Investigating The Effect of Universal Design For Learning on Learner Performance, Engagement, And Self-Efficacy

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INVESTIGATING THE EFFECT OF UNIVERSAL DESIGN FOR LEARNING
ON LEARNER PERFORMANCE, ENGAGEMENT, AND SELF-EFFICACY

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ABSTRACT

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This study sought to address the gap in knowledge about the effect of UDL features on asynchronous online postsecondary learners’ achievement, engagement, and self-efficacy. The study also described a process for redesigning an online course to incorporate UDL components and provided specific examples of the implemented UDL guidelines. The study was conducted in a three-phase multimethod research design, which included quantitative and qualitative data collected from the participants, the learning management system (LMS), and the course instructor.

In collaboration with the course instructor, the researcher redesigned an existing asynchronous online university Computer Science course using UDL guidelines to address learning barriers. The researcher developed the UDL Redesign Cycle for Online Courses during this process. The UDL-enhanced course was taught during the same semester as the original course as two separate sections taught by the same instructor. Participants in the original course served as a comparison group \((n = 20)\), and participants in the UDL-enhanced course \((n = 23)\) served as the treatment group. Canvas LMS collected grade and participation data throughout the semester. Near the end of the semester, participants completed an online survey that contained demographic items, an adapted version of the Online Learning Self-Efficacy Scale (OLSES), and three open-ended items related to their achievement, engagement, and self-efficacy. Final course grades, measures of participation in the LMS, and OLSES scores were compared between the
groups at the end of the course. A semi-structured interview with the instructor was conducted to investigate observed differences between groups and perceptions about the benefits and challenges of implementing ULD.

Results from the study showed that UDL interventions had no effect on learner achievement but did positively affect engagement. UDL interventions had a strong, positive effect on self-efficacy, measured using an adapted version of the OLSES. Recommendations for implementing UDL in online courses and recommendations for future research are provided.
I dedicate this dissertation to my late father, the harpsichord maker Peter William Redstone; my mother, Ruth; my husband Andy; my children Vickee, Jonathan, Natasha, and Ryan; my children by marriage, Nathan and Jonathan; my descendants; and the first of many teachers who made me fall in love with learning and teaching, Mrs. Mary Farley.
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CHAPTER I
INTRODUCTION

In the last 65 years, advancements in health sciences and modern medicine have dramatically increased life expectancy worldwide. Before about 1820, global life expectancy was about 25 years (World Economic Forum, 2022). The most significant gains in life expectancy occurred after 1950, with advancements in medicine and sanitation spreading globally (World Economic Forum, 2022). In the United States, life expectancy has risen to 76.4 years (CDC, 2021). With the increase in population and life expectancy, the number of people living with physical or cognitive disabilities has increased. The Architectural Barriers Act of 1968 and Section 504 of the Rehabilitation Act of 1973 were the first major pieces of legislation in the U.S. to improve access and provide discrimination protections for disabled people. Since then, additional public policy and social reforms have sought to increase inclusion.

The design of buildings is one of the first areas where the concepts of access and inclusion were applied (The R. L. Mace UDI, 2019). People in wheelchairs or with other mobility issues often could not enter or navigate buildings, so they had limited employment and educational opportunities (The R. L. Mace UDI, 2019). The Architectural Barriers Act of 1968 required all federally funded buildings to be physically accessible (U.S. Department of Labor, n.d.). Early attempts to modify or retrofit existing buildings often led to expensive, unattractive, and stigmatizing features, and architects soon realized that designing buildings with built-in accessibility could benefit all people (The R. L. Mace UDI, 2019). This realization was the foundation of the Universal Design movement, which was an approach that embraces inclusivity, striving to shape environments, products, and experiences that are accessible, comprehensible,
and usable by individuals of diverse abilities and traits, irrespective of their age, physical condition, or other characteristics (Centre for Excellence in Universal Design, 2020).

Another institution that sought to increase access was education. The Individuals with Disabilities Education Act (IDEA) of 1975 was passed to provide all children with a free and appropriate education. Its provisions covered educational programs and physical spaces of instruction. In the same way that the Civil Rights Act of 1964 protected people against discrimination based on their sex, race, national origin, or religion, the Americans with Disabilities Act of 1990 protected people from discrimination based on their physical or mental disabilities (The R. L. Mace UDI, 2019). The ADA covered physical spaces, curricula, and academic programs. Additional legislation passed since then has broadened access and protection for people with disabilities.

As these laws took effect, K–12 educators sought solutions for providing access to young learners with disabilities. Personal computers became more mainstream in the 1980s and 1990s, and educators and hospital clinicians saw promise in computer-based technology tools for helping disabled children. Dr. David Rose and his colleagues at North Shore Children’s Hospital in Massachusetts formed a center dedicated to collaborating with local school systems to reduce barriers to learning with children using technology tools. After years of this work, the staff at the center realized that providing technology alone was not the best way to help children (CAST, 2023a). The staff noticed the problem was not with the disabled children but with the disabled curriculum (Bacon, 2014). To address the problem with the curriculum, Dr. Rose and his colleagues developed a framework for designing instruction based on cognitive neuroscience research: Universal Design for Learning (UDL) (CAST, 2023a). UDL includes three principles that guide the design of instruction by providing learners with multiple means of representation,
action and expression, and engagement. Though the framework was initially intended to benefit disabled learners by addressing learner variability and reducing barriers to learning, educators often found that implementing the framework's principles in their classrooms helped all learners (CAST, 2023a).

Over the past two decades, some postsecondary institutions have started implementing UDL for a variety of reasons. One reason is that many instructors have moved beyond the lecture-based, sage-on-the-stage teaching model to a more constructivist focus on learner needs in authentic contexts, such as problem-based and case-based learning. UDL also provides a holistic framework for integrating accessibility requirements that have become a focus of higher education institutions due to many legal challenges by disabled learners. Additionally, UDL offers the potential for addressing growing student diversity. Increased societal awareness of disability, individual differences, and civil rights have broadened the concepts of access and inclusion beyond disability to include socio-economic status, gender, race and ethnicity, sexual orientation, English-speaking language skills, and neurodiversity.

In addition to becoming more diverse, postsecondary students have increasingly sought online education. Even as overall enrollments continue to decline, the number of students taking distance learning courses has risen since 2012 (Seaman et al., 2018). In the fall of 2019, before the COVID-19 pandemic, over a third of postsecondary students (37.3%) were enrolled in at least one distance education course, and 17.6% were enrolled exclusively in distance learning courses (National Center for Educational Statistics, 2021). Since the start of the pandemic, many more students have enrolled in at least one distance education course (Hill, 2021). Online environments offer learners flexibility and control over when and where they learn, making postsecondary education more accessible to diverse learners with various abilities, limitations,
and needs (Rao, 2021). Designing online courses using UDL principles has the potential to reach and engage more diverse learners.

UDL is a framework developed to make it easier for learners to access and interact with the learning components. Though scholars have written about the potential benefits to learners of implementing the framework in a variety of educational settings, as explored later in this chapter, several recent literature reviews suggest that there is a significant lack of empirical research regarding academic performance, engagement, and self-efficacy in learning environments that implement UDL principles (Al-Azawei et al., 2016; Capp, 2017; Fornauf & Erickson, 2020; Gravel et al., 2015; Seok et al., 2018).

From its inception in the early 1990s to the present day, UDL has evolved from a theory or philosophy to a scientifically validated framework; however, the evidence that UDL is a valid intervention is scarce (Boysen, 2021; Edyburn, 2010; Edyburn, 2019; Edyburn, 2021; Murphy, 2021). Several scholars have described a pressing need for this type of research (Al-Azawei et al., 2016; Boysen, 2021; Capp, 2017; Fornauf & Erickson, 2020; Hamraie, 2017; Seok et al., 2018). Another potential reason for the lack of empirical studies in higher education is that only recently has UDL been implemented as part of the instructional design process. Until now, UDL has been studied mainly by K–12 educators working in special education (Fornauf & Erickson, 2020). These educators may have been chiefly concerned with describing and practicing the implementation of UDL in their classes. However, UDL has recently been widely accepted as a design framework in post-secondary environments (Fornauf & Erickson, 2020).

This lack of substantial evidence linking UDL to improved learning outcomes questions the justification of time, money, and effort used to implement UDL practices. One prominent UDL critic has asked whether UDL is a fad and has pointed to ongoing problems with
establishing a clear definition of UDL, identifying the specific elements that make UDL effective, determining UDL dosage guidelines required to achieve engagement, access, and success, and using appropriate, empirical research methodologies (Edyburn, 2010; Edyburn, 2019; Edyburn, 2021). Another critical analysis points to the similarities between the discredited learning styles concept and UDL in their lack of operationalization, lack of evidence for improved learner outcomes, and their overgeneralizations about links to neuroscientific research and questions using UDL for universal design (Boysen, 2021).

**Problem Statement**

There is a gap in the literature about how online courses designed with UDL principles are related to student achievement, engagement, and self-efficacy scores. Though the body of empirical research about UDL in postsecondary environments has grown, recent reviews of the literature show that this type of research is scarce (Al-Azawei et al., 2016; Burgstahler, 2015; Capp, 2017; Fornauf & Erickson, 2020; Gravel et al., 2015; Rao et al., 2014; Seok et al., 2018). Additionally, there is little research on implementing UDL in online courses (Gravel et al., 2015; Rao & Tanners, 2011; Seok et al., 2018; Scott et al., 2015). Experimental or quasi-experimental studies about the implementation of UDL in online courses are almost non-existent (Al-Azawei et al., 2016; Capp, 2017; Fornauf & Erickson, 2020; Hamraie, 2017; Seok et al., 2018). A few studies have examined elements of self-efficacy in postsecondary UDL-designed learning environments, but none used a validated instrument to directly examine learners’ self-efficacy (Al-Azawei et al., 2017; Griful-Freixenet et al., 2021; He, 2014; Kreider et al., 2018; Kumar & Wideman, 2014). The current study aims to fill this gap in research by examining learning outcomes in an online course that has been developed using UDL principles using a comparison section of a course in a multimethod design.
The results of this study sought to address claims that there is little compelling evidence of improved learning outcomes when UDL principles are implemented in online course design. The study examined UDL’s connection to self-efficacy and filled the literature gap regarding the use of UDL in online postsecondary environments. In addition, the study provided detailed data about how UDL principles and guidelines were implemented in the design of the treatment section. Finally, this study may guide and inform future UDL scholarship.

**Conceptual Framework**

**Universal Design for Learning (UDL)**

As a teaching and learning framework, UDL provides principles and guidelines for designing instructional materials, assessments, and methods. Traditional teaching methods and materials can unintentionally create barriers for some learners. UDL seeks to identify and eliminate these barriers, making education more inclusive, flexible, and effective, ensuring that all students, regardless of their abilities or backgrounds, have equal opportunities to succeed. UDL is an overarching concept that connects to many educational strategies and theories, including Multiple Intelligences Theory, Bloom’s Taxonomy, Differentiated Instruction, Self-Regulated Learning, Constructivism, and Cognitive Learning Theory (Dalton, 2020).

UDL’s principles and guidelines are rooted in evidence-based research from cognitive neuroscience (Rose et al., 2006; Rose & Strangman, 2007). Some research in psychology and neuropsychology, as it relates to learning, demonstrates three distinct cognitive functions involved in mental processes: recognizing patterns, planning and generating patterns, and determining which patterns are important (Rose & Strangman, 2007). CAST identifies these functions as recognition, strategic, and affective networks, and recent neurocognitive studies of the brain have confirmed the activation of these networks during learning (Siew et al., 2019;
Wardle & Baker, 2020). Rose and Strangman (2007) pointed out that the networks align with Vygotsky’s research that described learning as recognizing information to be learned, applying information-processing strategies, and engaging with the learning task. Differences identified in neurological studies in recognition, strategic, and affective networks form the foundation of UDL’s three core principles: provide learners with flexible means of representation, engagement, and action and expression (Rose & Strangman, 2007).

Dr. David Rose and his colleagues, Anne Meyer, Grace Meo, Skip Stahl, and Linda Mensing developed the UDL guidelines to respond to their shift in thinking about children’s disabilities. When they first formed CAST, they focused on providing schools with learning interventions with technology tools like the personal computer. Though they saw success with this approach, they realized that the problem was with the curricula, not the students. They aimed to fix the curriculum so that “it helps whoever walks in the door” (Bacon, 2014). In the 30 years since UDL’s inception, CAST has shifted its mission to center on UDL, with additional funding and research driving the refinement and expansion of its three principles to include nine guidelines and 31 other checkpoints that can be used to guide instructional design decisions (CAST, 2018).

*Provide Multiple Means of Engagement*

The principle of providing multiple means of engagement to learners is based on the affective network, which represents the “why” of learning and is responsible for emotion and affect (CAST, 2018). In UDL, learner engagement is considered the most critical component in the learning process, and learners vary widely in how they can be motivated to learn (CAST, 2018; Gravel et al., 2015). Prior knowledge, culture, and neurology are some of the factors that can influence learner engagement. Some learners prefer routine over novelty or working alone
rather than in a group, so learning environments must offer options. Guidelines include recruiting interest, sustaining effort and persistence, and self-regulation (CAST, 2018).

**Provide Multiple Means of Representation**

The principle of providing multiple means of representation to learners is based on the representation network: the “what” of learning (CAST, 2018). Learners have diverse ways of perceiving and comprehending information, so they should be able to access different formats. For example, some learners prefer written materials, while others prefer auditory materials. Offering multiple representations can help learners make connections and transfer what they have learned. Guidelines include perception, language and symbols, and comprehension (CAST, 2018).

**Provide Multiple Means of Action & Expression**

The principle of providing multiple means of action and expression to learners is based on the strategic network, which represents the “how” of learning and is responsible for planning, organizing, and executing (CAST, 2018). Learners differ in how they can physically move and speak, so providing options to navigate their learning environments and express themselves is critical. For example, some learners may prefer to express themselves in writing, while others may like to express themselves in speech. Guidelines include physical action, expression and communication, and executive functions (CAST, 2018).

**Develop Expert Learners**

The UDL framework describes the three principles and nine guidelines in terms of its ultimate goal: developing expert learners who are purposeful, motivated, resourceful, knowledgeable, strategic, and goal-oriented (CAST, 2018). The concept of expert learners is closely related to self-efficacy and self-regulation (CAST, 2018; Navaitienė & Stasiūnaitienė,
Self-efficacy refers to a learner’s belief that they can perform a task and reach a goal (Bandura, 1999). Two meta-analyses and a recent systematic review found that in postsecondary environments, self-efficacy was the strongest predictor of academic performance (Honicke & Broadbent, 2016; Richardson et al., 2012; Robbins et al., 2004). Self-regulated learning (SRL) occurs when learners generate “thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals” (Zimmerman, 2000, p.14). Learners’ SRL strategies have been shown to significantly predict academic performance (Broadbent & Poon, 2015). To employ SRL strategies, learners must first believe they can use them effectively, so developing their self-efficacy is important (Usher & Pajares, 2008).

**Literature Review**

**Inclusion in Higher Education**

The American Association of Colleges and Universities (AAC&U) describes the mission of advancing diversity, equity, inclusion, and accessibility (DEIA) as an urgent priority for higher education institutions to make campuses more inclusive and welcoming for all (AACU, 2022). Several factors are driving this push. First, Americans and, therefore, American student populations have become much more diverse in the past decade (Jensen et al., 2021). Another reason is recognizing the many benefits that inclusive environments engender, such as improved cultural awareness, improved critical thinking, and the broader perspectives that diverse people bring to the table (Milem, 2003). Finally, the COVID-19 pandemic has brought issues of inequity to the forefront (Kwakye & Kibort-Crocker, 2020).

**Learner Diversity**

When the first American colleges were founded, Harvard College in 1636 and The College of William and Mary in 1693, students were male, White, and wealthy. In fact, for most
of its history, higher education was an activity for elites and excluded people based on race, ethnicity, gender, and social class (Eckel & King, 2004). The wide-sweeping social and economic changes of the 20th century made it more possible for many Americans to access higher education. The ideal of America as a land of opportunity and equality and higher education as a driver of social mobility paved the way for increasingly diverse student populations (Eckel & King, 2004). American colleges and universities are much more diverse today than ever before. Still, policies surrounding DEIA are at the forefront of many institutional initiatives and are often included in organizations’ mission statements (Westine et al., 2019).

Post-secondary students are diverse in many ways: race, ethnicity, age, disability status, English language abilities, and socio-economic status. Of the more than 19 million people currently seeking degrees at U.S. postsecondary institutions, most undergraduates and graduate students are women (55%), a little more than half are White, and most are older, nontraditional students, work, are married, or have children (Hanson, 2021). The trend toward increasing racial diversity is expected to continue, with a projected decrease in the number of White students and an increase in the number of other races, even as overall postsecondary enrollment continues to decrease (Dinkes, 2020). Approximately one million students attending a postsecondary institution in the U.S. in 2016-17 were English language learners (Bergey et al., 2019). Almost a quarter (23.4%) of postsecondary students were over 25 in 2019 (NCES, 2019).

The percentage of college students with disabilities is also increasing (Sarid & Raveh, 2020). In 2020, the National Center for Education Statistics reported that 19.4% of students enrolled in postsecondary institutions reported having a disability. The most recent statistics indicate that 31% of disabilities reported by institutions were specific learning disabilities,
followed by 18% ADD/ADHD disabilities, 15% psychological or psychiatric conditions, and 11% percent health conditions (Raue & Lewis, 2011).

Central to the concept of DEI in higher education is meeting the needs of learners, who vary in terms of culture, race, socio-economic status, age, English language skills, cognitive abilities, physical capabilities, and more. In K–12 settings, learner variability is addressed through classroom interventions provided by classroom and special education teachers as required by law. However, this is not the case in higher education, where students must self-identify their disabilities to receive accommodations. One way faculty and instructional designers who support faculty can address learner variability and reduce learning barriers is to incorporate Universal Design for Learning (UDL) principles into the instructional design process.

In colleges and universities, instructional designers (IDs) aim to improve learning by systematically analyzing, designing, developing, implementing, evaluating, and managing instructional resources and processes (Reiser, 2018). They do this primarily by working closely with the subject-matter expert (the instructor) to determine course goals and objectives and then develop aligning instructional materials, learning activities, and assessments. To ensure quality, IDs use evidence-based practices built into quality assurance guidelines, checklists, or rubrics such as the Quality Matters (QM) Rubric, which is widely used in colleges and universities. UDL is another framework that IDs in higher education can use to foster inclusive learning environments (CAST, 2018).

**Online Learners**

In the twenty-plus years since online learning has become mainstream in the U.S. and Canada, “online” has become more challenging to define. First referred to as “computer-
mediated communication” and “computer conferencing,” the term “online” emerged in the early 2000s (Garrison et al., 1999; Garrison et al., 2010). Sometimes, the terms “distance learning” and online learning” are frequently interchanged. Still, they are not the same. Distance learning “uses one or more technologies to deliver instruction to students who are separated from the instructor and to support regular and substantive interaction between the students and the instructor synchronously or asynchronously” (Seaman et al., 2018, p. 5). It is currently considered an umbrella term for various forms of technology-enabled learning environments, including variations of online and hybrid environments (Moore et al., 2011). In its infancy, online learning in postsecondary institutions meant an asynchronous learning environment where learning took place on the Internet with no synchronous elements. When instructors began incorporating synchronous elements into their online courses, the terms hybrid or blended were used to describe the combination of synchronous and asynchronous elements within a course (Garrison & Kanuka, 2004).

In recent years, the blurring of lines between online and blended courses has increased, with some scholars referring to “online” (or “e-learning”) as any course that uses synchronous and asynchronous tools (Rao et al., 2015; Rao & Tanners, 2011). More face-to-face instructors have embraced flipped pedagogy by using features of their institution’s learning management system (LMS) to host readings and assessments while using class time for interactions. Conversely, some asynchronous online instructors have incorporated synchronous elements such as web-conference office hours in their asynchronous courses or have added a combination of asynchronous and synchronous elements in blended learning environments. To complicate the term further, emergency remote teaching early in the COVID-19 pandemic has also often been called “online” (Hill, 2021). Little research about UDL in online courses has been conducted to
date, and some researchers use the term “online” in the broad sense described above. In contrast, others use “online” to mean asynchronous online environments. Therefore, this literature review includes studies in which authors have described the learning environments of their investigations as “online.”

Before the COVID-19 pandemic, the number of students enrolled in higher education distance courses steadily increased from 2012 to 2018, even as overall enrollments declined (Seaman et al., 2018). According to the National Center for Education Statistics, in the fall of 2019, 36% of undergraduate students took at least one distance learning course, and 16% were enrolled in a distance learning program exclusively (National Center for Educational Statistics, 2021). During 2020, when many face-to-face classes were converted to emergency remote teaching using online learning platforms, the numbers increased to 75% and 44%, respectively. Most campus-based higher education institutions returned to offering face-to-face courses again in 2021. Still, the number of students taking distance education courses remained much higher than before the pandemic, with 61% of undergraduate students taking at least one distance learning course and 28% taking distance learning courses exclusively (National Center for Educational Statistics, 2021). Though the types of learning environments (e.g., hybrid or asynchronous environments) were not specified in these numbers, it seems clear that online enrollments will continue to play a significant factor in the sustained health of higher education institutions.

Students often take online because they have jobs, children, or other relatives to care for, limited ability to attend on-campus classes, limited English-speaking language skills, limited mobility, cognitive differences, or other reasons that make face-to-face learning environments unfeasible (Rao, 2012). Online learners often cite the flexibility of attending at a convenient time
as their primary motivation. This is usually because they fall into the 75% of students attending colleges and universities that are labeled as non-traditional (Hanson, 2021). The growing diversity of students and the ever-increasing enrollments of students enrolling in one or more online courses indicate that instructors could benefit from using inclusive instructional design decisions to meet the needs of their learners.

**Legislation and Disability**

Though UDL aims to remove barriers for all learners, the framework’s conception and implementation have historically centered around one dimension of learner differences: disabilities (Navaitienė & Stasiūnaitienė, 2021). UDL was conceived in the early 1990s by CAST, the Center for Applied Special Technology, which was founded by five medical practitioners from North Shore Children’s Hospital in Salem, Massachusetts, in 1984 (CAST, 2023a). CAST was created to research and develop best practices for using computers to assist disabled children. In CAST’s early years, Dr. David Rose, one of the leading researchers, led collaborative efforts with Apple Computer to integrate assistive technologies such as built-in text-to-speech. From its inception, CAST has been instrumental in developing tools and software to assist children with disabilities (CAST, 2023a). UDL was initially developed to help disabled children learn, but its principles have since extended beyond its initial purpose and have been applied in various settings. Through his research over the years, Rose and his colleagues discovered that curricula designed with UDL principles were beneficial to all learners, and CAST has since shifted its focus of UDL research to addressing the disability of the learning environment rather than the disability of the learner (Rappolt-Schlichtmann et al., 2012). This section will explore federal disability legislation in education and support for incorporating UDL principles in the online postsecondary environment.
American public policy passed in the 1970s was an impetus to calls for increased accessibility and inclusion, starting with Section 504 of the Rehabilitation Act, passed into law in 1973 (U.S. Department of Health and Human Services, 2006). This law protects certain people with disabilities from discrimination in workplaces and organizations that receive federal funding (U.S. Department of Education, 2023). People with a mental or physical impairment that significantly limits at least one major life activity, such as seeing, hearing, or learning, qualify for protection under this law. Section 504 prohibits discrimination of participation, access, and employment opportunities in these environments. Many postsecondary institutions receive federal funding and must provide these protections to students (U.S. Department of Education, 2023). The federal government plays an essential role in funding higher education and spent $174.8 billion in 2021, primarily funding students with Pell grants and research projects (Statista, 2023).

Another significant piece of civil rights legislation relevant to college and university students was the Americans with Disabilities Act (ADA) of 1990. Like Section 504, The ADA protects people with disabilities with mental or physical impairment that limits at least one major life activity. It also protects people who have a history of impairment or are perceived by others as having an impairment. This law is broader than Section 508 because it is a federal civil rights law that prohibits all entities open to the public, including transportation, telecommunications, and commercial facilities, from discriminating against people based on disability (U.S. Department of Justice, n.d.a). Even institutions that do not receive federal funding are required by law to comply with the ADA. The ADA Amendments Act of 2008 (ADAAA) broadened the definition of disability to include impairments that include major bodily functions, systems, and organs. Additionally, the ADA had previously specified that disabilities that were transitory and
minor would not be protected under the law. Still, the ADAAA clarified that “minor” must be determined case-by-case. The ADAAA also established that these changes applied to Section 504 requirements.

The ADA requires postsecondary institutions to provide services and accommodations or modifications to students, but students must identify and document their disabilities to receive support. Support is typically offered through a centralized accessibility office. Though these measures can help, institutions can vary widely regarding student availability and level of support (Newman & Madaus, 2015). One study revealed that only 28% of postsecondary students disclosed they had a disability, and fewer than one in five received assistance in some form (Newman & Madaus, 2015). Results of one large-scale study showed that 80% of students who indicated on a survey that they had a disability chose not to report their disability to the institution (Schelly et al., 2011). Some reasons that students may not self-identify include a desire for self-sufficiency, a desire to avoid negative peer reactions, a lack of knowledge about the existence of support services, perceived lack of utility of support services, negative experiences with instructors, and fear of future ramifications (Black et al., 2015; Lyman et al., 2016). One study found that some students did not request accommodations because they did not want to burden anyone with their needs or be stigmatized (Black et al., 2015).

Students who disclose a disability to their campus Office of Accessibility often request support such as extended test time, alternate assignments or exams, additional course notes, assistance with study skills or learning strategies, and adaptive technology and equipment (Newman & Madaus, 2015). The Office of Accessibility then collaborates with an instructor to provide accommodation for a single student. This results in a crisis-driven approach, where university leaders dodge potential lawsuits by focusing on legal compliance (Tobin, n.d.).
When post-secondary institutions fail to comply with disability laws, the Office of Civil Rights (OCR) initiates and monitors investigations in response to complaints. Almost a thousand complaints regarding postsecondary disability discrimination have been resolved on the OCR website since 2013 (U.S. Department of Justice, Civil Rights Division, n.d.b). With the increase of hybrid and online courses at colleges and universities, many complaints deal with inaccessible materials posted on websites or in LMSs. To resolve complaints, institutions must agree to mitigate inaccessible student-facing materials within a corrective action plan and timeline determined by the OCR (U.S. Department of Justice, Civil Rights Division, n.d.b). Institutions that do not address and resolve complaints risk losing federal funding or being sued, so making learning accessible is a top priority for all institutions (Baldwin & Ching, 2021).

However, there is no standard method of implementing and evaluating accessibility requirements (Baldwin & Ching, 2021). Rather than having to retrofit instructional materials, some post-secondary institutions have started approaching accessibility as a proactive instructional design effort by using Web Content Accessibility Guidelines (WCAG), Universal Design for Learning (UDL) guidelines, and various online course design evaluation instruments, such as the Quality Matters (QM) Higher Education Rubric and the OLC Quality Scorecard (Baldwin & Ching, 2021).

The Higher Education Opportunity Act (HEOA) of 2008 promoted UDL to increase access to postsecondary education for those with disabilities, provide financial assistance, and strengthen resources for postsecondary institutions. Title IV of the Act authorized the creation and federal funding of comprehensive transition and postsecondary (CPT) programs for learners with developmental and intellectual disabilities. Title VII of the Act awarded five-year grants to
higher education institutions to implement model programs focused on supporting disabled students with a variety of strategies:

UDL was first defined and endorsed by federal legislation in the HEOA as follows:

Universal Design for Learning (UDL) means a scientifically valid framework for guiding educational practice that —(A) provides flexibility in the ways information is presented, in the ways students respond or demonstrate knowledge and skills, and in the ways students are engaged; and (B) reduces barriers in instruction, provides appropriate accommodations, supports, and challenges, and maintains high achievement expectations for all students, including students with disabilities and students who are limited English proficient (HEOA, 2008).

UDL is mentioned in eight sections of the HEOA, with specific recommendations that funds be used for training teacher candidates in instructional practices, strategies, and technology tools that align with UDL principles. There are additional recommendations that funds be used to provide postsecondary instructors, staff, and administration with “in-service training, professional development, customized and general technical assistance, workshops, summer institutes, distance learning, and training in the use of assistive and educational technology” (HEOA, Section 762, 2008).

In recent years, the HEOA’s definition of UDL has been adopted and incorporated into two additional pieces of legislation that extend UDL’s reach to other environments: Every Student Succeeds Act (ESSA) of 2016 and the Strengthening Career and Technical Education for the 21st Century Act of 2018. The ESSA was passed to increase greater opportunity and equity for learners in K–12 public schools and includes four references to applying UDL principles. This law required that states develop assessments and comprehensive literacy instruction using
UDL principles and provide funding for the use of technology that applies UDL principles for students with disabilities and those who are English language learners (CAST, 2023b). The Strengthening Career and Technical Education for the 21st Century Act directs states to provide professional development and training activities in UDL principles to prepare instructors and staff at career and technical education centers to accommodate students with disabilities and English language learners (CAST, 2023b).

Despite broader legal protections and legislative support for people with disabilities, gaps in coverage remain. Learners with short-term or less severe disabilities and those who do not want to be identified are not protected under the law. However, they would likely benefit from flexible, inclusive ways of gaining, creating, and using new knowledge. Unlike Section 504 and the ADA, UDL is not regulated by federal law but can provide broader opportunities for learners. Proactive course design using UDL principles can potentially increase learning opportunities for all students (Rao, 2012).

Applying the UDL framework is not meant to be a substitute for accommodations or accessibility standards. Rather, UDL is intended to enhance access and accessibility by focusing on how students learn and instructors teach online (Thomson et al., 2015). There is less need for targeted interventions and retrofitting (i.e., adding accessible elements to a previously designed inaccessible course) when learners can interact with learning materials to meet their needs (Tobin, 2014). In addition, when targeted interventions and retrofitting take place, they
may be ineffective because they focus on the disabilities of the learner instead of what learners need in the overall context of the course (Rao, 2012).

**UDL in Online Environments**

Little research has been conducted about the application of UDL in online courses, but online environments provide access to technology tools, which aligns well with UDL implementation and offers a fertile ground for studies (Gravel et al., 2015; Rao & Tanners, 2011; Scott et al., 2015; Seok et al., 2018). Online environments provide time and space flexibility that can promote learning, and most have built-in accessibility features (Gravel et al., 2015; Seok et al., 2018). However, recent survey research indicated that over a quarter (28.4%) of online faculty are unfamiliar with UDL principles or guidelines (Westine et al., 2019). The growing diversity of students and the ever-increasing enrollments of students enrolling in one or more online courses indicate that postsecondary instructors and instructional designers could benefit from using UDL as an inclusive framework to meet the needs of their learners.

**Learning Outcomes**

**Academic Achievement**

A central criticism of UDL stems from the lack of evidence of its effectiveness in enhancing academic achievement in diverse learners (Crevecoeur et al., 2014; Edyburn, 2010; Edyburn, 2019; Hollingshead et al., 2020). CAST (n.d.a) describes anecdotal reports of improved grades in higher education, but there is little conclusive evidence about improved academic performance in college students. Few studies examine academic performance, and most involve UDL treatments with a small number of learners, mainly in elementary or middle school environments. Several studies found improved quiz or test scores with UDL treatments. Spooner et al. (2007) conducted an experimental study of 72 graduate and undergraduate students and
found statistically significant differences between the pre and post-test scores. In a study of elementary students with disabilities, five of nine teachers received training in UDL-enhanced literacy practices that used an e-book (Coyne et al., 2012). Students were divided into two groups \((n = 16)\) based on their teacher’s exposure to the training. Comparisons of the two groups found more significant gains on a standardized comprehension test after controlling for initial reading achievement. Rappolt-Schlichtmann et al. (2013) conducted a randomized controlled study with 621 elementary students to examine the effects of a UDL-enhanced web-based science notebook on learning outcomes. They found improved performance in the treatment group \((\gamma = 34, p \leq 0.01)\) after controlling for reading and writing proficiency and pretest motivation for science learning scores. In another study, high school students with and without disabilities were randomly assigned to a control or treatment group that used a UDL-enhanced instructional tool (Kennedy et al., 2014). Students in the treatment group had higher weekly assignment and post-test scores. Yu et al. (2021) used a UDL science intervention with 683 elementary students with disabilities and found improvements in quiz scores of students with disabilities and those who were English language learners. Two other studies found mixed results when examining GPA, course grades, and test scores (Marino et al., 2013; Moon et al., 2011). A recent meta-analysis by King-Sears et al. (2023) identified 20 experimental studies using treatment and control research designs of academic achievement in pre-K through adult learners. They found a moderate positive combined effect for learners who received UDL treatments \((g = 0.43)\). The current study used a comparison course to examine academic performance as measured by final course grades.

**Engagement**

CAST states that providing learners with multiple means of engagement stimulates interest and motivation, and it gives anecdotal support to improved postsecondary learner
engagement using the UDL guidelines (CAST, n.d.a). However, little experimental research examining engagement and UDL was found. A quasi-experimental study of 107 undergraduate students enrolled in a fully online class examined LMS login rates as a measure of engagement and found a statistically significant positive difference between the unit that included UDL features vs. the unit that did not include UDL features (Garrad & Nolan, 2023).

CAST recommends using learning analytics to examine learner engagement and inform course design (CAST, n.d.b). Learning analytics can capture online learners’ interactions with digital tools and instructional materials, so their use is appropriate for the current study to measure student engagement.

To date, no empirical study has used LMS learning analytics that include page views, percentage of assignments turned in on time, and participation to investigate engagement in UDL-enhanced instruction in postsecondary settings. However, experimental learning analytics research in postsecondary environments points to ways that an LMS can be used to collect data about learner engagement. Researchers have used analytics to measure how frequently learners have accessed specific tools and their frequency and duration of performing certain tasks (Angeli et al., 2017; Chang et al., 2017; Cheng et al., 2017; Gauthier et al., 2015; Kerr, 2015; Yang et al., 2018). Some research indicates that increased course logins and interactions with videos and quizzes can predict increased achievement, engagement, motivation, and course completion (de Barba et al., 2016; Pursel et al., 2016; Strang, 2017). One recent study found that Canvas page views, participations, and submissions positively correlated with final grades (Araiza & García Leal, 2021). By examining the number of page views (how learners access different representations of instructional materials) and the number and types of participations and
submissions (how learners choose to act and express themselves), the current study may be able to identify engagement patterns.

**Self-Efficacy**

CAST’s (2018) Universal Design for Learning website posits that UDL aims to develop expert learners by addressing learner variability and removing barriers to learning. Learners develop expertise as they become more motivated, skillful, and knowledgeable through sustained engagement in learning tasks of increasing difficulty and complexity (Edyburn, 2010; Meyer et al., 2014). UDL implementation can help develop expertise by increasing learners’ understanding of their learning needs and helping them regulate their emotions, thinking, and behavior (Navaitienė & Stasiūnaitienė, 2021). Self-efficacy is the foundation of this self-regulated behavior, as a learner’s confidence in their ability to learn motivates them to set and attain goals.

Several studies in this review examined elements of self-efficacy in various settings, and all found improved self-efficacy scores in UDL settings. However, none used a validated instrument to examine learners’ self-efficacy directly. In one case study, an online teacher education course was designed with UDL principles, data analytics, and a pre-and post-course survey indicated learner increases in confidence and self-efficacy (He, 2014). While self-efficacy was not measured directly in another study, students in a technology-enhanced face-to-face postsecondary course reported feeling more successful, in control of their learning process, and empowered to make choices to support their learning. (Kumar & Wideman, 2014). Al-Azawei et al. (2017) investigated university students studying computer science in a hybrid environment using a control group (n = 77) and an experimental group (n = 92) designed with UDL features. They distributed a questionnaire of items related to self-efficacy, perceived satisfaction, and the
Technology Acceptance Model (TAM) to both groups. Statistical analysis showed that self-efficacy and satisfaction were related to the treatment group's perceived ease of use of online learning environments. Another study used pre and post-test surveys to examine the application of UDL principles to teaching strategies and mentorship and found improved self-efficacy in learners (Kreider, 2018). In examining pre-service teachers’ attitudes toward UDL, researchers found that growth mindsets about learning, self-regulation, and self-efficacy to implement UDL were predictors of their use of UDL in the classroom. They also found that self-efficacy was the strongest predictor (Griful-Freixenet et al., 2021).

There is little research on self-efficacy in online courses, and no studies investigating the effect of online course design on learners’ self-efficacy could be found. Before the last decade, much of the self-efficacy research examined learners’ confidence in using a computer or an LMS (Alqurashi, 2016). A systematic review of self-efficacy studies in online learning environments identified several factors that affected learners’ self-efficacy, including previous experience taking online classes, instructor skills, feedback, and features of the LMS (Peechapol et al., 2018). Online self-efficacy has also been correlated with higher final course grades (Wang et al., 2013). Recently, researchers have developed instruments to investigate online self-efficacy more thoroughly. In developing one instrument, the Online Academic Success Indicators Scale (OASIS), researchers found that high levels of self-efficacy reliably predict academic achievement in online classes (Bradley et al., 2017). In the current study, the Online Learning Self-Efficacy Scale (OLSES) was selected to measure online self-efficacy because of the high level of internal consistency among the items in its three subscales (Appendix A).
Purpose of the Study

This study aims to fill this research gap using a multimethod design to investigate the effect of postsecondary online course design using UDL principles on academic performance, engagement, and self-efficacy. Academic performance is a variable of interest in this study because while there are anecdotal reports of improved academic performance in UDL-treated postsecondary environments, there is little evidence to support such claims. This study will also examine the effect of UDL elements on learner engagement, which has been previously described mainly using qualitative research designs. Several studies have investigated self-efficacy in a UDL environment, so it is another variable that will be examined in this study.

Research Questions and Hypotheses

These research questions and hypotheses were developed to examine the effects of a UDL-designed postsecondary online course on learners’ final course grades, engagement, and self-efficacy.

**RQ1**

Are there differences in academic achievement measured by final course grades between an asynchronous online course designed with UDL principles and an online asynchronous course without UDL principles?

**H1.** Final course grades will be higher in an asynchronous online course designed with UDL principles.

**RQ2**

Are there differences in engagement measured by percentages of assignments turned in on time, page views, and participation between an asynchronous online course designed with UDL principles and an asynchronous online course without UDL principles?
**H2.** The percentages of assignments turned in on time, page views, and participation will be higher in an asynchronous online course designed with UDL principles.

**RQ3**

Will an asynchronous online course designed with UDL principles affect online learners’ self-efficacy after controlling for GPA, age, and prior experience taking asynchronous online courses?

**H3.** An asynchronous online course designed with UDL principles will positively affect online learners’ self-efficacy after controlling for GPA, age, and prior experience taking asynchronous online courses.

**RQ4**

What were the course instructor’s perceptions of the course that used UDL principles compared to the course that did not use UDL principles?
CHAPTER II
METHODOLOGY

This chapter includes a description of the study’s research design, the setting and participants, the variables, the materials, the instruments, the self-efficacy instrument, and the procedures. The research design section describes the rationale for using a multimethod design. The setting and participants section describes the target population and method of sampling in this study, as well as other features to control confounding variables. In the variables section, the independent and dependent variables are identified. The materials section describes in detail the comparison course with no added UDL features and the treatment course with added UDL features. The instruments section describes the demographic questionnaire and the self-efficacy instrument. Finally, the procedures section describes how the experiment is conducted.

Research Design

This study was conducted in three phases using a multimethod research design consisting of integrated quantitative and qualitative data to answer the research questions. Though multimethod and mixed-method research designs share similarities, multimethod research seeks congruence and harmony among data. It does not seek to mix across different ways of understanding or to mix different standpoints (Greene, 2015).

In the study's first phase, students accessed their course in Canvas LMS. The comparison group accessed the original asynchronous online course developed by the instructor in Canvas. Students in the treatment group accessed the asynchronous online redesigned course in Canvas that included UDL features as outlined in the Materials section. Because students register for classes themselves, random assignment of participants used in true experimental studies was not feasible for this study, and a nonprobability sample was used instead. Near the end of the
semester, a TA posted an announcement in both courses to recruit participants for the study (Appendix B). The announcement directed students to the Research Task module page, which contained a link to a Qualtrics survey.

As part of the survey, participants were asked to complete demographic items, the OLSES, and three short open-ended items related to the first three research questions concerning academic achievement, engagement, and self-efficacy. Data was collected in Qualtrics anonymously, so it was impossible to link aggregate grade and engagement data collected in Canvas. This made it impossible to control for confounding variables when comparing the final course grades and engagement data between the groups during the subsequent data analysis phase.

The second data collection phase happened after the course ended and consisted of quantitative data. Final grade and participation data were collected automatically and anonymously by Canvas and downloaded for later analysis.

The final phase of the study took place a week after the courses ended and included a semi-structured interview with the course instructor.

**Research Paradigm**

The concept of a research paradigm is crucial, reflecting a researcher's worldview or interpretation of the world (Morgan, 2007). The importance of recognizing a researcher's worldview, particularly in the context of multimethod designs, is due to its influence on the
methodology and potential biases (Creswell & Guetterman, 2019; Creswell & Plano-Clark, 2011; Morgan, 2007).

**Epistemology**

Epistemology, a vital component of a research paradigm, pertains to understanding the nature of knowledge (Hofer & Bendixen, 2012). This study employed a pragmatist epistemology, a common choice for mixed design studies, prioritizing practical outcomes and permitting the use of necessary tools and theories to comprehensively understand the research phenomenon (Creswell & Guetterman, 2019). This pragmatic approach considers the best solution as one that is effective in each moment and context, considering the influence of social, historical, and political factors (Creswell & Guetterman, 2019). Therefore, it empowers researchers to utilize all available tools to explore the complex world, resisting reduction to purely quantitative or qualitative analysis (Creswell & Guetterman, 2019; Greene, 2015).

**Participants**

For this study, the target sample was second and third-year college students taking a three-credit asynchronous online course over a 16-week spring 2023 semester. The sample consisted of students who enrolled in one of two sections of a 300-level computer science course taught by the same instructor who is not affiliated with the researcher. The treatment course had 50 students at the beginning and 44 at the end of the semester, with 23 participants. The comparison course had 46 students at the beginning and 38 at the end of the semester, with 20 participants. In educational research, an appropriate sample size for group comparisons is typically determined by identifying a significance level of .05, determining the power needed to reject the null hypothesis as .80, and determining the effect size as .50 (Creswell & Guetterman, 2019). Lipsey’s (1990) Sample Size Table, as cited in Cresswell and Guetterman (2019),
indicates that a sample size of 65 is appropriate. However, by varying the criterion levels of power and effect size, a sample size as small as 30 for each group can be used (Creswell & Guetterman, 2019). To address the small group sizes in this study, the effect size was lowered to $p < .01$.

Students in the treatment and comparison groups who agreed to participate in the study were offered the chance to enter a drawing for a $400 Visa gift card or five extra credit points. Participants in both sections completed a survey during the second half of the semester. The survey included the demographics items and the Online Learning Self-Efficacy Scale (see Appendix A), and this data was used for analysis.

**Setting**

Participants accessed the course sections in Canvas LMS using their university login credentials. The course was online and asynchronous, with no required or optional synchronous elements. A syllabus outlined the course, the course objectives, the expectations, the course materials, and the assessments. The course description was as follows:

This course covers changes in the world’s society due to continuing implementation of computing technologies. Evaluation of technological expansions in areas of government, business/industry, education, medicine, transportation, communication, and entertainment. Topics include intellectual property, software piracy, computer crimes and ethics. Students must research a societal topic and present in written and oral forms.

Learners were expected to meet the following objectives by the end of the course:

- Examine and summarize the impact of computer technology on historical and contemporary societal issues.
- Describe the influence of digital communication and social networks.
• Analyze the impact of computer crime and fraud.
• Analyze intellectual property rights and constitutional issues in the context of historical and contemporary computer technology.
• Analyze technological reliability in the context of historical failures.
• Identify contemporary computer systems (hardware and/or software) and investigate the technological reliability in these contemporary systems.
• Describe and differentiate ethical and unethical uses of computer technology.
• Explain the fundamental importance of privacy and encryption in contemporary systems.

Learners were expected to work at their own pace while adhering to the due dates on the course calendar. The course was a topical survey course, and every week contained a module that covered a topic about computers in society, such as the history of computers, privacy, computers in education, etc. Graduate Teaching Assistants (TAs) helped the instructor grade assignments and answer students’ questions.

Variables

Independent and Dependent Variables

In this study, the UDL course design was the independent variable the researcher implemented in the treatment group, as described in the Materials section. The dependent variables were the final course grades, engagement interactions captured by Canvas analytics, and self-efficacy scores measured by the Online Learning Self-Efficacy Scale (OLSES).

Course grade

Canvas automatically collected student data, including grade data, that the instructor and researcher accessed by logging in using university credentials and a password. Grade data included grades on individual assignments, individual students’ overall course grades, and the
average of all students’ grades in the course. The dependent variable of interest for this study was the average course grade, which was point-based and ranged from 0 to 100 points. Aggregate data was downloaded from Canvas in a CSV file and uploaded to SPSS for data analysis.

Engagement

Canvas also collected student activity data, including total and average participations over time. Any action a student took was counted as a participation, including comments to announcements, assignment submissions, viewing or editing a course document, posting to a discussion forum, creating a page, and starting or submitting a quiz (Instructure, 2022). This study examined the differences between the comparison and treatment groups in the average number of page views and average number of participations.

Self-Efficacy

The Online Learning Self-Efficacy Scale (OLSES) was used with modification to collect students’ self-reported self-efficacy scores. Two of the 22 items were removed from the scale because they referred to group projects and synchronous meetings, which were not used in the course. Three items were revised to remove redundancy of the word “online.”

The OLES was developed by Zimmerman and Kulikowich in 2016 in a study to measure online self-efficacy in both novice and experienced online learners. Participants using the scale were asked to rate their beliefs that they could perform 22 tasks on a six-point scale from 1, which indicates a participant believes they would perform a task poorly, to 6, which indicates a participant believes that they could ask participants to rate their belief that they could perform a task at an expert level. The scale included three components: learning in the online environment, time management, and technology use. The Cronbach’s alpha for the three subscales in the
Zimmerman and Kulikowich study was .890, .855, and .843, respectively, indicating a high level of internal consistency among the items (Zimmerman & Kulikowich, 2016). Correlational analysis showed that all variables in the study except GPA were positively correlated with the three subscales. In the current study, the OLSES was selected as an appropriate instrument to measure the self-efficacy of online learners (Appendix A). The Cronbach’s alphas for the three subscales in the current study were .854 for learning in the online environment, .941 for time management, and .845 for technology use.

Instruments measuring SRL were not selected for several reasons. First, the literature review revealed that studies that touched on learners’ self-regulation investigated the construct through the lens of self-efficacy, which precedes the development of SRL strategies (Navaitienė & Stasiūnaitienė, 2021). This may be because developing expertise and self-regulation happens over time and may not be accurately measured by an SRL self-report questionnaire that investigates learners’ experiences over a semester. Additionally, participants in this study were potentially novices in developing SRL strategies. Investigations using SRL instruments may be more appropriate in a longitudinal study.

**Control Variables**

Control variables were collected in the Demographics and Qualitative survey (Appendix C), including GPA, age, and number of previously taken asynchronous online classes. The control variables enhanced internal validity by keeping the treatment and comparison conditions constant. This helped to accurately assess the effect of UDL design on the dependent variables.

**Grade Point Average (GPA)**

Researchers have widely used GPA as a predictor of academic achievement (Caskie et al., 2014). In this study, GPA on a scale of 0.00 to 4.00 was used as a control variable.
**Age**

Some research has shown a relationship between older students and lower levels of engagement, as well as older students and higher levels of self-efficacy (Yukselturk & Top, 2013). In this study, age, as measured by years, was used as a control variable.

**Number of Previously Taken Online Courses**

The number of previous online courses a student has taken has been shown to correlate with self-efficacy (Wang et al., 2013), predict self-efficacy (Shen et al., 2013) and predict course outcomes (Hachey et al., 2015). Therefore, this study used the number of prior asynchronous online courses taken as a control variable.

**Instrumentation**

To examine the variables of interest, this study collected data from Canvas analytics and a Qualtrics survey containing demographic items, the OLSES, and interview questions asked of the instructor.

**Demographic and Qualitative Questionnaire**

A short questionnaire was used to collect data about participants’ age, gender, disability status and type, disability reporting status, type of accommodation used, ethnicity, generational status, English language proficiency, GPA, and the number of previously taken asynchronous online classes. It also contained one open-ended item related to the three variables of interest to provide context to the quantitative data (Appendix C). Age, GPA, and the number of previously
taken asynchronous classes were used as control variables to limit the influence of confounding variables and enhance the internal validity of this study.

**Age**

Participants entered their age as a whole number of years in this continuous variable.

**GPA**

Participants entered their GPA as a continuous variable ranging from 0.00 to 4.00.

**Number of Previously Taken Online Courses**

Participants entered a whole number in this continuous variable.

**Interview with the Course Instructor**

The researcher developed a protocol for semi-structured interview questions with the course instructor to answer RQ4 (Appendix D). The initial questions were reviewed by an expert, the researcher’s chair, and further refined. A pilot test of the questions was conducted with the researcher’s colleague. At the start of the interview, the researcher requested and received permission to conduct the interview and to record it using Zoom video conferencing. To establish rapport with the instructor, the researcher asked open-ended questions about the instructor’s perceptions of the benefits and challenges of adopting UDL practices. The main questions related to the first three RQs were regarding the instructor’s perceptions of differences between the two groups' academic achievement, engagement, and confidence to succeed. Follow-up questions included asking for specific examples of each variable under investigation. The interview took about 25 minutes to complete. The researcher obtained a transcription immediately after the interview using Rev.com transcription software.

**Materials**

**Description of the Comparison Course**
The survey course about computers in society was initially developed by a faculty member with online teaching experience at a mid-sized public university on the East Coast. It was taught in a traditional 16-week semester in spring 2023. The faculty member was not affiliated with the researcher. The course was taught online for about ten years before this study by several instructors and had not been designed or redesigned by an instructional designer. There were 14 modules, each corresponding to a week. Instructional materials contained embedded PDFs containing text, graphics, and a few website links. Neither the text nor the graphics met basic accessibility standards. There were no multimedia materials in the course. Because of the large class sizes, students were placed in one of six color-coded groups. Group members shared only assignment due dates and a research topic. Students individually submitted six blog posts uploaded as Word documents and viewed only by the instructor and TAs. Assignments were well-scaffolded and culminated with a research paper and a presentation with accompanying presentation critiques. Though students were placed in a group, they submitted assignments individually and were not required to interact with each other. The course did not contain a class discussion forum, and there was no way for students to connect. All assignments required written submissions, including the optional extra credit paper. The course did not use a textbook, nor were there quizzes or exams. Specific features of the course are provided in Tables 1, 2, and 3.

**Description of the Treatment Course**

The researcher, an instructional designer with a decade of experience designing online courses, used the comparison course as a starting point for redesigning the treatment course. To redesign the course, the researcher adapted Rao’s (2021) UDL Design Cycle for applying UDL to online learning (Figure 1). Rao’s UDL Design Cycle was previously adapted from Rao &
Meo’s (2016) original UDL cycle of instructional planning for developing UDL-based lessons in K–12 settings.

Figure 1

*Rao’s 2021 UDL Design Cycle*

Rao’s UDL Design Cycle was developed to be a process for instructors developing UDL-based online lessons. In developing the treatment section, the researcher worked closely with an
instructor to redesign the original course, which already contained assessments, methods, and materials. Thus, an adapted design cycle, the UDL Redesign Cycle for Online Courses, was necessary for the researcher to develop. See Figure 2.

Figure 2

*UDL Redesign Cycle for Online Courses*

**Step 1:** Discuss learner variability with the instructor

**Step 2:** Discuss with the instructor:
- Course syllabus
- Objectives
- Previous learning barriers

**Step 3:** Review the course thoroughly in the roles of student and instructor to identify additional potential learning barriers

**Step 4:** Collaborate with the instructor to redesign assessments, methods, and materials that incorporate UDL components

**Step 5:** Implement UDL-based course

**Step 6:** Reflect and revise based on student and instructor feedback
The UDL Redesign Cycle for Online Courses was developed as a tool for instructional designers to use when working with instructors in the flexible implementation of UDL components during a course redesign. This cycle was used to develop the treatment course in the current study. In steps 1 and 2, the researcher met with the course instructor, who had taught the course asynchronously online for several years. Together, they reviewed the course syllabus. The researcher asked the instructor about the types of learners who had taken the course in the past and their abilities and needs. Then, the researcher and the instructor discussed the course objectives and the learning barriers students encountered in past semesters. The instructor identified several barriers, including learners' confusion about the purpose of groups and frequent questions about how to request various types of support, where to locate the schedule and due dates, and assignment expectations. Next, in step 3, the researcher analyzed the original course by navigating through the LMS using both student and instructor roles to identify additional potential learning barriers. Barriers included mainly disorganized text-based materials that did not meet current WCAG accessibility requirements, no options for learner expression, no engagement with the instructor, and no opportunities for learner collaboration and community.

After this analysis, in step 4, the researcher selected course components based on UDL guidelines that could address learning barriers. Then, the researcher met again with the instructor to negotiate which assessments, methods, and materials could be redesigned. The primary consideration was time limitations on both the researcher’s and instructors’ parts, so it was agreed that time would be spent on revisions that would offer the most impact in terms of reducing learning barriers, with the understanding that additional modifications could be made by the instructor in future iterations of the course. Unfortunately, the volume of inaccessible text-based learning materials made it impossible to make the course entirely accessible to learners.
within the timeframe. However, the researcher ensured that alt-text, video captions, and transcripts were added and that documents added to the course were accessible.

Next, in step 5, the researcher implemented the agreed-up revisions to the course syllabus, discussion forums, and course modules of the treatment section, as described in detail in Tables 1, 2, and 3. The graded assessments and grading criteria were not changed to maintain consistency between the two courses when comparing final grades. Step 6 includes CAST’s (n.d.a) recommendation that iterative revisions should be partly based on student feedback. During step 6, the researcher reflected on the quantitative and qualitative data collected from participants and the instructor as part of the current study. Since the researcher has not continued to work with the instructor after this study, it was determined that the course instructor would conduct an ongoing revision of the course described in step 6.
<table>
<thead>
<tr>
<th>Section</th>
<th>Comparison</th>
<th>Treatment</th>
<th>UDL Guidelines Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor information</td>
<td>• None</td>
<td>• Photo and bio</td>
<td>• Offer alternatives for auditory information (1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Location of instructor introduction video with captions and transcript</td>
<td>• Offer alternatives for visual information (1.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Location of syllabus walkthrough video with captions and transcript</td>
<td>• Illustrate through multiple media (2.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Location of LMS walkthrough video with captions and transcript</td>
<td>• Foster collaboration and community (8.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• List of multiple contact methods</td>
<td>• Promote expectations and beliefs that optimize motivation (9.1)</td>
</tr>
<tr>
<td>Course description and objectives</td>
<td>• Objectives only</td>
<td>• Description of how flexible assessments will meet course objectives</td>
<td>• Highlight patterns, critical features, big ideas, and relationships (3.2)</td>
</tr>
<tr>
<td>Course policies</td>
<td>• Plagiarism</td>
<td></td>
<td>• Guide appropriate goal setting (6.1)</td>
</tr>
<tr>
<td></td>
<td>• Communication</td>
<td>(Additional policies)</td>
<td>• Support planning and strategy development (6.2)</td>
</tr>
<tr>
<td></td>
<td>• Computer competency</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Technical issues</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Attendance</td>
<td>• Facilitate managing information and resources (6.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Academic honesty</td>
<td>• Minimize threats and distractions (7.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Academic support</td>
<td>• Facilitate personal coping skills and strategies (9.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Time commitment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Participation expectations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Due dates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Technology expectations and support</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Syllabus acknowledgement</td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Comparison</td>
<td>Treatment</td>
<td>UDL Guidelines Applied</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Overview of assignments</td>
<td>• Assignment overview</td>
<td>• Assignment overview that highlights alternative means of expression</td>
<td>• Support planning and strategy development (6.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Description of topic options for assignments</td>
<td>• Facilitate managing information and resources (6.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Location of assignment instructions and rubrics</td>
<td>• Enhance capacity for monitoring progress (6.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Visual map of assignments with alt text (See Figure 3)</td>
<td>• Offer alternatives for visual information (1.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Links to the library and writing center</td>
<td>• Optimize individual choice and autonomy (7.1)</td>
</tr>
<tr>
<td>Course schedule</td>
<td>• None</td>
<td>• Instructions for adding assignments to the calendar</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Week</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Module dates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Module topic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Assignments</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Due dates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Color-coded groups (See Figure 4)</td>
<td></td>
</tr>
<tr>
<td>Course materials</td>
<td>• Not described</td>
<td>• Brief description of all learning materials</td>
<td>• Illustrate through multiple media (2.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Description of alternatives to the text-based materials</td>
<td>• Vary demands and resources to optimize challenge (8.2)</td>
</tr>
</tbody>
</table>
Figure 3

Example of Visual Map of Assignments
### Example of Course Schedule

#### Course Schedule

**Tips:**
- Note the highlighted colors that indicate the due dates for your assigned group.
- To add assignment due dates to your student Google calendar, go to Canvas > Calendar > Select this course section > Calendar feed. Copy and paste the link into your Google calendar.

<table>
<thead>
<tr>
<th>Week</th>
<th>Module Dates (Mon-Sun)</th>
<th>Module Topic</th>
<th>Assignments</th>
<th>Due Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jan 7 – Jan 15</td>
<td>History of Computers</td>
<td>Syllabus Quiz</td>
<td>Jan 15</td>
</tr>
<tr>
<td>2</td>
<td>Jan 16 – Jan 22</td>
<td>History of the Internet</td>
<td>Group discussion: Self-Introduction post</td>
<td>Jan 20</td>
</tr>
<tr>
<td>3</td>
<td>Jan 23 – Jan 29</td>
<td>Societal Issues</td>
<td>Blue group: Presentation Thesis, Yellow group: Research Paper Thesis and Outline, Group discussion: Societal Issues</td>
<td>Jan 26, Jan 26, Jan 27</td>
</tr>
<tr>
<td>6</td>
<td>Feb 13 – Feb 19</td>
<td>Computers in Education</td>
<td>Yellow group: Rough and Final Drafts of Research Papers</td>
<td>Feb 13</td>
</tr>
<tr>
<td>Element</td>
<td>Comparison</td>
<td>Treatment</td>
<td>UDL Guidelines Applied</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Post format</td>
<td>Text or file upload. Used for asking questions about the course or submitting a presentation.</td>
<td>• Choices for post format (e.g., text, audio, video, etc.)</td>
<td>• Use multiple media for communication (5.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use multiple tools for construction and composition (5.2)</td>
<td>• Optimize individual choice and autonomy (7.1)</td>
<td></td>
</tr>
<tr>
<td>Prompts</td>
<td>• None. Blog posts are used as topical reflections instead of discussions.</td>
<td>• Group discussions with topical reflections (6)</td>
<td>• Optimize relevance, value, and authenticity (7.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Added questions to the self-introduction prompt:</td>
<td>• Foster collaboration and community (8.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Topics of interest</td>
<td>• Enhance capacity for monitoring progress (6.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Goal setting</td>
<td>• Promote expectations and beliefs that optimize motivation (9.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Feedback preferences</td>
<td>• Develop self-assessment and reflection (9.3)</td>
<td></td>
</tr>
<tr>
<td>Directions</td>
<td>• No description of how instructor feedback will be provided.</td>
<td>• Description of mastery-oriented feedback to be provided during and after discussions</td>
<td>• Increase mastery-oriented feedback (8.4)</td>
<td></td>
</tr>
<tr>
<td>Netiquette</td>
<td>• None</td>
<td>• Description of standards of discussion behavior</td>
<td>• Minimize threats and distractions (7.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Facilitate personal coping skills and strategies (9.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element</td>
<td>Comparison</td>
<td>Treatment</td>
<td>UDL Guidelines Applied</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>---------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Rubric</td>
<td>• Simple</td>
<td>• More detailed</td>
<td>• Enhance capacity for monitoring progress (6.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Develop self-assessment and reflection (9.3)</td>
<td></td>
</tr>
<tr>
<td>Support Options</td>
<td>• None</td>
<td>• Troubleshooting and access support</td>
<td>• Minimize threats and distractions (7.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Facilitate personal coping skills and strategies (9.2)</td>
<td></td>
</tr>
</tbody>
</table>
### Table 3

**Course Modules UDL Implementation**

<table>
<thead>
<tr>
<th>Element</th>
<th>Comparison</th>
<th>Treatment</th>
<th>UDL Guidelines Applied</th>
</tr>
</thead>
</table>
| Module structure and pages | • All modules grouped into one large module  
  • One page for each resource | • Modules separated  
  • Resources grouped onto one page | • Minimize threats and distractions (7.3)  
  • Highlight patterns, critical features, big ideas, and relationships (3.2) |
| Syllabus quiz            | • None                                           | • Mandatory ungraded quiz with unlimited attempts | • Highlight patterns, critical features, big ideas, and relationships (3.2) |
| Assessment objectives   | • None                                           | • Indicate alignment of module objectives and assessment | • Support planning and strategy development (6.2)  
  • Highlight patterns, critical features, big ideas, and relationships (3.2) |
| Module to-do lists       | • None                                           | • Text and color-coded graphic to-do-list graphic with alt text (See Figure 5) | • Illustrate through multiple media (2.5)  
  • Maximize transfer and generalization (3.4)  
  • Offer alternatives for visual information (1.3) |
| Assessment objectives   | • None                                           | • Indicate alignment of module objectives and assessment | • Support planning and strategy development (6.2)  
  • Highlight patterns, critical features, big ideas, and relationships (3.2) |
| Group collaboration     | • None                                           | • Group discussions  
  • Directions for using group tools | • Optimize individual choice and autonomy (7.1)  
  • Foster collaboration and community (8.3) |
<table>
<thead>
<tr>
<th>Element</th>
<th>Comparison</th>
<th>Treatment</th>
<th>UDL Guidelines Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course materials</td>
<td>• Text</td>
<td>• Text, audio, video, graphics</td>
<td>• Offer alternatives for auditory information (1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Offer alternatives for visual information (1.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Illustrate through multiple media (2.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Optimize relevance, value, and authenticity (7.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Vary demands and resources to optimize challenge (8.2)</td>
</tr>
<tr>
<td>Direct instruction</td>
<td>• None</td>
<td>• Videos explaining assessment requirements and differing approaches</td>
<td>• Highlight patterns, critical features, big ideas, and relationships (3.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Build fluencies with graduated levels of support for practice and performance (5.3)</td>
</tr>
</tbody>
</table>
**Procedure**

Near the end of both courses, assignment instructions directed students to complete a module task. The module task text is as follows:

Every Canvas course collects data about students’ performance and their interactions with course materials. That data is available to the course instructor(s) and teaching assistants (TAs) to review and analyze for making course improvements. A research study is being conducted in this class to examine learner outcomes and activities, but your data will only be included if you agree to participate. Your decision about participating in the study has no effect on your course grade. Please review the attached link containing the Informed Consent information and indicate your decision about participation in the research study by answering Yes or No.
Within this module task was an embedded Qualtrics survey directing students to complete the Informed Consent (see Appendix E). Students marking Yes were directed to complete the demographic questionnaire containing the open-ended items (Appendix C) and the OLSES (Appendix A).

At the end of the course, aggregate data on overall course grades and engagement activities was downloaded from Canvas to a CSV file and imported to SPSS for analysis. In addition, a semi-structured interview with the course instructor was conducted to add context to the results (Appendix D).

**Data Analysis**

After data was uploaded from Qualtrics into the Statistical Package for the Social Sciences (SPSS) software, a thorough review of the quantitative data was conducted, following the methods established by De Waal et al. in their 2011 study. This was to identify any prominent issues that could compromise the data, such as outliers and missing data. The review identified two survey entries where the participants had only completed the first item. These entries were removed. After this initial data review, descriptive statistics were analyzed to understand and summarize the characteristics of the study participants. This statistical method helped capture measures of description and dispersion like the mean, median, mode, standard deviation, and frequency distributions.

**Research Question 1**

To evaluate differences in overall course grades between the treatment and comparison groups, the researcher used an independent samples $t$-test. This test was used because control variables could not be used as they were collected anonymously as part of the survey.
Research Question 2

A series of *t*-tests were conducted to test the effect of the treatment on the percentage of assignments turned in on time, number of page views, and number of participations. Like RQ1, a *t*-test was used because control variables could not be used as they were collected anonymously as part of the survey.

Research Question 3

Comparing self-efficacy scores between the groups involved several steps. First, the OLSES was separated into three subscales, as intended by the OLSES developers: learning online, time management, and technology. Next, descriptive statistics and Cronbach’s alpha for the overall scale and its subscales were analyzed. An ANCOVA was used next to investigate the effect of the treatment condition on self-efficacy using the covariates of age, GPA, and number of asynchronous online courses previously taken.

Research Question 4

The open-ended questions and interview responses were examined for the qualitative portion of the study. These responses allowed the respondent to offer answers in her unique expressions and detailed insights. The researcher and a colleague reviewed the transcripts several times before coding the responses to identify themes and patterns. The open-coding procedure is an initial step where raw data are categorized based on their properties and dimensions, transforming the data into more understandable and interpretable information (Saldaña, 2013).

The researcher refined the data by asking a colleague to analyze and code the transcripts. The researcher and colleague compared codes and agreed with the interpretation of the data. After finalizing the analysis, the researcher examined the relationship between the results and the other quantitative and qualitative data. The central aim of employing these comprehensive
analytical procedures was to help increase the credibility and validity of the research findings by drawing a complete picture of the phenomena under study (Creswell, 2019).

Ethical considerations are inherent in all research endeavors, but they take on prominence in any design incorporating qualitative research due to the inherent subjectivity of the methodology (Creswell, 2009). In the case of the semi-structured interview conducted with the instructor, this researcher acknowledged the potential for these elements to have been impacted, given the existing relationship and rapport established through numerous in-person and virtual meetings. Despite this, utilizing an audit trail ensured ethical conduct and the safeguarding of participant data. This trail included preserving the original interview audio recordings, corresponding transcripts, and raw survey data. Therefore, any conclusions drawn can be deemed as having been reached ethically.
CHAPTER III

RESULTS

The results of the analyses conducted for this study are presented in this chapter. T-tests were conducted on the Canvas data collected to answer RQ1 and RQ2 regarding differences between groups in academic performance and engagement. The data collected in the anonymous survey included the OLSES to measure self-efficacy and demographic items. GPA, age, and number of asynchronous online courses taken previously were used as control variables in an ANCOVA to answer RQ3 regarding differences in self-efficacy scores between the treatment and comparison groups. Qualitative data collected from open-ended items in the survey are included with the results for each RQ to provide additional context to the quantitative data. The responses from an interview with the instructor to answer RQ4 are also included in the results of each RQ.

Demographic Characteristics

Of the 43 respondents included in this analysis, 53.5% \( (n = 23) \) were in the treatment group, and 46.5% \( (n = 20) \) were in the control group. The majority, at 58.1% \( (n = 25) \), were male, 37.2% \( (n = 16) \) were female, and 4.7% \( (n = 2) \) preferred not to disclose their gender. Precisely 46.5% \( (n = 20) \) were African American or Black, 2.3% \( (n = 1) \) Hispanic or Latinx, 4.7% \( (n = 2) \) South Asian, 9.3% \( (n = 4) \) Southeast Asian, 23.3% \( (n = 10) \) white, 9.3% \( (n = 4) \) “other”, and 4.7% \( (n = 2) \) did not want to disclose their race or ethnicity. The respondents had a mean age of 22.89 \( (SD = 6.75) \) years and a mean grade point average (GPA) of 3.10 \( (SD = 0.58) \), ranging from 1.80 to 3.93. They reported taking a mean of 4.65 \( (SD = 5.14) \) in previous online courses.

When asked about their English proficiency level, 74.4% \( (n = 32) \) reported that they were native, 20.9% \( (n = 9) \) advanced, 2.3% \( (n = 1) \) intermediate, and 2.3% \( (n = 1) \) basic. Precisely
18.6% considered themselves to be a first-generation immigrant to the United States, and 9.3% (n = 4) had a disability, with 2.3% (n = 1) reporting a psychological disability, 2.3% (n = 1) “other,” and 4.7% (n = 2) preferred not to disclose their disability type. Exactly 4.7% (n = 2) reported their disability to the campus office of accessibility. When asked how the design of the course has affected their grades, 20.9% (n = 9) reported better grades than expected, 60.5% (n = 26) reported grades as they expected, and 18.6% (n = 8) reported worse grades than expected.

**Research Question 1: Academic Achievement**

**Canvas Data**

An independent samples t-test was conducted to compare the overall course grades between the treatment and comparison groups. There was no significant difference in scores for the treatment group (M = 88.38, SD = 14.87) and the comparison group (M = 82.62, SD = 15.77); t (74) = 1.63, p = .107 (two-tailed), d = 15.266 (Table 4). Levene’s Test indicated equal variances (p = .13)

<p>| Table 4 |
|------------------|------------------|------------------|
| <strong>Comparison of Treatment and Comparison Means on Course Grades</strong>                        |</p>
<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>Comparison</th>
<th>Treatment</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
</tr>
<tr>
<td>Course Grade</td>
<td>43</td>
<td>88.383</td>
<td>14.87</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>


Open-Ended Survey Items

The qualitative analysis of the open-ended survey responses compared the treatment and comparison groups. Participants in both groups were asked to the prompt, “Describe how elements of this course affect your anticipated final grade.” The responses are grouped into five categories: Flexibility and Convenience, Structure and Clarity, Asynchronous Environment, Workload and Assignment Difficulty, and Personal Skills and Circumstances.

Flexibility and Convenience

Both groups highlight the benefits of working on the coursework independently. This flexibility seems to be associated with higher expected grades, especially for those balancing work and study. However, a participant from the treatment group mentioned that forgetfulness due to the course’s online nature impacted their grades negatively.

Structure and Clarity

The treatment group seems to value a well-structured and predictable course, especially having a rubric for major assignments. Some students from the comparison group found it challenging to understand the course structure initially but noted that it became easier over time. Unclear assignment explanations were also mentioned as a source of distress in the comparison group.

Asynchronous Environment

The asynchronous environment of the course seems to have varied effects on both groups. In the Treatment group, some students felt their grades were lower than expected due to forgetfulness, while others benefited from the online course. Similarly, the lack of in-person meetings was described as a challenge in the comparison group, but the ease of course navigation was also appreciated.
Workload and Assignment Difficulty

In the treatment group, the workload, mainly writing assignments, seemed challenging, causing some students to rush and find it difficult to catch up. Some also felt that rigid deadlines added stress. The comparison group also mentioned workload in terms of weekly modules, essays, presentations, and blog posts. However, these were not necessarily seen as negatives. Instead, these assignments seemed to provide structure and means of reviewing material.

Personal Skills and Circumstances

Personal attributes and circumstances also significantly impacted the anticipated final grade for both groups. One participant admitted to being “lazy” in the treatment group, and another struggled with essays. In the comparison group, one participant mentioned the challenge of managing their coursework due to ADHD. Another student felt that the inability to see grades until the end of the course affected their progress.

In summary, both groups appreciated the flexibility and convenience provided by the course, although the course's online nature had varied effects. The structure and clarity of the course were important, as were the workload and the difficulty of assignments. Lastly, personal skills and circumstances also influenced the anticipated final grades in both groups.

Research Question 2: Engagement

Canvas Data

An independent samples t-test was conducted to compare the effect of treatment on assignments percent turned in on time, number of page views, and number of participations. There was no significant difference in the percent of assignments submitted on time between the treatment group \((M = 89.67, SD = 13.42)\) and the comparison group \((M = 86.15, SD = 15.48)\), \(t (74) = 1.06, p = .292\). Similarly, there was no significant difference in page views between the treatment
group ($M = 1357.88, SD = 534.28$) and the comparison group ($M = 1418.76, SD = 680.34$), $t(74) = -0.44, p = .663$. However, there was a significant difference in participation between the treatment group ($M = 39.30, SD = 13.41$) and the comparison group, with the treatment group participating more ($M = 29.06, SD = 9.26$), $t(74) = 3.75, p < .001$ (Table 5). Levene’s Test indicated equal variances ($p = .37$).

The effect size for participation was calculated using Cohen’s $d$ ($d = .868$), Hedges’ correction ($d = .859$), and Glass’s delta ($d = 1.106$). These values indicate a large effect size.

**Table 5**

*Comparison of Treatment and Comparison Means on Percent of Assignments Turned in on Time, Page Views, and Participations*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Treatment</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n$</td>
<td>$M$</td>
<td>$SD$</td>
<td>$n$</td>
<td>$M$</td>
<td>$SD$</td>
<td>$t$</td>
<td>$df$</td>
<td>$p$</td>
<td>$d$</td>
<td></td>
</tr>
<tr>
<td>Percent of Assignments Turned in on Time</td>
<td>43</td>
<td>89.670</td>
<td>13.42</td>
<td>33</td>
<td>86.148</td>
<td>15.48</td>
<td>1.061</td>
<td>74</td>
<td>.292</td>
<td>.246</td>
<td></td>
</tr>
<tr>
<td>Page Views</td>
<td>43</td>
<td>1357.88</td>
<td>534.28</td>
<td>33</td>
<td>1418.76</td>
<td>680.34</td>
<td>-.437</td>
<td>74</td>
<td>.332</td>
<td>-.101</td>
<td></td>
</tr>
<tr>
<td>Participations</td>
<td>43</td>
<td>39.30</td>
<td>13.41</td>
<td>33</td>
<td>29.06</td>
<td>9.26</td>
<td>3.752</td>
<td>74</td>
<td>&lt;.001</td>
<td>.868</td>
<td></td>
</tr>
</tbody>
</table>

**Open-Ended Survey Items**

The qualitative analysis of the open-ended survey responses compares the treatment and comparison groups. Participants in both groups were asked to the prompt, “Which parts of this course make you feel engaged?”

Based on the responses provided, the treatment group primarily emphasized the value they find in discussions and interactions with their classmates. They appreciated the opportunity
to engage with others on the discussion boards. Additionally, they expressed enthusiasm for research assignments, presentations, and the overall process of researching and drafting their papers.

In contrast, the comparison group focuses more on different aspects of the course. They mention the presentation, research paper, and writing blog posts. They highlight their enjoyment in projects, critiques of classmates’ presentations, and specific due dates for assignments. The presentation component is also mentioned several times, with participants describing it as simple, straightforward, fun, and enjoyable.

Research Question 3: Self-Efficacy

Scale Reliability

The OLSES was used to evaluate the level of self-efficiency in students. The modified OLSES used in this study was composed of 20 questions and had a strong level of internal consistency with a Cronbach’s alpha score of 0.926. The Cronbach’s alphas for the three subscales of learning online, time management, and use of technology in the current study were .854, .941, and .845, respectively. See Table 6.

Table 6

Descriptive Statistics and Cronbach’s Alpha for OLSES Scale and Subscales (both groups, N = 43)

<table>
<thead>
<tr>
<th>Scale</th>
<th>No. of Items</th>
<th>M</th>
<th>SD</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLSES Learning Online</td>
<td>8</td>
<td>32.47</td>
<td>5.28</td>
<td>.854</td>
</tr>
<tr>
<td>OLSES Time Management</td>
<td>5</td>
<td>17.95</td>
<td>5.56</td>
<td>.941</td>
</tr>
<tr>
<td>OLSES Technology</td>
<td>7</td>
<td>29.07</td>
<td>4.63</td>
<td>.845</td>
</tr>
<tr>
<td>OLSES</td>
<td>20</td>
<td>3.97</td>
<td>.65</td>
<td>.926</td>
</tr>
</tbody>
</table>
Self-Efficacy Scores

Self-efficacy scores ranged from 2.75 to 5.00, with a mean of 3.97 (SD = 0.65). Self-efficacy scores were higher in the treatment group ($M = 4.23$, SD = 0.63) than in the comparison group ($M = 3.68$, SD = 0.56), with a statistically significant difference, $M = 0.55$, 95% CI [0.18, 0.92], $t(41) = 3.006$, $p = .005$ (Figure 5).

Figure 5

*Self-Efficacy Scores by Group*

Before running an ANCOVA, the researcher checked assumptions. The normality of the dependent variable (self-efficacy scores) and the covariates (age, GPA, and number of previous online courses) were examined for skewness and kurtosis. While the rest of the variables were
within the accepted range of normality of -1 to +1 for skewness and less than 3 for kurtosis, age had a skewness of 2.19, and number of previous online courses had a skewness of 1.18 and a kurtosis of 5.53. Next, the researcher found no significant effect of self-efficacy scores on the covariates \( p = .95 \). A Pearson’s product-moment correlation was run to assess the relationship between self-efficacy, age, GPA, and the number of online courses previously taken as well as test the assumption of multicollinearity among control variables. There was a statistically significant, weak positive correlation between self-efficacy and GPA, \( r(40) = .32, p = .040 \), with GPA explaining 10.1% of the variation in self-efficacy (Table 7). There were no other significant correlations found. To check the homogeneity of regression, a test of between-subject effects was conducted and found no significant interactions between self-efficacy scores and the covariates. The result of Levene’s test indicated that the group variances are equal \( p = .58 \), and the assumption of homogeneity of variance was not violated.

Table 7

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Self-Efficacy</td>
<td></td>
<td>-0.016</td>
<td></td>
</tr>
<tr>
<td>2. Age</td>
<td></td>
<td></td>
<td>-0.104</td>
</tr>
<tr>
<td>3. GPA</td>
<td>.318*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Number of</td>
<td>-0.030</td>
<td>0.213</td>
<td>-0.021</td>
</tr>
<tr>
<td>Online Courses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previously Taken</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).

An ANCOVA was run to determine the effect of an online course designed with UDL principles after controlling for respondent age, GPA, and the number of previously asynchronous online courses. Self-efficacy was greater in the treatment group \( M = 4.23, SD = 0.63 \) compared
to the comparison group ($M = 3.67, SD = 0.57$), with a mean difference of 0.555, 95% CI [0.18, 0.93], $p = .005$. After adjustment for age, GPA, and the number of online courses previously taken, there was a statistically significant difference in self-efficacy between the two groups, $F(1, 37) = 9.112, p = .005$, partial $\eta^2 = .198$ (Table 8).

Table 8

_Adjusted and Unadjusted Means and Variability for Self-Efficacy with Age, GPA, and Previous Experience with Online Courses as Covariates_

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Unadjusted</th>
<th></th>
<th>Adjusted</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Treatment</td>
<td>23</td>
<td>4.23</td>
<td>0.63</td>
<td>4.22</td>
<td>0.12</td>
</tr>
<tr>
<td>Comparison</td>
<td>20</td>
<td>3.67</td>
<td>0.57</td>
<td>3.67</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Open-Ended Survey Items

The qualitative analysis of the open-ended survey responses compares the treatment and the comparison groups. Participants in both groups were asked to the prompt, “Which parts of this course give you confidence to succeed?”

_Course Content and Structure_

This was a prominent theme in the treatment group, with students mentioning aspects like relevant module material, easy-to-understand content, and the weekly exploration of new topics. Topics like cybersecurity also seemed to engage students and boost their confidence. In the comparison group, explicitly setting deadlines and specific due dates for assignments helped students manage their time efficiently. It gave them confidence in their ability to complete the work.
**Grades and Feedback**

Both the easy grading system and constructive feedback from instructors or TAs provided reassurance of their performance. They helped students gain confidence in their ability to do well in the course.

**Instructor Availability**

The teacher’s availability was explicitly cited in both groups as a confidence-boosting element, indicating that accessible support from the instructor was significant to their confidence.

**Coursework**

In the treatment group, the discussion boards appeared to enhance students’ confidence, likely due to their interactive and in-depth nature. Participants in the treatment and comparison groups both mentioned that presentations and research papers played a significant role in boosting students’ confidence. They reported that these elements helped them develop and validate their research and writing skills.

**Blogs and Extra Credit**

Participants in the comparison group mentioned that writing blog posts and having the opportunity to earn extra credit gave them confidence. They likely allowed students to grasp course material more effectively and make up for any shortcomings in other areas of the course.

Interestingly, a few responses indicated “none” or “I’m not sure” from both groups, suggesting that for some students, no specific part of the course stood out as particularly confidence-boosting.

**Research Question 4: Instructor’s Perceptions**

During the semi-structured interview, the course instructor indicated that she did not see differences between the treatment and comparison groups regarding students’ grades or the
quality of their work. The instructor noted that many students in both groups chose to focus their research papers on emerging topics such as Generative Artificial Intelligence. She was delighted with the quality of their work.

Regarding engagement, the instructor noted that the main difference in engagement between the treatment and comparison groups was due to the discussion boards, which were only used in the treatment group. In the comparison group, students were asked to submit seven reflections on weekly topics throughout the 16 weeks as individually submitted blog posts. Outside of an “Ask the Professor” class discussion board, there was no opportunity for student interaction in the comparison course. Students in the treatment group were required instead to post seven reflections on the weekly topics in their group’s discussion board by the middle of the week and reply to two classmates by the end of the week.

The instructor saw a significant difference in the treatment and comparison groups regarding students’ self-efficacy. She noted that very few students requested assistance from her or the TAs in the treatment group and cited the consistent module structure, syllabus overview, assignment videos, detailed assignment descriptions, and graphic assignment and module overviews as potential reasons for the difference. One of the students’ main learning gaps noted by the instructor during the instructional designer’s analysis phase of the treatment course redesign was understanding the requirements of the staggered assignments and the group due dates. In prior semesters, the instructor and TAs had been inundated with emails and posts to the “Ask the Professor” discussion board, asking for help and clarification. During the interview, the instructor indicated that she was pleased to see that the UDL-designed course provided the support the students needed.
CHAPTER IV

DISCUSSION

This study examined the effects of a UDL-designed postsecondary online course on learners’ academic achievement, engagement, and self-efficacy. The following paragraphs discuss the findings of each research question.

Impact of UDL Implementation on Academic Achievement

Results of a t-test in this study found no significant differences in final course grades between the treatment and comparison groups. These results are confirmed by the course instructor, who did not perceive differences in grades or the quality of assignments between the two groups. A few students in the treatment group who responded to the open-ended item mentioned the course structure and clarity as having a positive impact on their anticipated final course grade, so it is possible that the treatment course's design impacted academic achievement.

These findings are consistent with the mixed findings in empirical studies that implementing UDL in postsecondary environments increases academic achievement (Capp, 2017; Seok et al., 2018; Spooner et al., 2007). While anecdotal reports and some studies suggest that UDL interventions can lead to improved academic performance, particularly in terms of test scores and assignments, the overall evidence base is limited, and the effects may vary across different educational contexts and student populations (King-Sears et al., 2023). In the current study, the small number of participants may explain the difficulty in finding differences in course grades between the treatment and comparison groups.

Impact of UDL Implementation on Engagement
T-tests revealed no significant differences in engagement as measured by page views and percentages of assignments turned in on time. However, when examining participation, a t-test revealed a strong significant difference between the courses, with the treatment group participating much more than the comparison group. This outcome is likely due to a lack of peer-to-peer interaction in the comparison group compared to the group discussions in the treatment group. The course instructor did not perceive significant differences in engagement between the courses. However, she noted the interactions among students in the treatment group because of the discussion board posting requirements. Responses to the open-ended survey item about parts of the course that made participants feel engaged focused mainly on the discussions in the treatment group. In contrast, the comparison group responses described a variety of course assignments.

The results of the current study indicate that online courses that include opportunities for learners to interact with each other may increase learner’s interactions with the LMS. Previous research has shown that increased interactions can predict achievement, motivation, engagement, and course completion (de Barba et al., 2016; Pursel et al., 2016; Strang, 2017). The current study is the first to examine LMS participation in an online UDL-designed treatment course and a comparison course. Though the present study found no evidence to support the effect of increased interactions on achievement, future studies may align with those previous findings.

Interestingly, although students in the treatment group were allowed to participate in the discussions using text, audio, or video, only two audio recordings were posted in the discussion forums over the entire semester. Though instructions on how to post using audio and video tools were included in each discussion prompt, the tools are not labeled prominently in the rich content editor window where students post, and students may have been unfamiliar with the tools or had
difficulty finding them. During the interview, the course instructor was enthusiastic about implementing multiple means of expression in her other online courses. She mentioned that the LMS should highlight these tools for easy student access.

**Impact of UDL Implementation on Self-Efficacy**

Of the three dependent variables under investigation in this study, self-efficacy was the most strongly supported by the literature review to be affected by UDL design. The results from the ANCOVA indicate that students in the UDL-design treatment group had significantly higher self-efficacy scores than the comparison group after controlling for age, GPA, and the number of previously taken asynchronous online courses.

The course instructor also found that students had higher self-efficacy in the treatment group. She noted several times throughout the interview that she was pleased that fewer students in the treatment group sought help from her and the TAs for finding course materials, submitting assignments, and managing their time. Participants in the treatment course responded in the open-ended survey item that the course content, structure, and discussions made them feel confident in their ability to succeed. Both groups also mentioned the instructor's availability and the assignments as boosting their confidence.

These results align well with the idea that courses designed with UDL features promote self-efficacy and self-regulation. Self-efficacy underpins self-regulation; learners' confidence in their learning ability encourages them to set and achieve goals. CAST posits that the end goal of Universal Design for Learning (UDL) is to foster expert learners. Learners become more proficient as they grow more motivated, knowledgeable, and skillful, especially when continuously exposed to increasingly challenging and complex learning tasks (Edyburn, 2010; Meyer et al., 2014). UDL facilitates this development by enhancing learner’s understanding of
their learning needs and by helping them manage their emotions, thoughts, and behavior (Navaitienė & Stasiūnaitienė, 2021).

**Implications of Implementing UDL in the Current Study**

The results of this study provide important implications for instructors and instructional designers. In this study, an asynchronous online course was successfully redesigned by an instructor and an instructional designer to include UDL features that helped reduce barriers to learning and develop learners' self-efficacy. Developing self-efficacy in learners could be particularly useful to novice online learners as they develop self-regulation and become expert learners.

As evidenced by this study, redesigning a course to incorporate UDL features meaningfully requires an instructional designer to conduct a substantial and time-consuming initial analysis of the course, the learners, learning gaps, and the instructor’s need for workload balance. The design of the treatment course in this study also required educating the instructor and TAs about UDL. To optimize the incorporation of UDL in online higher education settings, educators should be trained to identify potential learning barriers and implement relevant UDL features in their courses.

**General Recommendations for Implementing UDL in Higher Education Settings**

UDL-designed courses take more time and effort to develop, so it is essential to plan them carefully (Al-Azawei et al., 2016; Kumar & Wideman, 2014; Ofiesh et al., 2006; Robinson & Wizer, 2016). CAST provides suggestions from higher education instructors to start implementation of UDL by beginning with a particular challenge in mind, making small changes, focusing on objectives, and finding multiple ways for learners to reach them, including students’ perspectives when deciding what changes to make; thinking about how UDL guidelines
can be applied to assignments; and discuss implementation with peers (CAST, n.d.a). The researcher incorporated these recommendations in the current study by developing and using the UDL Redesign Cycle for Online Courses (Figure 2). Though some practices overlap, the following sections provide specific best practices in providing multiple means of representation, action and expression, and engagement.

**Representation**

Most of the recommendations for implementing multiple means of representation focus on varying the format of the instructional materials. At the course-wide level, most authors recommended taking advantage of the tools provided by learning management systems, course management systems, or course websites, even in face-to-face, on-campus environments (Gradel & Edson, 2010; Gravel et al., 2015; La et al. 2018; Rose et al., 2006; Webb & Hoover, 2015). In the current study, the researcher incorporated technology tools that allowed multiple versions of instructional materials, including videos with captions, podcasts, graphics, and hyperlinks, to supplement text-based instructional materials. Using this approach, learners could select the materials they wanted to use. The redesign of the structure of modules within the course website itself in this study provided an improved skeletal structure for developing learning schema, with multimedia and hyperlinks used as scaffolded supports for presenting information, including information for learners on how to access these materials, as recommended by Gradel and Edson (2010) and Rose et al. (2006). The design of the treatment course included best practices included chunking videos into small pieces and focusing lecture videos on the most salient points (Rose et al., 2006; Tobin, 2014), verbally describing graphics in lectures (Gravel et al., 2015), and sharing learner-created materials with the class (La et al., 2018; Rose et al., 2006).
**Action and Expression**

Design considerations for providing multiple means of action and expression center on how learners express themselves and demonstrate their learning. Several authors identified small group discussions as important to include in course design. (La et al., 2018; Rose et. al, 2006). In the current study, students in the treatment group used a group discussion forum and were provided a choice of topic. Another best practice is using various evaluation methods and ways learners can demonstrate their learning (Gradel & Edson, 2010; Tobin, 2014). This practice was incorporated in the treatment course in the discussion forums, where learners were prompted to consider posting text alternatives such as video or audio and were provided instructions for creating those types of media.

**Engagement**

To create engagement, many authors mentioned offering learners choices, making learning relevant and authentic, minimizing learner discomfort and distractions, creating opportunities for collaboration and community, encouraging persistence with quality feedback, and asking students to reflect and self-assess (Gravel et al., 2015; Mora & Reynolds, 2010; Rao et al., 2015; Rose et al., 2006; Tobin, 2014). In the current study, learners in the treatment section participated in robust group discussions centered on current, authentically situated reflections related to the module theme. Students and the TAs provided feedback on the discussion forum, which participants described as engaging. Researchers also discussed strategies for developing self-efficacy and self-regulation in learners, such as explicitly drawing connections between prior and future learning and providing advice about managing time and developing milestones (Tobin, 2014). The syllabus in the treatment group included these strategies by explaining connections and providing tips on time management.
Recommendations for Implementing UDL in Online Settings

A fundamental principle of UDL is seamlessly integrating into learning experiences and fostering social connections without drawing attention. Online technology tools facilitate this smooth integration. (Burgstahler, 2015; Morra & Reynolds, 2010). Studies conducted in on-campus, online, and hybrid courses found that technology tools, typically provided by an LMS, CMS, course website, or social media sites, are essential to supporting learning with UDL principles and guidelines (Dell et al., 2015; Smith, 2012). Online technologies are perceived by learners as useful to improve learning engagement, reduce learning stress, and increase performance, understanding, and interaction (Al-Azawei et al., 2017). As discussed previously, technology tools offer myriad opportunities for providing multiple means of engagement, action and expression, and representation with collaborative tools, social media, multimedia, digital texts, speech-to-text, text-to-speech, alt-text, hyperlinks, built-in accessibility-checking tools, auto-captioning of videos and live web conferencing, screen readers, screen magnifiers (Carr-Chellman, & Choi, 2018; Gravel et al., 2015; Navarro et. al, 2016; Rogers-Shaw, 2018; Tobin, 2014; Williams et. al, 2013).

Researchers described specific best practices for implementing UDL in online environments, mainly in addressing particular challenges and characteristics of online learners. Rao (2012) noted that online learners can experience uncertainty about expectations, an insufficient learning community, and technology challenges. Online learners cannot immediately communicate with their instructors and peers. Hence, creating effective communication strategies and many interaction opportunities is essential for learners to express themselves (Davies et al., 2013). In the Getting Started module and syllabus in the treatment group, explicit information about the available assistive technologies, how to request accommodations, how to
navigate the environment and use support tools, and how to communicate effectively in
discussion boards and email was included, as recommended by several authors (Carr-Chellman,
& Choi, 2018; Dell et al., 2015; Rogers-Shaw et al., 2018).

In addition to technology tools, the online environment offers an opportunity for
implementing UDL principles through course design. In courses mainly conducted in
asynchronous online environments, instructors must thoughtfully design all components in
advance, including social, cognitive, and teaching presences (Garrison et al., 1999). Because
most faculty are subject-matter experts in their fields rather than pedagogical experts, most
higher education institutions offer specialized instructional design support for developing online
or hybrid courses. Designing an online course does not simply entail transforming a face-to-face
class into a digital format; it requires rethinking assumptions about teaching and learning and
rethinking objectives, teaching strategies, assessments, and interactions. The involvement of one
or more instructional designers in the online course development process offers faculty who are
unlikely to be familiar with UDL the opportunity to effectively incorporate UDL principles and
guidelines proactively (Evmenova, 2018; Estes et al., 2020). A way instructional designers and
instructors can do this is to use the UDL Redesign Cycle for Online Courses developed by the
researcher in this study.

**Limitations**

Addressing the limitations of this study is crucial for maintaining transparency,
credibility, and the overall integrity of the research. This section provides context for
understanding the study's results and highlights areas for potentially refining future
methodologies and approaches.
Threats to Internal Validity

The main threats to internal validity in RQ1, RQ2, and RQ3 concern selection bias and attrition. Regarding selection bias, two sections of the online course were offered for enrollment prior to the start of the semester. The registrar placed students who enrolled early into the first section, which was assigned by a coin toss as the treatment group. Students who enrolled later were placed in the second section, the control group. Early enrollment may suggest characteristics such as higher levels of academic readiness and motivation, so the differences among participants before the treatment could have affected the outcome. Attrition could have also affected the study’s outcome because more students dropped from the control group course section (8) than the treatment group course section (6), reducing the potential sample size and decreasing statistical power.

RQ1

An additional threat to internal validity in RQ1 involves confounding variables. The aggregate data for final course grades was collected anonymously by Canvas, so it was impossible to use control variables. Therefore, if confounding variables existed in the study, the results of this research question may be inaccurate.

RQ2

Likewise, the aggregate data for participation was collected anonymously, and control variables were not used. If confounding variables existed in the study, the results of this research question may also be inaccurate. Another threat to internal validity involves measuring participation in the LMS, as participation may not accurately reflect learner engagement.

RQ3

Another threat involves instrumentation. The Online Learning
Self-Efficacy Scale was selected because of its high level of internal consistency. However, it is a self-report tool that relies on participants’ assessments of their abilities and can potentially create self-report bias. For this RQ, age, GPA, and the number of previous online courses taken were used as control variables. However, GPA was also self-reported by participants and may not be accurate.

**RQ4**

The instructor in this study was involved in the course redesign of the treatment group and may have unknowingly exhibited bias in her interactions with the different groups. Additionally, extended interactions between the researcher and the course instructor during the study may have introduced researcher bias.

**Threats to External Validity**

External validity refers to the extent to which the conclusions in this study can be generalized to a larger population. The current study's main threat to external validity was the small sample size. Small samples may not accurately represent the larger population from which they are drawn. This can lead to biased or unrepresentative results that cannot be generalized to the broader population. The small sample size may lack the power to detect real differences between groups and may increase the susceptibility of chance variations.

**Recommendations for Future Research**

This study was an early attempt to examine the effect of UDL design on learners’ achievement, engagement, and self-efficacy in a postsecondary online environment. As research about UDL in online postsecondary settings is nascent, a vast range of research needs to be conducted to explore the effect of UDL features on learning outcomes, including research that uses different research designs, populations and contexts, instruments, and variables.
Research Design

Experimental and Quasi-Experimental Designs

Research about UDL in online asynchronous courses is scarce, and there is a significant lack of empirical evidence regarding UDL’s effect on learning and engagement outcomes. One reason for the lack of empirical evidence could be the time and effort it takes to retrofit courses to include UDL features to study the differences between groups. However, this kind of research needs to be conducted. To make such analysis more feasible, researchers could compare smaller units of instruction. Future research could use a much larger number of participants and random assignment to add more credibility to claims of UDL’s benefits to learners.

Qualitative Designs

There is much potential for qualitative studies to examine UDL implementation in online college classes. Qualitative studies could include the perspectives of the instructor, instructional designer, and the learners. Interviews with learners and instructors before UDL implementation could investigate their perceptions of existing learning barriers. Follow-up interviews after UDL implementation could explore how effective the UDL treatments were in removing or reducing the identified learning barriers. The researcher observed robust discussion in the treatment section of the current study. However, an analysis of the discussions was not under investigation. Researchers could conduct content analysis of text discussion posts and multimedia submissions in UDL-enhanced courses to examine patterns, trends, and insights. Finally, the researcher in this study developed the UDL Redesign Cycle for Online Courses. Instructional designers and instructors could conduct action research using this process to plan iteratively, incorporate UDL features, observe, and reflect on their efforts. Additional research
about the UDL Redesign Cycle for Online Courses could include interviews with instructional designers or instructors engaged in this work.

**Mixed Methods and Multimethod Research Designs**

The current study used a multimethod design for consistency and alignment of data. Future research could emulate this type of research or use a mixed-method approach that uses multiple philosophical perspectives or paradigms. These designs could offer even greater insights into which elements of UDL implementation are most effective for postsecondary learners.

**Populations and Contexts**

The current study investigated UDL in the context of a second-year Computer Science class. Four participants acknowledged having a learning disability, and only two of them had registered with the Office of Accessibility to receive accommodations, which is consistent with research showing that many students with disabilities do not report them (Newman & Madaus, 2015). More research should be conducted with participants taking classes in other disciplines, which may have larger populations of students with disabilities or other learner differences. The current study included survey items about English language proficiency and immigrant status, but responses were not examined in depth. Future studies could explore the effects of UDL treatments on populations with basic or intermediate English language skills.

Though UDL has been studied widely in K–12 and, more recently, in higher education, it would also be interesting to research UDL within the context of asynchronous training modules. King-Sears et al. (2023) recommend UDL research in professional and business settings.

**Variables**

This study investigated achievement, engagement, and self-efficacy; future research should continue to study those variables. The current study provided evidence that UDL features
can increase self-efficacy, and additional studies should be conducted to confirm this finding. Self-efficacy is a beginning step toward developing what CAST calls expert learners. Other variables related to self-efficacy should be investigated in the context of UDL-enhanced online courses over a more extended period. These variables include self-regulation, persistence, and completion (e.g., course, certificate, degree, etc.) (See Figure 6).

Figure 6

Progression of Self-Efficacy to Course and Program Completion

Instruments

The current study used a modified version of the OLSES to measure learners’ self-efficacy. Other instruments that measure self-efficacy could be used in future studies, such as the Self-Efficacy Questionnaire for Online Learning (SeQoL) (Tsai et al., 2020). Additional research could be conducted using instruments that measure self-regulated learning, such as the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991), or persistence, such as the Persistence Scale for Online Education (PSOE) (Hart, 2012).

In the past few years, researchers have begun investigating UDL within the framework of Self-Determination Theory (SDT), a theory of motivation and personality that focuses on the psychological needs of autonomy, competence, and relatedness (Ryan & Deci, 2017). Both UDL and SDT emphasize the importance of intrinsic motivation. While SDT provides a theoretical understanding of what motivates individuals, UDL offers practical ways to implement learning
environments that support intrinsic motivation. When students feel competent, related, and autonomous in their learning environment, they are more likely to be intrinsically motivated to learn (Ismailov & Chiu, 2022; Naffziger & Alvarado, 2022; Navaitienė & Stasiūnaitienė, 2021; Stenn & Osterholt, 2023). The widely used Self-Determination Scale (SDS) (Sheldon & Deci, 1993) is an instrument that could be used to investigate this construct in UDL-designed environments.

**Conclusion**

This study sought to address the gap in knowledge about the effect of UDL features on online postsecondary learners’ achievement. Previous empirical research in online postsecondary environments is scarce, and results have been mixed. Results from this study show that UDL features did not affect online learners’ achievement, indicating that researchers should conduct additional studies to resolve these mixed results. Empirical research studies, mainly in K–12 environments, seem to support a moderate effect of UDL features on achievement and add more clues for future researchers to puzzle through (King-Sears et al., 2023).

The current study also sought to fill in the gap in knowledge about the effect of UDL features on learners’ engagement. Results from the present study were consistent with the results of the one previous empirical study found in the literature review, which indicated that online courses designed with UDL features affect learners’ engagement. In the past few years, research has been conducted around the use of learning analytics to measure levels of engagement, and those results support the idea that getting learners to interact within the LMS can improve multiple measures of learning outcomes (de Barba et al., 2016; Pursel et al., 2016; Strang, 2017). This is an important implication for those designing online courses; incorporating UDL features to increase learner activity can potentially increase engagement and motivation.
The current study sought to investigate self-efficacy in a UDL-designed online course. Previously, limited research described a positive effect of UDL design on self-efficacy, and the results of this study strongly support that finding. Instructors and instructional designers can build learners’ self-efficacy by implementing UDL features. Self-efficacy is the foundation for self-regulated learning, potentially leading to persistence and course completion, so UDL features should be implemented in first-year online courses.

The findings of this study are particularly salient for institutions of higher education dealing with a declining number of overall enrollments. Even with overall enrollments, more students in higher education choose online courses (Seaman et al., 2018). The COVID-19 pandemic, starting in 2020, has led to an even more pronounced shift toward online learning. Online education offers several benefits that make it attractive to many students. One of the primary advantages is the flexibility it provides; students can choose when and where they learn, accommodating their personal schedules, commitments, and locations. This flexibility can make postsecondary education more accessible to diverse students with various abilities, limitations, and needs, as Rao (2021) noted. UDL can help address the needs of diverse learners in online environments, contributing to online education's overall effectiveness and inclusiveness. The flexibility and accessibility offered by online learning environments, particularly when designed with UDL principles, make them an attractive option for a broad range of learners. UDL prepares educators and students for a diverse and ever-changing world. As new technologies emerge and demographics shift, the flexibility inherent in UDL helps ensure that education remains relevant and responsive. By dedicating minimal time and resources to training educators on UDL implementation, postsecondary institutions stand to substantially bolster accessibility and equity for their students, potentially leading to increased online enrollments.
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APPENDICES

APPENDIX A: STEM ITEMS FOR THE ONLINE LEARNING SELF-EFFICACY SCALE (OLSES)

(1 = would perform task poorly; 6 = could perform task at an expert level)

1. Navigate online course materials efficiently
2. Find the course syllabus
3. Communicate effectively with my instructor via e-mail
4. Communicate effectively with technical support via e-mail, telephone, or live online chat
5. Submit assignments
6. Overcome technical difficulties on my own
7. Navigate to view my grades
8. Manage time effectively
9. Complete all assignments on time
10. Learn to use a new type of technology efficiently
11. Learn without being in the same room as the instructor
12. Learn without being in the same room as other students
13. Search the Internet to find the answer to a course-related question
14. Search the online course materials
15. Communicate using asynchronous technologies (discussion boards, e-mail, etc.)
16. Meet deadlines with very few reminders
17. Focus on schoolwork when faced with distractions
18. Develop and follow a plan for completing all required work on time
19. Use the library’s online resources efficiently
20. When a problem arises, promptly ask questions in the appropriate forum (e-mail, discussion board, etc.)
APPENDIX B: RECRUITMENT MATERIALS

Announcement posted in Canvas by a Teaching Assistant:

Hello, students. A research study is being conducted in this class, and the researchers are recruiting participants. Your data will only be included in the study if you agree to participate. Your decision about participating in the study has no effect on your course grade. Please open the Course Design Research Study module and review the Overview of the Research Study page. This page will direct you to complete the Research Participation Task. Please review the information about the study and select Yes or No to indicate your decision to participate in the study. Then mark the Overview of the Research Study page “done” after completing or exiting the survey.

Research Participation Task:

Every Canvas course collects data about students’ performance and their interactions with course materials. That data is available to the course instructor(s) and teaching assistants (TAs) to review and analyze for making course improvements. A research study is being conducted in this class to examine learner outcomes and activities, but your data will only be included if you agree to participate. Your decision about participating in the study has no effect on your course grade. Please review the attached Informed Consent document and indicate your decision about participation in the research study by answering Yes or No. If you decide to participate, you will have the option of entering a drawing for a $400 Visa gift card.
APPENDIX C: DEMOGRAPHIC AND QUALITATIVE ITEMS

Section 1. Demographic items

1. How old are you?

2. What is your gender identity?
   - Woman
   - Man
   - Transgender woman
   - Transgender man
   - Non-binary or genderqueer
   - Two-spirited (refers to a person who has both a masculine and a feminine spirit, and is used by some First Nations people to describe their sexual, gender or spiritual identity. This is a Native American identity.)
   - I prefer not to answer
   - Other, please specify

3. What racial or ethnic identity do you identify with most strongly?
   - African-American/Black
   - East Asian
   - Hispanic/Latinx
   - Middle Eastern
   - American Indian/Alaskan Native
   - Pacific Islander
   - South Asian
   - Southeast Asian
   - White
   - I prefer not to answer
   - Other, please specify

4. What is your level of proficiency in English?
   - Basic
   - Intermediate
   - Advanced
   - Native

5. What is your GPA? For example: 3.18.

6. How many online classes have you previously taken where there were no mandatory class meetings?

7. Do you consider yourself a first-generation immigrant to the U.S.?
   - Yes
   - No
8. Some research shows that most students with a disability do not report it to their college. Do you have a disability?

8a. What type of disability do you have? Select all that apply.
- Visual
- Auditory
- Neurological
- Cognitive
- Psychological
- Mobility
- Other, please specify

8b. Have you reported your disability to the campus Office of Accessibility?
- Yes
- No

9. How is the design of this course affecting your grades?
- My grades are worse than I expected.
- My grades are about the same as I expected.
- My grades are better than I expected.

Section 2. Open Reflection

1. Describe how elements of this course affect your anticipated final grade.
2. Which parts of this course make you feel engaged?
3. Which parts of this course give you the confidence to succeed?
APPENDIX D: SEMI-STRUCTURED INTERVIEW QUESTIONS

1. From your perspective, what are some benefits of adopting UDL?
   • Example?

2. From your perspective, what are some challenges of adopting UDL?
   • Example?

3. How would you describe the experience overall?

4. You observed students in the treatment and comparison groups during the semester. What did you observe in terms of differences in students’…
   • Academic performance? Quality of their assignments, such as their reflections, presentations, and papers? Examples?
   • Engagement with the course materials, each other, or their interest in the class? Examples?
   • Self-efficacy (or confidence/belief they could succeed)? Students’ comments or requests for clarification or assistance? Examples?

5. What would you do differently if you were to implement UDL features again in a future course?

6. What can you recommend to other instructors interested in adopting UDL?

7. What are your additional thoughts or comments about implementing UDL in your course?
APPENDIX E: INFORMED CONSENT DOCUMENT

PROJECT TITLE: Investigating Elements of Course Design in a Computer Science Education Setting

INTRODUCTION
This form’s purpose is to give you information that may affect your decision whether to say YES or NO to participation in this research and to record the consent of those who say YES. The proposed study will be conducted online in the Canvas Learning Management System.

RESEARCHERS
Principal Investigator: Dr. Tian Luo (Associate Professor, Old Dominion University, STEM Education and Professional Studies)
Investigators: Ana Redstone, doctoral candidate in ODU’s Instructional Design & Technology program.

DESCRIPTION OF RESEARCH STUDY
Several studies have been conducted on the subject of course design in Canvas.
If you say YES, you will join a study involving research involving various data, including Canvas page views, participation, and submissions, that will last for the spring 2023 academic semester.
Approximately 80 students in different sections of this course will be participating in the study.
Toward the end of this course, all students will take a brief survey asking questions about themselves and how they perform specific tasks in an online learning environment. The survey will take about fifteen minutes to complete.

If you decide to participate in this study, we will include your anonymized data for analysis.
If you decide not to participate, we will not include your data for analysis.

EXCLUSIONARY CRITERIA
You should be age 18 or older to participate in the study.

RISKS AND BENEFITS
RISKS: As with any research, there is a possibility that you may be subject to risks that have not yet been identified. There may be a risk of the release of confidential information. However, any documented information and responses will be secured and confidential. These documents will be destroyed once the data have been aggregated and the study is complete.
BENEFITS: There are no direct benefits to participating in this study. If you decide not to participate, we will not include your data for research and analysis.

COSTS AND PAYMENTS
The researchers want your decision to participate in this study to be voluntary. If you decide to participate, you can enter a drawing for a $400 Visa gift card.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, they will give it to you.

CONFIDENTIALITY
The researchers will take reasonable steps to keep private information confidential, such as interview responses and analysis. The researcher will remove any real names or key identifiers from the survey and interview responses. The results of this study may be used in reports, presentations, and publications, but the researcher will not identify you. Of course, your records may be subpoenaed by court order or inspected by government bodies with oversight authority.
WITHDRAWAL PRIVILEGE
It is OK for you to say NO. Even if you say YES now, you can say NO later and walk away or withdraw from the study anytime. Your decision will not affect your relationship with Old Dominion University or otherwise cause a loss of benefits to which you might otherwise be entitled.

COMPENSATION FOR ILLNESS AND INJURY
If you say YES, your consent in this document does not waive your legal rights. However, if any physical or mental injuries arise from this study, neither Old Dominion University nor the researchers can give you any money, insurance coverage, free medical care, or any other compensation for such injury. If you suffer injury as a result of participation in any research project, you may contact Dr. John Baaki, the current IRB chair, at 757-683-5491 at Old Dominion University or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT
By marking YES on the Canvas, you are saying several things. You are saying that you have read this form or had it read to you and are satisfied that you understand it, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them:
Principal Investigator: Dr. Tian Luo (757-683-5369 OR tluo@odu.edu)
Ana Redstone 757-619-2533 OR areds001@odu.edu

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call or email Dr. John Baaki, the current IRB chair, at 757-683-5491 or jbaaki@odu.edu, or the Old Dominion University Office of Research, at 757-683-3460.
You may download a copy of this form for your records.

INVESTIGATOR’S STATEMENT
I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I know my obligations under state and federal laws and promise compliance. I have answered the subject's questions and encouraged them to ask additional questions at any time during this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature

Date
VITA

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Experience
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- Senior Learning Experience Designer
  Kaplan North America
  Feb 2022 – May 2023
- Instructional Designer/Lead Instructional Designer
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  Feb 2013 – Feb 2022

Peer-Reviewed Publications

Professional Presentations
- “Making Your Online Class a Community of Inquiry,” May 2018. Summer Conference, Old Dominion University, Norfolk, VA
- “Fostering Creativity in Online Faculty Developers,” October 2016. Association for Educational Communications and Technology (AECT) International Convention, Las Vegas, NV

Membership in Professional Societies
- American Educational Research Association (AERA)
- Association for Educational Communications and Technology (AECT)
- UPCEA (Leaders in Professional, Continuing, and Online Education)