrepresented backgrounds found the peer interaction much more impactful. This relates to other research that has found collaborative peer learning to be

important for students in general (Alzen et al., 2018, 2018; Batz et al., 2015; Kornreich-Leshem et al., 2022), but particularly for historically underrepresented minorities, closing equity gaps (Sellami et al., 2017; Snyder et al., 2016; Toven-Lindsey et al., 2015).

Motivation

My study has shown the importance of motivation in student success and suggests that active learning increases student motivation. As cited by Getty, Barron, and Hulleman (2021) much research has shown the importance of motivation to students' achievement, engagement, and persistence in education (Elliot et al., 2017; Pintrich, 2003; Stipek, 2002). This study adds to the wider literature that has shown that interventions to bolster students' motivation to be particularly beneficial for students from historically underrepresented backgrounds, including women, first-generation college students, and people of color (Harackiewicz et al., 2014; G. M. Walton & Cohen, 2011).

The implications of this study align with the Persistence Framework (Graham et al., 2013). Active learning among a community of learners leads students to both learn science and also to identify as scientists, leading to increase in confidence and likewise increase in motivation, helping them to further learn science and identify as scientists.

Implications

This research will have long-term implications in both the local and broader academic context. This study demonstrates the importance of active learning in college biology classes. This study is especially relevant to the California State University system, as my participants represent the diverse student body of California, particularly Historically Underrepresented Minority students. Furthermore, this study showcases the numerous

ways active learning can be successfully incorporated into online courses. This study also highlights the impact of active learning on increasing student motivation and closing equity gaps.

My Future Practice

Since completing this study, I have grown as both a teacher and researcher. I have continuously strived to improve my teaching ever since I first started my career as a Teaching Associate. However, my previous attempts at improvement were based on speculation and informal polls of my students. This research was by far the most in-depth look I have taken into my teaching and my students' experiences. Action research like this is an important endeavor for real-world problem solving within the community for the betterment of society (J. S. Lederman & Lederman, 2015). Since completing this study, I now have a much greater understanding of how my teaching practices, and active learning interventions in particular, can impact student motivation. I will continue to incorporate active learning into all of my courses that I teach. The next time I teach this or any class, I will add more options for You-pick Assignments and ensure the options are engaging active learning options. I will also emphasize in my course introductory video that the Skeletal Notes are for students' benefit. While students were mixed on the importance of peer interaction through the discussion boards, the cost associated with sharing their You-pick Assignments with their peers was either positive or neutral. Since there was no negative association, I will continue to facilitate this type of interaction since it may have a very positive impact on a significant portion of students. This may be especially impactful in online asynchronous course format.

Furthermore, since active learning appears to increase student motivation which in turn closes equity gaps, I will explore further strategies that have been shown to increase motivation as a means to close equity gaps. I will incorporate interventions that have been shown to increase motivation in my own courses and seek feedback from my students.

Recommendations

The results of this study have shown us the importance of motivation for student success and the impact of active learning on student motivation. To other instructors, I would suggest they implement active learning assignments including Skeletal Notes and hands-on activities, offer students choices, and give students the opportunity to interact with peers in their classes. These interventions can easily be incorporated into an online learning environment, ensuring an engaging and equitable learning experience regardless of learning modality.

College instructors vary widely in their knowledge of pedagogy, including active learning (Andrews et al., 2019; Auerbach & Andrews, 2018). Resources guiding instructors on how to incorporate active learning into their classes should be readily available to faculty. Framing the importance of active learning as an equity issue as a means to close achievement gaps for their students may inspire the California State University to support funding for this faculty support, which is important because instructors themselves very in knowledge of (H. A. Barron et al., 2021) and sensitivity to (Russo-Tait, 2022) inclusive STEM teaching practices.

Future Research

I am fortunate that the planning, execution, and analysis of this research went fairly smoothly. There were some hiccups along the way, such as the strike at the beginning of the semester, but since the strike concluded within a single day, the work stoppage (me not checking my email) had little impact on the research itself, although it caused a great deal of anxiety in me. The vast majority of my students consented to participate, and seven took the time out of their schedules to be interviewed over the summer without renumeration. I am grateful that my students value my research and see its importance in improving education for themselves and their peers. Another challenge and source of stress was the IRB process, complicated by the fact that I was orchestrating this project between three universities in two different states. Fortunately, I started the IRB process many months in advanced of beginning the experiment, so the numerous delays and back-and-forth between university personnel did not delay the project. The completion of this research has answered my research questions and given rise to new questions that I hope to further explore myself and with colleagues.

My Future Research

I would like to replicate this study in the future, both with my own students and students of other instructors. In this study, there was no significant difference between students who had taken the corresponding laboratory classes taught by a wide variety of Teaching Associates versus those who did not. At the community colleges where I also teach, the corresponding laboratory class is mandatory, instead of optional as it is at my universities, and is more closely tied to the lecture, usually having the same instructor for both lecture and laboratory. I would like to build upon this study in a future term at a

community college where I will be the instructor for the same group of students for both the online asynchronous lecture and in-person laboratory. I wonder if the laboratory will be more impactful to students in lecture if they have the same experienced instructor.

Collaborative peer learning has been shown to not only increase student achievement in STEM classes, but to also increase STEM persistence (Kornreich-Leshem et al., 2022), particularly for underrepresented minorities (Kudish et al., 2016). To further explore these impacts, I would like to follow up with my participants years from now and measure both their academic achievement and how their motivation has changed long after taking my class. I would like to know what intervention is most impactful in increasing their motivation to learn biology long term.

I would also like to redesign this study to examine student participants taking classes with other instructors, instead of just my own students. Having a larger sample size will increase the power of the statistics in the quantitative aspect of this mixed methods research design. Also, by examining students of other instructors, I could design this study for other courses, both within biology departments, such as major's biology or upper-division courses, or in other departments within the College of Science.

Going forward, as I prepare manuscripts that I intend to publish, I will collaborate with other researchers throughout the entire process. Collaboration will be particularly critical in the data analysis stage. Having other researchers also code the qualitative data to compare to my own codes will increase the reliability of our analyses and validity of our claims about the data.

In addition to their motivation, I would like to further explore how active learning impacts my diverse population of students' sense of belonging. A truly inclusive

environment fosters a sense of belonging among the community. A student's sense of belonging is their sense of feeling accepted, valued, and included by their community. Studies have shown the importance of a sense of belonging to STEM students' college achievement (Lewis & Hodges, 2015) and persistence (Hausmann et al., 2007; Murphy et al., 2020). Along with active learning, studies have shown the importance of a sense of belonging to closing achievement gaps (G. M. Walton & Cohen, 2007). Students from underrepresented backgrounds may not feel included in college settings, even if they are part of a majority demographic on campus (Murphy et al., 2020). When indigenous and ethnic minority students' values and cultures are devalued it leads to negative effects that can act as barriers to participation and achievement in class (McKinley & Gan, 2014). Instructors and institutions as a whole need to create a welcoming environment where students can feel like they belong there. A Teaching Guide to help STEM instructors teach in ways that are more inclusive, especially in terms of race, ethnicity, and gender has been made available in an interactive web-based format that was very clear and easy to use. The main points of the guide, which is cited with empirical evidence, are to first develop self-awareness and empathy, explore the role of class climate and support students' sense of belonging and ability, and to practice inclusivity at the community level outside the classroom (Dewsbury & Brame, 2019). I would like to author a similar guide for my colleagues that is reflective of my campus's unique makeup of students.

Other's Future Research

There is still important work to be done on researching equity in STEM education. I believe this will be a never-ending task considering the constantly changing and dynamic nature of the research subject itself. I hope that other researchers will replicate my study in

their own classes. Perhaps they could also compare sections of the same class that rely on either active or passive learning.

I also agreed with Hostetler's take that research should conclude with not just a solid answer, but with more questions (Hostetler, 2005). This is something I have always impressed upon my students: that scientific discoveries build on each other, and that for every question we answer we have five more questions. When I teach my students how to write a scientific paper, I tell them to include in their discussions what new questions they have and plans for future experiments.

Validity

External Validity

My fairly large sample size for both quantitative and qualitative data offers quite generalizable findings for an action research project. Furthermore, there were no differences between the two campuses, so I have confidence that my findings are at least somewhat generalizable to the population of California State University students from Southern California campuses.

Internal Validity

I had a high proportion of consenting participants from my study site. I also had standardized study conditions, including pre-class and post-class surveys. I utilized varied data sources, including motivation surveys, interviews, demographic information, and grades to inform analysis. My detailed researcher journal documenting implementation notes, methodological challenges, and reflections. I gained a rich and nuanced understanding of students' perceptions through in-depth interviews.

Limitations of Findings

Regrettably, I had a smaller sample size than I had expected for this study. I usually teach four sections of my online asynchronous biology class, but during the term in which I collected data I only taught two. Fortunately, the vast majority of my students consented to participate so I had an acceptable sample size, but a larger sample would have still been preferred to draw stronger conclusions. I will replicate this study in the future to compile additional data.

Not enough students visited with a Learning Assistant to draw any conclusions. Perhaps I could do a better job sharing this resource with students. For future research I might study what incentivizes students to visit with a Learning Assistant. I also had a limited number of students who identified as Black/African American or Hawaiian/Other Pacific Islander, and students who identified as nonbinary. I had limited statistical power to draw meaningful conclusions about these demographic groups.

Interestingly, some of the responses from the student interviews were inconsistent with their own survey responses. In our interview, Rita often said that her expectancy and value increased, while her cost decreased. However, her pre-class and post-class survey responses were unchanged. Likewise, Ángel consistently shared in his interview that his value increased during our course, but in contrast, his calculation for value went slightly down between the pre-class survey and the post-class survey. When I brought up this discrepancy during our interview, he attributed the lower post-class value score as being a product of the stress of finals week coupled with his friends and him battling illness, giving him a more pessimistic view in general.

Due to the nature of action research, I conducted this study on my own students, vis a vis, my own teaching. While this research was extremely beneficial to improving my own classes, my findings may not be generalizable to other classes or student populations. A subsequent larger study involving researchers studying multiple other classes taught by different instructors could provide more generalizable results. Furthermore, involving more researchers in the process could remove bias on the part of the teacher/researcher. In the case of action research, involving collaborators to co-code data and offer their perspectives could decrease bias in the study's conclusions.

Benefits

This study has uncovered a previously unexplored phenomenon within the context of my teaching. This study has explored the learning experiences of my students in a way that had never been done before. Whereas most published research on equity gaps are extremely large quantitative studies, this study was unique in that it was a mixed methods study with a strong qualitative aspect. Much publish quantitative research, though extremely valuable, is broad yet shallow in its exploration. My study was much smaller in size, limited to just my own students, yet I dug much deeper, thoroughly exploring an issue within my smaller local context.

Researcher Comments

Equity in science is a dynamic issue that needs to be explored from many angles. No single solution to the problem exists. Education does not happen in a vacuum, and parents, communities, and broader society influence students outside the classroom. Educators,

researchers, and communities need to question how we measure student success and what educational excellence actually means. It could mean different things for different individuals and for different communities. When researching student success, we cannot assume that success means the same thing for everyone. Furthermore, institutionalized obstacles need to be removed to increase equity among students. From my own experience, institutions give huge amount of support to certain groups with the admirable goal of decreasing equity gaps, and yet the barriers to success still remain. The obvious thing in my mind is to remove those barriers in the first place. Tear down the wall instead of building a bridge over it.

Conclusion

By conducting this study, we now have a better understanding of how and to what extent active learning can influence student motivation. Although students largely come to class inherently motivated, active learning, as opposed to passive learning, can increase their motivation further. This motivating effect of active learning is evident even in online asynchronous courses. Combined with the correlation between motivation and class performance, I suggest that active learning could be an effective intervention to increase student motivation and grades.

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Appendix

Appendix A: Survey Invitation

Survey instructions:

This is an optional survey that I am using for my doctoral dissertation research.

The aim of my research is to explore the interactions of action research on student motivation among a diverse student population. My goal is to improve the learning experience for all students and provide equitable science education.

You will receive 10 points of extra credit for completing this survey. Your responses will be analyzed after the end of the term, which will ensure that your responses and whether you choose to participate or not will have no impact on how you are treated in my class or on your grades.

Please see the informed consent study information sheet: (IU consent document attached)

Thank you!
Prof. Marin

Appendix B: Survey

Expectancy-Value-Cost Survey of Student Motivation © The Motivate Lab (K. Barron et al., 2017)

Response options and scoring for questions 1-10, Likert scale:
1 - Strongly disagree
2 - Disagree
3 - Slightly disagree
4- Slightly agree
5 - Agree
6- Strongly agree

Questions:

1. I think biology is important.

2. I know I can learn the material in biology.

3. I value biology.

4. My biology classwork requires too much time.

5. I believe that I can be successful in biology.

6. Because of other things that I do, I don't have time to put into my biology

7. I think biology is useful.

8. I'm unable to put in the time needed to do well in biology.

9. I am confident that I can understand the material in biology.

10. I have to give up too much to do well in biology.

A. In the space below, please list specific things that INCREASE your motivation to learn in your biology class.

B. In the space below, please list specific things that DECREASE your motivation to learn in your biology class.

Demographics

What is your gender?
Woman
Man
Non-binary
Decline to state

Are you a first-generation college student?

Yes, I am a first-gen college student. My parent(s)/guardian(s) have not received a four-year U.S. bachelor's degree.
No, I am not a first-gen college. At least one of my parent(s)/guardian(s) have received a four-year U.S. bachelor's degree.
Decline to state

What is your race/ethnicity?
Hispanic or Latino/a/x
Asian
Black/African American
Native Hawaiian or Other Pacific Islander
American Indian/Alaskan Native
White
Two or More Races
Unknown
Decline to state

Are you Pell Grant eligible?
Yes
No
Decline to state

Peer learning

For Cal Poly students:
Are you currently (this semester) enrolled in Bio 1110**L**, Life Science **Laboratory?**
For CSUDH students:
Are you currently (this semester) enrolled in Bio 103, General Biology **Laboratory?**
Yes
No, and I have never taken it.
No, but I took it a previous semester.

Did you attend any live sessions (Zoom or in-person) with a Learning Assistant (LA) or tutor?
Yes, once
Yes, more than once
No, I did not

Appendix C: Interview Invitation

Thank you for participating in my dissertation research project this past semester. I am contacting you now to invite you to interview for further data collection, as I explore connections between active learning and motivation among a diverse population of biology students. If you are interested in participating, please reply to this email with your availability. Interviews will be conducted via Zoom, and last 20-30 minutes.

Thank you very much,

Prof. Stephanie Marin Rothman

semarin@cpp.edu

Appendix D: Interview Protocol

Participant Description

I will be conducting semi-structured interviews on a portion of my former students from my Spring 2024 biology classes. They are adult college students at California State Polytechnic University, Pomona and California State University Dominguez Hills. After term ends, I will contact students who have already consented in this study through the survey, inviting them to participate in interviews for further data collection.

Interview Questions

(((Note to self: Remember to hit record!)))

(((Note to self: go over consent form with students before interview starts)))

VERBAL CONSENT!!!

Before we begin, do you have any questions for me?

Topic domain: Motivation

Lead off question: Think about our class. How did it impact your motivation?

[*Covert categories*: active learning, online, course design, instructor]

Describe Expectancy, Value, Cost as measurements of motivation.

Describe how their E-V-C changed from pre- to post-class survey.

Possible follow-up questions

1. What about our class impacted your expectancy?
2. What about our class impacted your value?
3. What about our class impacted your cost?

4. Could you please clarify _____?
5. So, in summary, _____. Is that correct?

Topic domain: Skeletal Notes

Lead off question: Think about the Skeletal Notes assignments. How did they impact your motivation?

[*Covert categories*: skeletal notes, active learning]

Possible follow-up questions

1. How did the Skeletal Notes assignments impact your expectancy?
2. How did the Skeletal Notes assignments impact your value?
3. How did the Skeletal Notes assignments impact your cost?
4. Could you please clarify _____?
5. So, in summary, _____. Is that correct?

Topic domain: You-pick Assignments

Lead off question: Think about the You-pick Assignments. How did they impact your motivation?

[*Covert categories*: active learning, choice]

Possible follow-up questions

1. How did the You-pick Assignments impact your expectancy?
2. How did the You-pick Assignments impact your value?
3. How did the You-pick Assignments impact your cost?
4. Could you please clarify _____?
5. So, in summary, _____. Is that correct?

Topic domain: Peer Interaction

Lead off question: Think about the how you interacted with other students in this class. How did that impact your motivation?

[*Covert categories*: active learning, peer interaction, inclusivity]

Possible follow-up questions

1. How did interacting with other students impact your expectancy?
2. How did interacting with other students impact your value?
3. How did interacting with other students impact your cost?
4. Could you please clarify _____?
5. So, in summary, _____. Is that correct?

Appendix E: IRB Acceptance Letter

PROTOCOLS

INDIANA UNIVERSITY

APPROVAL LETTER

To: Akerson, Valarie

Protocol #: 20595

Protocol Title: Exploring The Effects of Teaching Practices on Motivation and the effects of Motivation on Equity Gaps: A Mixed-Methods Action Research of Large, Online, Introductory Biology Courses

Type of Submission: Initial

Level of Review: Expedited

Approval Date: Thursday, October 12th 2023

Expiration Date: no date provided

**If Expiration Date = "No date provided," this research does not require annual renewal; thus there is no expiration date.*

IRB-IUB approved the above-referenced submission. Conduct of this study is subject to the IU HRPP Policies, as applicable.

Additional Notes:

This research is approved under the following expedited category:

-Category 7

Documents approved with this submission:

Attachments

Informed Consent Statement	IU consent.docx
Data Collection Instrument	survey.docx
Recruitment Materials	survey invitation.docx

You should retain a copy of this letter and all associated approved study documents in your research records.

If you have any questions or require further information, please contact the HRPP via email at irb@iu.edu or via phone at (317) 274-8289.

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EDUCATION

DOCTOR OF EDUCATION, Science Education — Indiana University Bloomington — 2024
- Dissertation: The Effects of Active Learning on Motivation Among a Diverse Student Population: Mixed Methods Action Research of Large, Online, Introductory Biology Courses
- *Advisor: Dr. Valarie Akerson*
- Minor: Sexual & Reproductive Health Promotion

Graduate Certificate: Sexual & Reproductive Health

Graduate Certificate: Qualitative Research & Inquiry Methodology

MASTER OF SCIENCE, Biological Sciences — Cal Poly University Pomona — 2011
- Thesis: Plant Tissue Culture to Save Rare CA Natives
- *Advisor: Dr. Kristin Bozak*

BACHELOR OF SCIENCE, Environmental Biology — Cal Poly University Pomona — 2009
- Emphasis in Biotechnology

COLLEGE FACULTY APPOINTMENTS

Lecturer	CA State Uni. Dominguez Hills	2019 – Present
Adjunct Professor	Mt. San Antonio College	2013 – Present
Lecturer	Cal Poly University Pomona	2011 – Present
Adjunct Faculty	Indiana University East	2022 – 2023
Adjunct Professor	Ventura College	2020 – 2021
Teaching Associate	Cal Poly University Pomona	2010 – 2011

COLLEGE COURSES TAUGHT

GENERAL BIOLOGY/LIFE SCIENCE (NON-MAJORS BIOLOGY)
- Bio 102, Lecture [Online], CSU Dominguez Hills
- Biol 1, Lecture & Laboratory [Online and in-person], Mt. San Antonio College
- Bio 1110, Lecture [Online and in-person], Cal Poly Pomona
- Bio 111 and 115 Laboratory, Cal Poly Pomona

BIOLOGY FOR MAJORS/FOUNDATIONS OF BIOLOGY (MAJORS BIOLOGY)
- Biol 4, Lecture & Laboratory, Mt. San Antonio College
- Bio 122L, Reproduction & Development Laboratory, Cal Poly Pomona

REPRODUCTION, DEVELOPMENT AND AGING
- Biol 13, Mt. San Antonio College

HUMAN SEXUALITY
- Biol 15, Mt. San Antonio College
- Bio 3010 [Online and in-person], Cal Poly Pomona

BASIC HUMAN ANATOMY
- Anat-A 215, Lecture & Laboratory [Online], Indiana University East

INTRO TO HUMAN PHYSIOLOGY
- Anat 10B, Lecture & Laboratory [Online], Mt. San Antonio College
- Phso V01, Lecture & Laboratory [Online], Ventura College

SCIENTIFIC COMMUNICATION
Bio 490, Cal Poly Pomona

BOTANY
Bot 201 Laboratory, Cal Poly Pomona

PEDAGOGY COURSES TAUGHT

ACCESSIBILITY AND QUALITY ASSURANCE WORKSHOP SERIES
Champions for Accessibility & Inclusivity (CHAI), Center for the Advancement of Faculty Excellence, Cal Poly Pomona

REMOTE COURSE DESIGN
Faculty Facilitator for professional development, Center for the Advancement of Faculty Excellence, Cal Poly Pomona

TEACHING ASSOCIATE TRAINING
Bio 692, Biology graduate student Teaching Associate training, Cal Poly Pomona

PUBLICATIONS

PEER-REVIEWED

2. **Marin Rothman, S.** (2022). College Students' Views of the Nature of Science. In V. L. Akerson & I. S. Carter (Eds.), Teaching Nature of Science Across Contexts and Grade Levels: Explorations through Action Research and Self Study (pp. 167-190). ISTES Organization.
1. **Marin Rothman, S**. (2022). Teaching the Nature of Science: A Self-Study of a Biology Lecturer turned Doctoral Student. In V. L. Akerson & I. S. Carter (Eds.), Teaching Nature of Science Across Contexts and Grade Levels: Explorations through Action Research and Self Study (pp. 267-304). ISTES Organization.

SCIENTIFIC COMMUNICATION

2. **Marin Rothman, S.** (2023) Sex Class with Prof. Marin, https://sexclasswithprofmarin.weebly.com/
1. **Marin Rothman, S.** (2020). The Unicorn Scale: Sex, explained. Bi.org. https://bi.org/en/articles/the-unicorn-scale-sex-explained

CURRICULUM DEVELOPMENT

5. *Human Sexuality,* Cal Poly Pomona, 2023-2024
4. *Foundations of Biology: Reproduction & Development Laboratory Manual*, Cal Poly Pomona, 2016
3. *Foundations of Biology Semester Conversion*, Cal Poly Pomona, 2014-2015
2. *Making Biology More Accessible Through Online Teaching*, Multimedia Educational Resource for Learning and Online Teaching (MERLOT), CA State University, 2014
1. *Biology Capstone Course: Scientific Communication*, Cal Poly Pomona, 2013

AWARDS

14. Wall of COOL (Celebrating Outstanding Opportunities for Learning) Award, Cal Poly Pomona, 2024
13. *Nominee*; Excellence in Encouraging Justice, Equity, Diversity, and Inclusion (JEDI) Award; National Association of Biology Teachers, 2023
12. *Nominee*, Outstanding Biology Teacher Award, National Association of Biology Teachers, 2023
11. Educator of Distinction Award, Mt. San Antonio College, 2021
10. Inspiring Woman Award, Mt. San Antonio College, 2021
9. *Nominee*, LGBTQ+ Educator of the Year Award, National Organization of Gay and Lesbian Scientists and Technical Professionals Inc., 2021
8. *Nominee*, Catherine H. Jacobs Outstanding Faculty-Lecturer Award, CSU Dominguez Hills, 2021-2024
7. College of Science Distinguished Teaching Award, Cal Poly Pomona, 2020
6. Champion for Accessibility & Inclusivity (CHAI), Cal Poly Pomona, 2020
5. Ten years of Service Award, Cal Poly Pomona, 2020
4. *Nominee*, Provost's Award for Excellence in Teaching, Cal Poly Pomona, 2020-2022
3. Wall of COOL (Celebrating Outstanding Opportunities for Learning) Award, Cal Poly Pomona, 2020
2. Diversity Champion Award, Cal Poly Pomona, 2019
1. Biological Sciences Department Award for Teaching Excellence, Cal Poly Pomona, 2015

FELLOWSHIPS

2. Faculty Fellow, The Center for Excellence in Mathematics and Science Teaching (CEMaST),
   Cal Poly University Pomona, 2023-2024
1. Fellow, Chancellor's Doctoral Incentive Program (CDIP), California State University (CSU), 2021-2024

SCIENTIFIC WORK EXPERIENCE

3. Graduate Researcher, Cal Poly Pomona, 2010-2011
2. Shoreline Cleanup Assessment Technician (Deepwater Horizon Oil Spill), Consol. Safety Services, 2010
1. Laboratory & Field Technician, Los Angeles County Sanitation Districts, 2007-2009

PRESENTATIONS

INVITED TALKS

9. *The Effects of Active Learning on Motivation Among a Diverse Student Population,* Equity in Practice Symposium, Cal Poly Pomona, 2024
8. *Using Active Learning Strategies to Close Equity Gaps for Biology Students of Historically Underrepresented Backgrounds*, NARST Annual International Conference, Denver, 2024
7. *Teaching and Learning NOS from Kindergarten through Graduate School*, NARST Annual International Conference, Chicago, 2023

6. *College Students' Views of the Nature of Science*, Science Education Research Symposium (SERS), Indiana University, 2023
5. *Women in Science*, *Inspiring Women of Mt. SAC, Valiant Women of the Vote: Refusing to be Silenced*, Mt. San Antonio College, 2021
4. *Offering Choices Encourages Engagement in Online Courses*, Wall of COOL Speaker Series, Cal Poly Pomona, 2020
3. *Teaching with Empathy: Giving Students the Chance to Succeed*, College of Science, Cal Poly Pomona, 2020
2. *Universal Design for Learning through Online Courses*, PolyTeach, Cal Poly Pomona, 2020
1. *Universal Design for Learning in Science Classrooms,* Opening the Pathway to Technician Careers: A Conference for Biology Teachers of Deaf Students, Rochester Institute of Technology, 2019

POSTERS

3. "*Online Courses Increase Accessibility*," 10th Annual oSTEM Conference + NOGLSTP's Out to Innovate (TM), 2020
2. "*You-pick Assignments Increase Student Motivation and Accessibility*," Getting Onboard with Online Equity and Excellence, CSUDH Teaching & Learning Symposium, 2020
1. "*Online Courses Increase Accessibility*," Opening the Pathway to Technician Careers: A Conference for Biology Teachers of Deaf Students, Rochester Institute of Technology, 2019

OUTREACH

10. Guest Speaker, Career Day, *Pomona Unified School District*, 2024-Present
9. Volunteer, *4-H, Los Angeles County*, 2024-Present
8. Troop Leader, *Girl Scouts, Greater Los Angeles*, 2023-Present
7. Guest Speaker, *Modern Empowerment of Women Scientists*, *SheCodes, and Sophie's Circle*, Cal Poly Pomona, 2021
6. Guest Speaker, *QWER Hacks: UCLA's first LGBTQIA hackathon*, UCLA, 2020
5. Writer, *The American Institute of Bisexuality (Bi Foundation),* Bi.org, 2019-Present
4. Expert Panelist, *Wellness Center presents: Sex in the Dark*, Cal Poly Pomona, 2019
3. Guest Speaker, *Girl Scouts*, *Greater Los Angeles*, 2015
2. Parks & Recreation Commissioner, *The City of Pomona*, 2014-2018
1. Community Life Commissioner, *The City of Pomona*, 2011-2014

SERVICE

18. Faculty Reciprocal Peer Coaching, Cal Poly Pomona, 2024
17. Textbook Reviewer, *The Story of Life: An Introduction to Biology.* Carroll & Jensen, 2024
16. *Expanded Course Outline and course curriculum, Human Sexuality*, Cal Poly Pomona, 2023
15. *College of Science Distinguished Teaching Award Selection Committee*, Cal Poly Pomona, 2021

14. *Inclusive Excellence Council: Student Academic Experience Committee*, Cal Poly Pomona, 2021
13. *Inclusive Excellence Council: Principles of Community Committee*, Cal Poly Pomona, 2021
12. *Faculty Community of Practice: Inclusive and Equity-Minded Teaching in STEM*, Cal Poly Pomona, 2021
11. *Wall of COOL Award Selection Committee*, Cal Poly Pomona, 2020
10. *QA Ambassador Networking Community*, Faculty Development Center, CSU Dominguez Hills
9. College of Science Representative, *Champions for Accessibility & Inclusivity (CHAI),* Center for the Advancement of Faculty Excellence, Cal Poly Pomona, 2020-2021
8. Facilitator, *Remote Course Design, professional development*, Center for the Advancement of Faculty Excellence (CAFE), Cal Poly Pomona, 2020
7. *Mt. SAC Remote Instruction Mentorship for Faculty*, 2020
6. *Pride Alliance*, Cal Poly Pomona
5. *Course Redesign Professional Learning Community*, CA State University, 2013-Present
4. AdA Diversity Champions Selection Committee, *Access & disABILITY Alliance*, Cal Poly Pomona, 2016
3. *Biological Sciences Department Award for Teaching Excellence Selection Committee*, Cal Poly Pomona, 2015-2016
2. Textbook Reviewer, *Discovering Human Sexuality, 3rd Edition.* LeVay & Baldwin, 2014
1. Textbook Reviewer, *Life: The Science of Biology, 11th Edition*. Sadava, et. al., 2014

GRANTS AND FUNDING AWARDED TOTAL: $88,070

30. Faculty Reciprocal Peer Coaching, Cal Poly Pomona, 2024
    $500
29. Chancellor's Doctoral Incentive Program (CDIP) Dissertation Award, California State University, 2024
    $5,000
28. The Center for Excellence in Mathematics and Science Teaching (CEMaST) Fellowship, Cal Poly University Pomona
    $2,000
27. Special Projects for Improving the Classroom Experience (SPICE) Innovative Approaches to Instruction program, 2024-2025
    $9,110
26. Travel Grant, Chancellor's Doctoral Incentive Program (CDIP), NARST conference, Denver, 2024
    $1,500
25. Travel Grant, Chancellor's Doctoral Incentive Program (CDIP), NARST conference, Chicago, 2023
    $1,500
24. CourseSource Writing Studio Workshop, 2022
    $2,000
23. Effective Online Teaching Practices, Association of College and University Educators, CSUDH, 2022
    $1,500

22. Chancellor's Doctoral Incentive Program (CDIP) Fellowship, California State University, 2021
    $30,000
21. Apprenticing Students into STEM Thinking Learning Community, CSUDH, 2021-22
    $1,000
20. Applying the Quality Mattes Rubric, Quality Assurance Course, CA State University: Office of the Chancellor, 2021
    $1,500
19. Designing Student Centered Courses, Association of College and University Educators, 2021
    $1,500
18. Introduction to Teaching with Canvas, Center for the Advancement of Faculty Excellence, Cal Poly Pomona, 2021
    $500
17. California Community Colleges LGBTQ+ Summit, Mt. Antonio College Pride Center, 2021
    $250
16. Faculty Community of Practice: Inclusive and Equity-Minded Teaching in STEM, NSF PASSION grant, Cal Poly Pomona, 2021
    $500
15. The Motivating Learners Course, Motivate Lab, NSF PASSION grant, Cal Poly Pomona, 2021
    $500
14. Improving your Online Course, Quality Assurance Course, CA State University: Office of the Chancellor, 2020.
    $1,500
13. Equity in Education Certificate Program, Center for Organizational Responsibility and Advancement, Mt. San Antonio College, 2020.
    $400
12. Skills and Pedagogy for Online Teaching (SPOT), Mt. San Antonio College, 2020.
    $500
11. Promoting Active Learning Online, Association of College and University Educators (ACUE). Center for the Advancement of Faculty Excellence, 2020.
    $2,100
10. Facilitator for Remote Course Design professional development, Center for the Advancement of Faculty Excellence (CAFE).
    $3,000
9. Champions for Accessibility & Inclusivity (CHAI), Center for the Advancement of Faculty Excellence, CA State University: Office of the Chancellor and Cal Poly Pomona, 2020.
    $2,000
8. Engaging the Digital Student Summer Institute (EDSI): Enhancing Inclusion & Student Motivation, Cal Poly Pomona, 2020.
    $500
7. Opening the Pathway to Technician Careers: A Workshop for Biology Teachers of Deaf Students, The Rochester Institute of Technology, National Science Foundation, 2019.
    $2,200

6. Special Projects for Improving the Classroom Experience Grant (SPICE), Cal Poly Pomona, 2016.
   $1,100
5. Faculty Professional Development Mini-Grant, Cal Poly Pomona, 2014.
   $482
4. Proven Course Redesign Biology eAcademy Grant, CA State University Office of the Chancellor, 2014.
   $6,910
3. Proven Course Redesign Online Sciences eAcademy Grant, CA State University: Office of the Chancellor, 2013.
   $1,198
2. SMART Classroom Improvement Grant, Cal Poly Pomona, 2013.
   $2,100
1. State University Grant, The State of California, 2011.
   $5,220

PROFESSIONAL DEVELOPMENT

PEDAGOGY

21. Faculty Reciprocal Peer Coaching, Cal Poly Pomona, 2024
20. *Credential in Effective College Instruction,* Association of College and University Educators (ACUE) and American Council on Education, 2022
19. *Effective Online Teaching Practices,* Association of College and University Educators, 2022
18. *Sexual Health Educator (SHE) Training Program*, CA Department of Public Health, Sexually Transmitted Diseases Control Branch, 2022
17. *Inspiring Inquiry and Lifelong Learning in Your Online Course*, Association of College and University Educators, 2022
16. *Applying the QM Rubric,* Quality Matters, 2021
15. *Designing Student Centered Courses*, Association of College and University Educators, 2021
14. *Introduction to Teaching with Canvas,* Center for the Advancement of Faculty Excellence, Cal Poly Pomona, 2021
13. *The Motivating Learners Course*, Motivate Lab, 2021
12. *Creating Inclusive and Supportive Online Learning Environments*, Association of College and University Educators, 2020
11. *Promoting Active Learning Online*, Association of College and University Educators, 2020
10. *Improving your Online Course*, Quality Matters, 2020
9. *Online Teacher Training Course in Canvas*, Ventura County Community College District, 2020
8. *Online Teaching Self-Paced Training Course*, CSU Dominguez Hills, 2020
7. *Online Teaching Conference*, California Community Colleges, 2020
6. *Skills and Pedagogy for Online Teaching (SPOT),* California Community Colleges, 2020

5. *Fully Online by Mutual Agreement Readiness (FOMAR),* California Community Colleges, 2020
4. *Engaging the Digital Student Summer Institute (EDSI): Enhancing Inclusion & Student Motivation*, Faculty Center and eLearning, Cal Poly Pomona, 2020
3. *Course Design Academy*, Faculty Center and eLearning, Cal Poly Pomona, 2018
2. *Proven Course Redesign Biology eAcademy*, CA State University: Office of the Chancellor, 2014
1. *Proven Course Redesign Online Sciences eAcademy*, CA State University: Office of the Chancellor, 2014

DIVERSITY, EQUITY & INCLUSION

10. *LGBTQ+ Virtual Health Care Conference*, Indiana University, 2022
9. *Fundamentals of Accessibility,* Faculty Center and eLearning, Cal Poly Pomona, 2022
8. *California Community Colleges LGBTQ+ Summit*, 2021
7. *Pathways to Equity Conference*, California Community Colleges, 2020
6. *Equitizing Higher Education Through Humanizing Online Learning*, California Community Colleges, 2020
5. *Unconscious Bias*, *Racial Equity and Education,* Center for Organizational Responsibility and Advancement, 2020
4. *Racial Microaggressions*, *Racial Equity and Education,* Center for Organizational Responsibility and Advancement, 2020
3. *Equity and Diversity in an Online Environment,* CSU Dominguez Hills, 2020
2. *Ability Ally Training*, Cal Poly Pomona, 2014
1. *Safe Zone Ally Training*, Cal Poly Pomona, 2013

ORGANIZATIONAL MEMBERSHIP

National Association for Research in Science Teaching (NARST)
California State University Chancellor's Doctoral Incentive Program (CDIP)
Online Learning Consortium
Partnership for Undergraduate Life Science Education
Association of American Colleges & Universities
GLSEN (formerly the Gay, Lesbian & Straight Education Network)
500 Queer Scientists
500 Women Scientists
We Can Stop STDs L.A.
Out in STEM (oSTEM)
Los Angeles LGBT Center
Access & disABILITY Alliance, Cal Poly Pomona
Pride Alliance, Cal Poly Pomona