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Empowering Learners in Higher Education: Redesigning an Online Computer Science Course Through Universal Design for Learning Implementation

Ana E. Redstone[1] · **Tian Luo**[2]

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Abstract
This article focuses on the practical implementation of Universal Design for Learning (UDL) in an online computer science course, articulating the collaborative efforts between the instructional designer (the first author) and the faculty member to redesign the course using UDL principles. Specific instances of redesigned learning modules and artifacts in adherence to UDL principles and results and insights gained from the implementation are reported. The article concludes with recommendations for higher education faculty and instructional designers to consider when applying UDL in their online courses.

Keywords UDL Redesign Cycle for Online Courses · Universal Design for Learning · Instructional design · Online course design · Higher education

Background

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 (AAC&U, 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 (Milem, 2003). Finally, the COVID-19 pandemic has brought issues of inequity to the forefront (Kwakye & Kibort-Crocker, 2020).

Learner Diversity

For most of its history, American 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 twentieth 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

✉ Tian Luo
tluo@odu.edu

Ana E. Redstone
ana.redstone@wgu.edu

[1] Western Governors University, Millcreek, UT, USA

[2] Old Dominion University, Norfolk, VA, USA

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students attending a postsecondary institution in the U.S. in 2016–17 were English language learners (Bergey et al., 2018). Almost a quarter (23.4%) of postsecondary students were older than 25 in 2019 (NCES, 2019).

The percentage of college students with disabilities is also increasing (Sarid et al., 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 (IDs) 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.

IDs working in colleges and universities 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).

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 (NCES, 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 (NCES, 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.

Enhancing Accessibility Through UDL

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.).

Rather than having to retrofit instructional materials, some post-secondary institutions have started approaching accessibility as a proactive instructional design effort by using UDL guidelines and various online course design evaluation instruments.

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 Implementation in Online Learning

UDL is a teaching and learning framework that was developed to make it easier for learners to access and interact with the learning components. It provides principles and guidelines for designing instructional materials, assessments, and methods. UDL's principles and guidelines are rooted in evidence-based research from cognitive neuroscience (Rose & Strangman, 2007; Rose et al., 2006). A recent systematic review study reported that the number of UDL studies has almost doubled since 201, highlighting the growing interest in this topic (Yang et al., 2024). Findings from this review also reveal the need for a framework or blueprint to guide practice when designing and teaching classes. Though more empirical research is needed in this area, some studies have investigated the effect of UDL implementation on learner achievement, engagement and self-efficacy (Al-Azawei et al., 2017; Griful-Freixenet et al., 2021; He, 2014; King-Sears et al., 2023; Kumar & Wideman, 2014; Redstone, 2023; Zhang et al., 2022).

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). 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).

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 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 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).

UDL Implementation in Higher Education

Over the past two decades, some postsecondary institutions implemented 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 approach focusing 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 (NCES, 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.

As the diversity of online learners continues to grow, the imperative to enhance inclusivity in online learning becomes increasingly urgent as 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). The growing diversity of students and the ever-increasing enrollments of students enrolling in one or more online courses indicate that postsecondary instructors and IDs could benefit from using UDL as an inclusive framework to meet the needs of their learners. Unfortunately, some research indicated that over a quarter (28.4%) of online faculty are still unfamiliar with UDL principles or guidelines (Westine et al., 2019). A recent survey found that about 13% of faculty had no knowledge of UDL and that most IDs (82.2%) introduced UDL to faculty in collaborative discussions (Kirsch & Luo, 2023).

In this article, we specifically address UDL implementation in an online computer science course where an ID (the first author) worked collaboratively with a faculty member to redesign the course while infusing UDL principles. We will share specific examples of redesigned course components and learning artifacts following UDL principles while sharing the results of this implementation. Lastly, we provide recommendations that higher education faculty could consider applying in their online courses.

The Course Redesign Case

Learning Context

The course redesign case occurred as the first author, an experienced ID collaborated closely with a faculty member who taught an online Computer Science survey course that explored the societal transformations driven by the ongoing integration of computing technologies. The faculty member who developed and taught the course was experienced in teaching online and not affiliated with the authors. The asynchronous online course was taught at a mid-sized public university on the East Coast in a traditional 16-week semester in spring 2023. The course was taught online for about ten years before the redesign by several instructors and had not been designed or redesigned by an ID.

There were 14 modules, each corresponding to a week. Instructional materials contained embedded PDFs with 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 Teaching Assistants (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.

Learners

Learners consisted of traditional second and third-year undergraduate students. At the start of the semester, there were two sections of the course, each containing around 50 students.

The Redesign Process

The ID used the original course as a starting point and worked closely with the course instructor to identify learning barriers that could potentially be improved by UDL

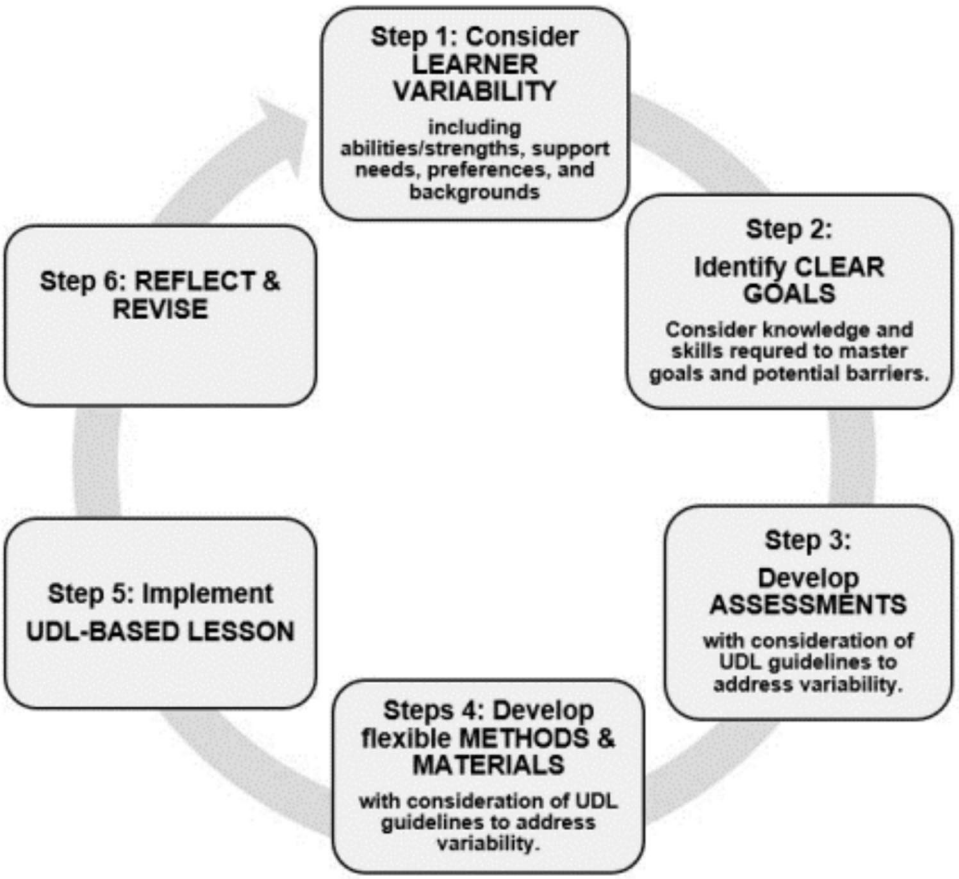

Fig. 1 Rao's 2021 UDL design cycle. Released by the author under a CC BY license

implementation.. To redesign the course, the ID transformed Rao's (2021) original UDL Design Cycle for applying UDL to online learning (Fig. 1) into an adapted version (See Fig. 2) while working closely with the course instructor.

The ID developed the UDL Redesign Cycle for Online Courses as a tool for IDs to use when working with instructors in the flexible implementation of UDL components during a course redesign. In steps 1 and 2, the ID met with the course instructor, who had taught the course asynchronously online for several years. Together, they reviewed the course syllabus. The ID asked the instructor about the types of learners who had previously taken the course and their abilities and needs. Then, the ID 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 ID 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 Web Content Accessibility Guidelines (WCAG), 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 ID selected course components based on UDL guidelines that could address learning barriers. Then, the ID met again with the instructor to negotiate which assessments, methods, and materials could be redesigned. The primary consideration was time limitations on both the IDs 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 ID ensured that alt-text, video captions and transcripts were added and that documents added to the course were accessible.

Next, in step 5, the ID implemented the agreed-upon revisions to the course syllabus, discussion forums, and course modules, as described in detail in Tables 1, 2, and 3. The graded assessments and grading criteria were not changed. Step 6 includes CAST's (n.d.) recommendation that iterative revisions should be partly based on student feedback. During step 6, the ID reflected on quantitative and qualitative data

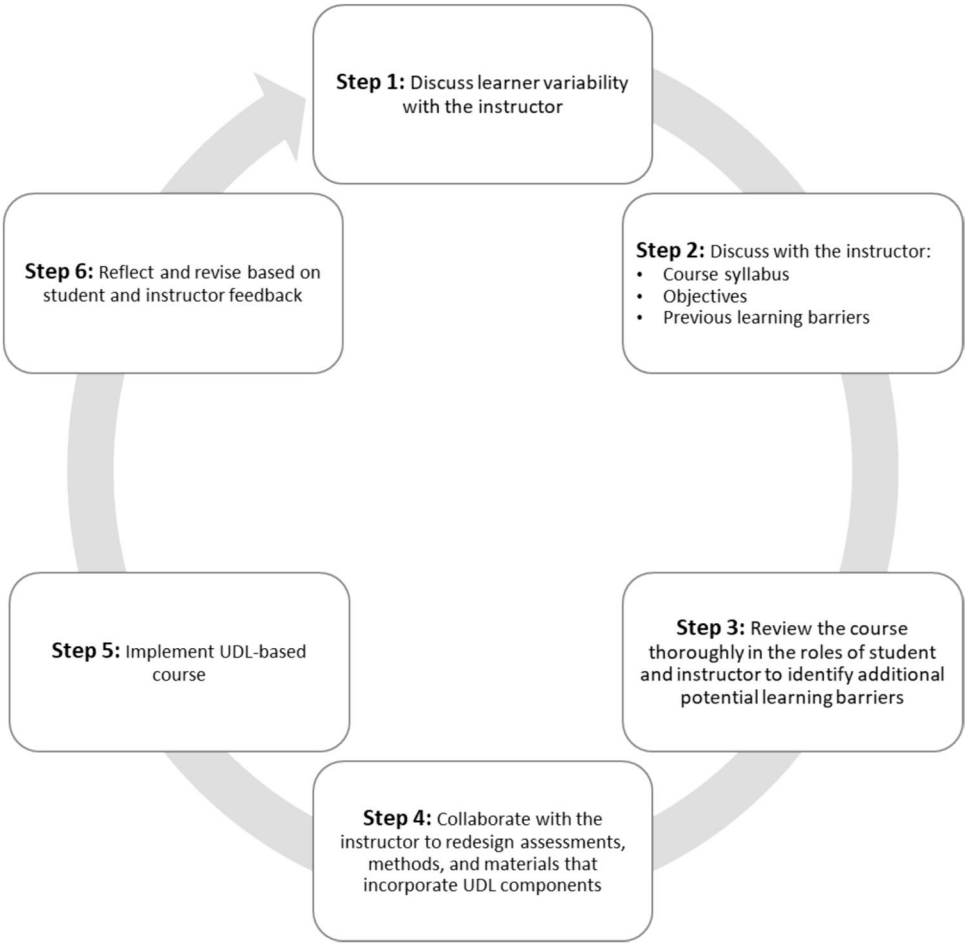

Fig. 2 UDL redesign cycle for online courses

collected from participants and the instructor. Since the ID did not continue to work with the instructor, it was determined that the course instructor would conduct an ongoing revision of the course described in step 6.

Course Components Redesigned Using UDL Guidelines

Course Syllabus

The original course syllabus was simple and contained only basic information. The syllabus was redesigned to add more detail to the instructor information section, course description and objectives section, and overview of assignments section. The ID added a new section describing the course materials and a schedule.

Discussion Board

The original course's discussion board was used only to share final presentations with the whole class. The ID converted short written assignments called blogs into group discussion forums where students could interact with each other and select the media format of their posts.

Course Modules

Modules were significantly redesigned to consolidate module materials into Canvas module format. Learning materials that were previously all text-based were supplemented with multimedia resources and consolidated into one page, making it easier for learners to access. New sections of the modules were added and included visual module to-do lists, assignment overview videos, assignment pages and group discussion pages.

Learning Artifacts using UDL Guidelines

Several learning artifacts were created during the redesign of the course components, as described in Tables 1 and 3.

Table 1 Changes made in the course syllabus

Section	Before	After	UDL guidelines applied
Instructor information	• None	• Photo and bio • Location of instructor introduction video with captions and transcript • Location of syllabus walkthrough video with captions and transcript • Location of LMS walkthrough video with captions and transcript • List of multiple contact methods	• Offer alternatives for auditory information (1.2) • Offer alternatives for visual information (1.3) • Illustrate through multiple media (2.5) • Foster collaboration and community (8.3) • Promote expectations and beliefs that optimize motivation (9.1)
Course description and objectives	• Objectives only	• Description of how flexible assessments will meet course objectives	• Highlight patterns, critical features, big ideas, and relationships (3.2) • Guide appropriate goal setting (6.1) • Support planning and strategy development (6.2)
Course policies	• Plagiarism • Communication • Computer competency • Technical issues	(Additional policies) • Attendance • Academic honesty • Academic support • Time commitment • Participation expectations • Due dates • Technology expectations and support • Syllabus acknowledgement	• Facilitate managing information and resources (6.3) • Minimize threats and distractions (7.3) • Facilitate personal coping skills and strategies (9.2)
Overview of assignments	• Assignment overview	• Assignment overview that highlights alternative means of expression • Description of topic options for assignments • Location of assignment instructions and rubrics • Visual map of assignments with alt text (See Fig. 3) • Links to the library and writing center	• Support planning and strategy development (6.2) • Facilitate managing information and resources (6.3) • Enhance capacity for monitoring progress (6.4) • Offer alternatives for visual information (1.3) • Optimize individual choice and autonomy (7.1)
Course schedule	• None	• Instructions for adding assignments to the calendar • Week • Module dates • Module topic • Assignments • Due dates • Color-coded groups (See Fig. 4)	• Facilitate managing information and resources (6.3) • Enhance capacity for monitoring progress (6.4) • Support planning and strategy development (6.2)
Course materials	• Not described	• Brief description of all learning materials • Description of alternatives to the text-based materials	• Illustrate through multiple media (2.5) • Vary demands and resources to optimize challenge (8.2)

Visual Map Assignment

The instructor mentioned confusion surrounding the purpose of groups as one of the major barriers to learning, so the ID created a visual map of assignments with alt-text (Figs. 3).

Course Schedule

The original course schedule was provided as a link to an instructor-created webpage, which students had complained about sometimes having technical problems. To remove this barrier, the ID created the course schedule as

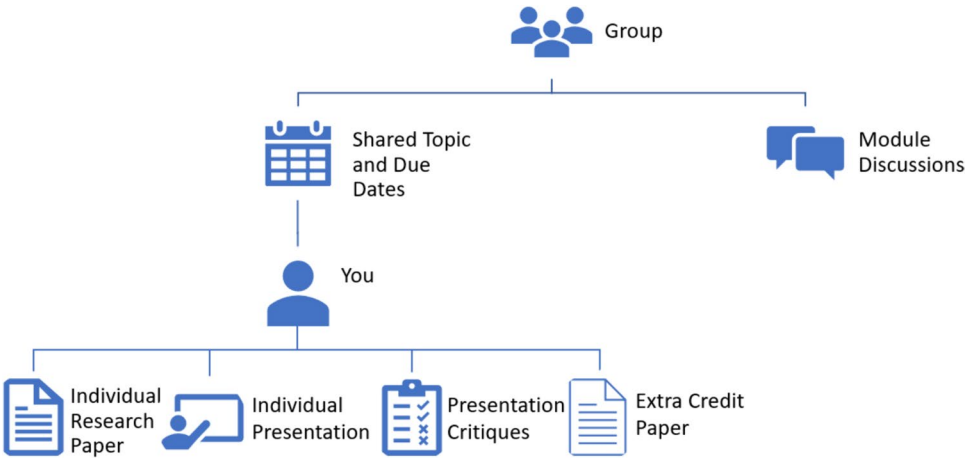

Fig. 3 Example of visual map of assignments

Fig. 4 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.

Week 1: Jan 7 – Jan 15: History of Computers

Assignment

- Syllabus Quiz: Due Jan 15

Week 2: Jan 16 –Jan 22: History of the Internet

Assignment

- Group discussion: Self-Introduction post: Due Jan 20

Week 3: Jan 23 – Jan 29: Societal Issues

Assignments

- Blue group: Presentation Thesis: Due Jan 26
- Yellow group: Research Paper Thesis and Outline: Due Jan 26
- Group discussion: Societal Issues: Due Jan 27

Week 4: Jan 30 – Feb 5: Communications and Social Networks

Assignments

- Cyan group: Presentation Thesis: Due Feb 2
- Red group: Research Paper Thesis and Outline: Due Feb 2
- Group discussion: Communications: Due Feb 3

Week 5: Feb 6 – Feb 12: Privacy, Crime, and Prevention

Assignments

- Green group: Presentation Thesis: Due Feb 9
- Magenta group: Research Paper Thesis and Outline: Due Feb 9
- Group discussion: Privacy: Due Feb 10

Week 6: Feb 13 – Feb 19: Computers in Education

Assignments

- Yellow group: Rough Draft of Research Paper: Due Feb 13
- Yellow group: Final Research Paper: Due Feb 13
- Blue group: Presentation: Due Feb 14
- Presentation Critiques: Due Feb 17

Table 2 Changes made in the discussion board

Element	Before	After	UDL guidelines applied
Post format	Text or file upload. Used for asking questions about the course or submitting a presentation	• Choices for post format (e.g., text, audio, video, etc.)	• Use multiple media for communication (5.1) • Use multiple tools for construction and composition (5.2) • Optimize individual choice and autonomy (7.1)
Prompts	• None. Blog posts are used as topical reflections instead of discussions	• Group discussions with topical reflections (6) • Added questions to the self-introduction prompt: • Topics of interest • Goal setting • Feedback preferences	• Optimize relevance, value, and authenticity (7.2) • Foster collaboration and community (8.3) • Enhance capacity for monitoring progress (6.4) • Promote expectations and beliefs that optimize motivation (9.1) • Develop self-assessment and reflection (9.3)
Directions	• No description of how instructor feedback will be provided	• Description of mastery-oriented feedback to be provided during and after discussions	• Increase mastery-oriented feedback (8.4)
Netiquette	• None	• Description of standards of discussion behavior	• Minimize threats and distractions (7.3) • Facilitate personal coping skills and strategies (9.2)
Rubric	• Simple	• More detailed	• Enhance capacity for monitoring progress (6.4) • Develop self-assessment and reflection (9.3)
Support options	• None	• Troubleshooting and access support	• Minimize threats and distractions (7.3) • Facilitate personal coping skills and strategies (9.2)

an accessible, color-coded Word document that learners could print. Instructions were also provided for learners to download due dates into their Google calendars (Fig. 4).

Visual Module To-Do List

The ID added a visual module to-do list with alt-text at the beginning of every module to supplement the text-based module overview section (Fig. 5).

Evaluation

Student learning was evaluated using two sections of the same course taught by the same instructor, including the original course and the redesigned course with UDL implementation (Redstone, 2023). Using a quasi-experimental design, we specifically examined learners' achievement, engagement and self-efficacy. Results from the study showed that UDL interventions had no effect on learner achievement but did positively affect engagement. UDL interventions also had a strong, positive effect on self-efficacy.

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. During the interview, the instructor indicated that she was pleased to see that the UDL-designed course provided the support the students needed. The instructor indicated that she planned to use the UDL-designed course in future semesters.

Recommendations

Incorporating Universal Design for Learning (UDL) into the redesign of online courses represents a significant commitment in terms of time and resources, necessitating a comprehensive approach to pedagogical planning and execution. This process involves more than simply converting traditional classroom content into a digital format; it requires a fundamental reevaluation of teaching and learning paradigms, including course objectives, teaching methodologies, evaluation techniques, and student interactions. To facilitate this transition, IDs play a pivotal role in guiding faculty members, who are typically more versed in their specific subject areas than in educational strategies, through the

Table 3 Changes made in the course modules

Element	Before	After	UDL guidelines applied
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 Fig. 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)
Course materials	• Text	• Text, audio, video, graphics	• Offer alternatives for auditory information (1.2) • Offer alternatives for visual information (1.3) • Illustrate through multiple media (2.5) • Optimize relevance, value, and authenticity (7.1) • Vary demands and resources to optimize challenge (8.2)
Direct instruction	• None	• Videos explaining assessment requirements and differing approaches	• Highlight patterns, critical features, big ideas, and relationships (3.2) • Build fluencies with graduated levels of support for practice and performance (5.3)

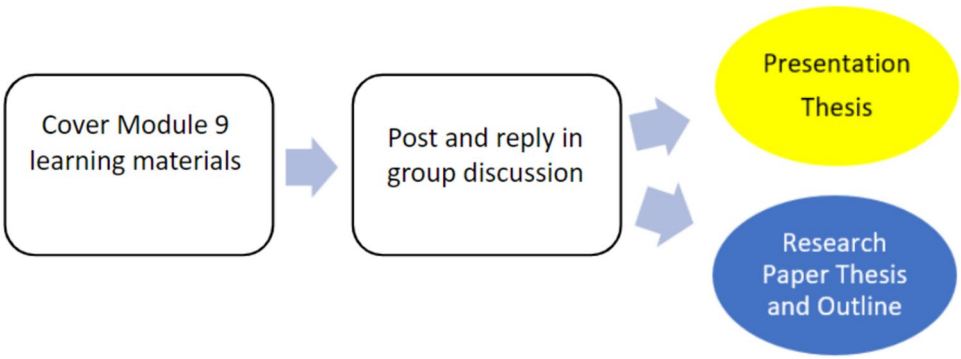

Fig. 5 Example of visual module to-do list with color-coded groups

intricacies of UDL. By leveraging specialized instructional design support provided by most higher education institutions, faculty can navigate the complexities of online or hybrid course development, ensuring that courses are not only accessible but also engaging and effective for a diverse student body.

The implementation of UDL in online course development begins with identifying specific challenges within

existing course structures and making targeted adjustments to address these issues. Training in UDL practices can enable instructors and TAs to recognize potential learning obstacles and incorporate appropriate UDL strategies into their courses. This iterative process involves continually considering student feedback and collaborating with peers to refine teaching approaches. The UDL Redesign Cycle for Online Courses (See Fig. 2), as illustrated in this article, offers a structured, collaborative framework for integrating UDL principles systematically, ensuring that courses are designed to meet the varied needs and preferences of all learners.

Technology tools are important to implementing UDL in online courses. 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. Technology tools, typically provided by an LMS, are essential to supporting learning with UDL principles and guidelines. 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). They 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 and screen magnifiers.

IDs and instructors must consider the nature of online learners in UDL course design. It is important to address particular challenges and characteristics of online learners. Online learners can experience uncertainty about expectations, an insufficient learning community and technology challenges (Rao, 2012). They cannot immediately communicate with their instructors and peers. Therefore, creating effective communication strategies and many interaction opportunities is essential for learners to express themselves (Davies et al., 2013). For example, in redesigning the Getting Started module and syllabus, the ID included explicit information about the available assistive technologies, how to request accommodations, navigate the environment and use support tools and communicate effectively in discussion boards and email.

Lastly, we present the following sections to provide more specific best practices in providing multiple means of representation, action and expression and engagement.

Representation

Implementing multiple means of representation focuses on varying the format of the instructional materials. At the course-wide level, tools provided by learning management systems, course management systems or course websites can facilitate hosting different kinds of learning materials, even in face-to-face, on-campus environments. In the redesign process, the ID 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 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).

Action and Expression

Design considerations for providing multiple means of action and expression center on how learners express themselves and demonstrate their learning. The original course offered learners few options for that, so the redesign focused on adding small group discussions. The redesigned course used a group discussion forum where learners 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 redesigned 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, the ID incorporated guidelines that included offering 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. Learners participated in robust group discussions centered on current, authentically situated reflections on the module theme. Students and the TAs provided feedback on the discussion forum, which participants described as engaging. Strategies for developing self-efficacy and self-regulation in learners included explicitly drawing connections between prior and future learning and providing advice about managing time and developing milestones. The syllabus included these strategies by explaining connections and providing tips on time management.

Conclusion

Even with overall enrollments declining, 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.

Data Availability The data that support the findings of this study are available from the corresponding author, AR, upon reasonable request.

Declarations All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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References

Al-Azawei, A., Parslow, P., & Lundqvist, K. (2017). The effect of Universal Design for Learning (UDL) application on e-learning acceptance: A structural equation model. *International Review of Research in Open and Distributed Learning: IRRODL, 18*(6), 54–87. https://doi.org/10.19173/irrodl.v18i6.2880

American Association of Colleges and Universities (AAC&U). (2022). Campus priority: Advancing diversity, equity, and inclusion. AAC&U. https://www.aacu.org/priorities/advancing-diversity-equity-and-inclusion?category=advancing-diversity-equity-and-inclusion

Bergey, R., Movit, M., Baird, A. S., & Faria, A. M. (2018). *Serving English language learners in higher education: Unlocking the potential*. American Institutes for Research. https://www.air.org/resource/report/serving-english-language-learners-higher-education-unlocking-potential

Black, R. D., Weinberg, L. A., & Brodwin, M. G. (2015). Universal Design for Learning and instruction: Perspectives of students with disabilities in higher education. *Exceptionality Education International*, *25*(2), 1–16. https://ojs.lib.uwo.ca/index.php/eei/article/view/7723/6339

CAST. (2018). Universal Design for Learning guidelines version 2.2. http://udlguidelines.cast.org

CAST. (n.d.). Getting started. http://udloncampus.cast.org/page/udl_gettingstarted

Davies, P. L., Schelly, C. L., & Spooner, C. L. (2013). Measuring the effectiveness of Universal Design for Learning intervention in postsecondary education. *Journal of Postsecondary Education and Disability*, *26*(3), 195–220. https://files.eric.ed.gov/fulltext/EJ1026883.pdf

Dinkes, R. (2020). Bar chart race: Changing demographics in postsecondary enrollment. NCES Blog. https://nces.ed.gov/blogs/nces/post/bar-chart-race-changing-demographics-in-postsecondary-enrollment

Eckel, P. D., & King, J. E. (2004). An overview of higher education in The United States: Diversity, access and the role of the marketplace. https://vtechworks.lib.vt.edu/bitstream/handle/10919/84029/OverviewHigherEducationUnitedStates.pdf?sequence=1&isAllowed=y

Gradel, K., & Edson, A. J. (2010). Putting Universal Design for Learning on the higher ed agenda. *Journal of Educational Technology Systems, 38*, 111–121.

Gravel, J., Edwards, L., Buttimer, C., & Rose, D. (2015). Universal Design for Learning in postsecondary education: Reflections on principles and their applications. In S. E. Burgstahler (Ed.), *Universal design in higher education: From principles to practice* (2nd ed., pp. 81–100).

Griful-Freixenet, J., Struyven, K., & Vantieghem, W. (2021). Toward more inclusive education: An empirical test of the Universal Design for Learning conceptual model among preservice teachers. *Journal of Teacher Education, 72*(3), 381–395. https://doi.org/10.1177/0022487120965525

Hanson, M. (2021) College enrollment & student demographic statistics. https://educationdata.org/college-enrollment-statistics

He, Y. (2014). Universal Design for Learning in an online teacher education course: Enhancing learners' confidence to teach online. *Journal of Online Learning and Teaching*, *10*(2), 283. https://jolt.merlot.org/vol10no2/he_0614.pdf

Hill, P. (2021). Alternative view: More than 50% of US higher ed students took at least one online course in 2019–20. https://

philonedtech.com/alternative-view-more-than-50-of-us-higher-ed-students-took-at-least-one-online-course-in-2019-20/

Jensen, E., Jones, N., Rabe, M., Pratt, B. Medina, L., Orozco, K., & Spell, L. (2021). 2020 U.S. population more racially and ethnically diverse than measured in 2010. United States Census Bureau. https://www.census.gov/library/stories/2021/08/2020-united-states-population-more-racially-ethnically-diverse-than-2010.html

King-Sears, M., Stefanidis, A., Evmenova, A., Rao, K., Mergen, R., Owen, L., & Strimel, M. (2023). Achievement of learners receiving UDL instruction: A meta-analysis. *Teaching and Teacher Education*, *122*. https://doi.org/10.1016/j.tate.2022.103956

Kirsch, B. A., & Luo, T. (2023). Universal Design for Learning implementation in higher education: Survey of faculty and instructional designers. *The Journal of Applied Instructional Design, 12*(4). https://edtechbooks.org/jaid_12_4/universal_design_for_learning_implementation_in_higher_education_survey_of_faculty_and_instructional_designers

Kumar, K. L., & Wideman, M. (2014). Accessible by design: Applying UDL principles in a first year undergraduate course. *The Canadian Journal of Higher Education*, *44*(1), 125–147. https://files.eric.ed.gov/fulltext/EJ1028772.pdf

Kwakye, I., & Kibort-Crocker, E. (2020). Lessons on recovery: The value and potential of higher education in response to the COVID-19 crisis. Higher Education and the Labor Market. *Washington Student Achievement Council*. https://files.eric.ed.gov/fulltext/ED613307.pdf

Lyman, M., Beecher, M. E., Griner, D., Brooks, M., Call, J., & Jackson, A. (2016). What keeps students with disabilities from using accommodations in postsecondary education? A qualitative review. *Journal of Postsecondary Education and Disability*, *29*, 123–140. https://files.eric.ed.gov/fulltext/EJ1112978.pdf

Milem, J. F. (2003). The educational benefits of diversity: Evidence from multiple sectors. In *Compelling interest: Examining the Evidence on racial dynamics in higher education* (pp. 126–169). http://www-leland.stanford.edu/~hakuta/www/policy/racial_dynamics/Chapter5.pdf

National Center for Educational Statistics (NCES). (2019) Digest of education statistics, Table 303.50. https://nces.ed.gov/programs/digest/d20/tables/dt20_303.50.asp?current=yes

National Center for Educational Statistics (NCES). (2021). Distance learning. https://nces.ed.gov/fastfacts/display.asp?id=80#:~:text=Response%3A,at%20degree%2Dgranting%20postsecondary%20institutions

Newman, L. A., & Madaus, J. W. (2015). Reported accommodations and supports provided to secondary and postsecondary students with disabilities: National perspective. *Career Development and Transition for Exceptional Individuals, 38*(3), 173–181. https://doi.org/10.1177/2165143413518235

Rao, K. (2012). Universal design for online courses: Addressing the needs of nontraditional learners. Paper presented at 2012 IEEE International Conference on Technology Enhanced Education, Kerala, India.

Rao, K. (2021). Inclusive instructional design: applying UDL to online learning. *The Journal of Applied Instructional Design*, *10*(1). https://doi.org/10.51869/101/kr

Raue, K., & Lewis, L. (2011). Students with disabilities at degree-granting postsecondary institutions (NCES 2011–018). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office. https://files.eric.ed.gov/fulltext/ED520976.pdf

Redstone, A. E. (2023). Investigating the effect of Universal Design for Learning on learner performance, engagement, and self-efficacy. https://digitalcommons.odu.edu/stemps_etds/139/

Reiser, R. A. (2018). What field did you say you were in? Defining and naming our field. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (4th ed., pp. 8–22). Pearson Education.

Rose, D. H., Harbour, W. S., Johnston, C. S., Daley, S. G., & Abarbanell, L. (2006). Universal design for learning in postsecondary education: Reflections on principles and their application. *Journal of Postsecondary Education and Disability*, *19*, 135–151. http://files.eric.ed.gov/fulltext/EJ844630.pdf

Rose, D. H., & N. Strangman (2007). Universal Design for Learning: Meeting the challenge of individual learning differences through a neurocognitive perspective. *Universal Access in the Information Society, 5*(4): 381–391. https://files.eric.ed.gov/fulltext/EJ844630.pdf

Sarid, M., Meltzer, Y., & Raveh, M. (2020). Academic achievements of college graduates with learning disabilities vis-a-vis admission criteria and academic support. *Journal of Learning Disabilities., 53*, 60–74. https://doi.org/10.1177/0022219419884064

Schelly, C. L., Davies, P. L., & Spooner, C. L. (2011). Student perceptions of faculty implementation of Universal Design for Learning. *Journal of Postsecondary Education and Disability*, *24*, 17–30. https://files.eric.ed.gov/fulltext/EJ941729.pdf

Seaman, J. E., Allen, I. E., & Seaman, J. (2018). Grade increase: Tracking distance education in the United States. Babson Survey Research Group. https://files.eric.ed.gov/fulltext/ED580852.pdf

Seok, S., DaCosta, B., & Hodges, R. (2018). A systematic review of empirically based Universal Design for Learning: Implementation and effectiveness of universal design in education for students with and without disabilities at the postsecondary level. *Open Journal of Social Sciences, 06*(05), 18. https://doi.org/10.4236/jss.2018.65014. Article 84751.

Thomson, R., Fichten, C. S., Havel, A., Budd, J., & Asuncion, J. (2015). Blending universal design, e-learning, and information and communication technologies. In S. Burgstahler (Ed.), *Universal design in higher education: From principles to practice* (pp. 275–284). Harvard Education Press.

Tobin, T. J. (2014). Increase online student retention with Universal Design for Learning. *Quarterly Review of Distance Education*, *15*(3), 13–24. http://www.infoagepub.com/quarterly-review-of-distance-education.html

Tobin, T. J. (n.d.) Making the UDL case to campus & school leaders. https://www.learningdesigned.org/sites/default/files/Done_TOBIN.final_.pdf

Westine, C. D., Oyarzun, B., Ahlgrim-Delzell, L., Casto, A., Okraski, C., Park, G., Person, J., & Steele, L. (2019). familiarity, current use, and interest in Universal Design for Learning among online university instructors. *International Review of Research in Open and Distance Learning, 20*(5), 20–41. https://doi.org/10.19173/irrodl.v20i5.4258

Yang, M., Duha, M. S. U., Kirsch, B. A., Glaser, N., Crompton, H., & Luo, T. (2024). Universal design in online education: A systematic review. *Distance Education*, 1–37. https://doi.org/10.1080/01587919.2024.2303494

Zhang, Jackson, H. A., Yang, S., Basham, J. D., Williams, C. H., & Carter, R. A. (2022). Codesigning learning environments guided by the framework of Universal Design for Learning: A case study. *Learning Environments Research, 25*(2), 379–397. https://doi.org/10.1007/s10984-021-09364-z