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Preparing Teachers to Use Universal Design for Learning to Support Diverse Learners

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Universal Design for Learning (UDL) is a scientifically-based framework for developing curricula that acknowledges learner diversity as a function of human variability. While it is possible to implement UDL without advanced technologies, it is easier and more efficient to provide multiple means of engagement, representation, and action/expression with technological support. In this exploratory study, 70 educators (including in-service general and special education teachers) learned about UDL implementation in an online course designed using UDL principles. At the end of the study, all educators could recognize specific UDL guidelines and checkpoints in the observed lessons across grade levels and subject areas. They also proposed revised lesson plans that extended the use of UDL to address the specific learning outcomes and learner variability. The thematic analysis was conducted to explore the most common ways to use no technology to high technology tools, providing UDL through blended learning. The findings from this study suggest the importance of modeling UDL practices to encourage implementation in classrooms.

Keywords: Universal design for learning, learner variability, online teacher preparation, professional development, teacher learning

Today's classrooms are characterized by ever-growing diversity. In one instructional setting students with disabilities, gifted students, English language learners, and students who are culturally and linguistically diverse learn side-by-side. Individual students engage in learning and reach mastery in different ways (Meyer, Rose, & Gordon, 2014). This variability makes it important to design instruction beneficial to all students. Universal Design for Learning (UDL) is a scientifically based framework for developing curricula that support a broad range of learners. The framework was introduced in the 1990s by the Center for Applied Special Technology (CAST; Edyburn, 2013). The concept of universal design originated earlier in architecture, where physical environments were designed to be accessible to all users regardless of their abilities and needs (Mace, 1997; Rao & Tanners, 2011). When applied to pedagogical practices, it is the teaching and learning that are designed to be accessible to students with and without special needs (Rao, Edelen-Smith, & Wailehua, 2015).

Overall, the principles of UDL are built on the redundancy effect allowing for clarity and easier comprehension of instruction (Rose, Meyer, & Hitchcock, 2005). This focus on redundancy is reflected in three overarching principles: (1) multiple means of engagement; (2) multiple means of representation; and (3) multiple means of action/expression (CAST, 2017; Rose & Meyer, 2002). In other words, teachers should use multiple ways to motivate students to learn; present content in multiple ways; and allow students to demonstrate what they know in multiple ways. These principles are supported by neuroscience and research on the cognitive learning process. Cognitive accessibility relates to the processes taking place in the three primary brain networks: affective networks responsible for motivation and setting the priorities; recognition networks responsible for gathering and analyzing information; and strategic networks responsible for planning and executing actions (Dell, Dell, & Blackwell, 2015; Meyer et al., 2014; Robinson & Wizer, 2016; Rao et al., 2015).

UDL helps provide instruction minimizing the need for individual accommodations (Black, Weinberg, & Brodwin, 2014; Rao & Tanners, 2011). While some students with more intense needs may still require additional supports, most learners' needs are addressed by the flexible curricula. Teachers are encouraged to analyze learner variability to proactively and intentionally build in flexible choices and scaffolds to predict and support the instruction for all up front, rather than making accommodations as an afterthought. The iterative UDL design cycle continues with implementation; reflection on what worked and what required change to further increase access; and lesson revisions as needed (Rao & Meo, 2016).

UDL implementation is supported by a set of guidelines (Back et al., 2014). Across three principles of UDL, there are nine guidelines and 31 checkpoints (listed in Table 3). The checkpoints are developed based on the research-based best educational practices (CAST, 2011; Israel, Ribuffo, & Smith, 2014). While guidelines and checkpoints are somewhat prescriptive, they leave plenty of room for instructional creativity (Rao et al., 2015). UDL principles, guidelines, and checkpoints can be applied to any grade level, subject area, and learning environment (e.g., face-to-face or online; Rao, Ok, & Bryant, 2014). There is no required number of checkpoints that need to be included for the instruction to be considered UDL-based (Rao et al., 2014). For example, Smith (2012) used a few strategies to address just one guideline—providing options for recruiting interest—while Kumar and Wideman (2014) offered a plethora of supports across three UDL principles. The design depends on the specific learning environment, learner variability, and barriers within that environment (Rao & Meo, 2016). To summarize, UDL offers guidance for developing flexible goals, methods, materials, and assessments recognizing the variability in students' abilities, needs, preferences (Robinson & Wizer, 2016).

UDL and Advanced Technologies

UDL allows creating educational settings inclusive of all students, not just students with disabilities (Back et al., 2014). While it is possible to implement UDL without advanced technologies, various assistive and instructional technologies make it easier and more efficient to achieve the redundancies (multiple means of engagement, representation of content, and action/expression) (Dell et al., 2015). Meaningfully-integrated technology makes learning environments more accessible to the diverse learners. Indeed, technology can provide many seamlessly built-in, cost-effective supports (CAST, 2011). Online and blended learning are great platforms for UDL implementation. Various multimedia tools, social media, and interactive websites facilitate the development of technology-enhanced UDL environments. Existing research that reports gains in students' academic outcomes in all major content areas because of UDL-based interventions includes the use of such technologies as content acquisition podcasts (e.g., Kennedy, Thomas, Meyer, & Alves, 2014); videos and narrated presentations (King-Sears et al., 2015); digital backpacks (e.g., Basham, Meyer, & Ernest, 2010); video games (e.g., Marino et al., 2014); and computer-based reading programs (Hall, Cohen, Vue, & Ganley, 2015). Teachers are encour-

aged to incorporate technology in the UDL design cycle to enrich any learning environment and ensure success of all learners (Castleberry & Evers, 2010; Coyne, Pisha, Dalton, Zeph, & Smith 2012; Lock, Altowairiki, Hill, & Johnson, 2016; Rao & Meo, 2016).

UDL and Teacher Preparation

To increase awareness and implementation of UDL, previous research has explored how UDL can be modeled in the face-to-face, hybrid, and online teacher education courses (Ashman, 2010; Coy, Marino, & Serianni, 2014; He, 2014; Parker, Robinson, & Hannafin, 2008; Rao & Tanners, 2011; Scott & Temple, 2017; van Laarhoven, Munk, Lynch, Bosma, & Rouse, 2007). Most of this research focuses on changing the perceptions of teacher educators towards implementing UDL in their learning environments. For example, Engleman and Schmidt (2007) designed a course about UDL using UDL principles. Thus, prospective teachers had a chance to experience UDL firsthand, resulting in deeper understanding of UDL and willingness to use it in their own classrooms. In addition to improved attitudes, even a brief exposure to UDL resulted in enhanced instruction for in-service educators in another study. Both general and special education teacher candidates increased the number of UDL strategies that they had incorporated in their lesson plans from pretest to posttest after just 1-hour training session (Spooner, Baker, Harris, Ahlgrim-Delzell, & Browder 2007). These findings were repeated in later studies (Courey, Tappe, Siker, & LePage, 2012; Navarro, Zervas, Gesa, & Sampson, 2016). However, researchers in these studies asked educators to develop lesson plans for hypothetical students presented in a case study. Thus, more empirical and authentic studies on how to translate UDL principles, guidelines, and checkpoints into practice are needed (Rao et al., 2015). To develop a rich UDL-based online or blended environment, it is important to make sure that teachers can bring together concepts related to instructional objectives, learner variability, UDL strategies, and technology affordances that meet the needs of all students (Edyburn, 2010; Lock et al., 2016).

Study Purposes

Therefore, the purpose of this study was to extend previous research and explore how experiencing UDL firsthand in a graduate online course

might help educators, including in-service general and special education teachers, learn about UDL framework and plan for its practical implementation. Specific research questions included:

1. How can educators enhance observed lessons with UDL strategies that address specific students' variability?
2. What are the specific UDL strategies that support blended learning for diverse learners across grade levels and subject areas?
3. What are educators' ability to recognize UDL as a potential form of support as they learn about it in an UDL-based environment?

METHODS

An exploratory mixed methods study was conducted to discover how various UDL strategies can be incorporated across grade levels and subjects to support diverse learners. This was the first attempt to review what specific UDL guidelines and checkpoints educators recommend to address existing barriers and students' abilities and needs. In addition, educators' attitudes were explored.

Participating Educators

Educators in this study were 70 educators enrolled in two graduate programs from two public universities in the Northeast and enrolled in the asynchronous course on UDL across three semesters. Educators from one university (n = 51) were working on the Master's degrees in learning technology, while educators from another university (n = 19) were a part of the assistive technology (AT) certificate/master's degree program. Most educators were in-service general and special education teachers in PreK-12 settings (n = 46) across grade levels and subject areas. Teaching experience ranged from 1-25 years (M = 7.75; SD = 5.17). In addition to current teachers, there were several school-based specialists including librarian; technology teachers; education, media, transition, AT specialists; behavior technicians; and occupational therapist (n = 15). A few educators were in leadership roles such as a principal, special education coordinator, leadership coach, federal employee (n = 4) as well as various full-time graduate student positions (n = 5). All educators had experience teaching in public and/or private schools. Table 1 provides additional demographic information about the educators.

Table 1
Demographic Information about the Educators

	Educators
Gender	
Male	31.4%
Female	68.6%
Occupation	
General education teacher	58.6%
Special education teacher	7.1%
Instructional specialist	21.4%
Administrators	5.7%
Full-time graduate students	7.1%
Grade Level	
PreK/Elementary	25.7%
Middle	21.4%
High	24.3%
Mixed grades	7.1%
Higher education/Adult learners	21.4%
Subject	
All subjects	17.1%
Language arts/English	8.6%
Math	4.3%
Social studies	10.0%
Science	4.3%
Art and music	7.1%
Foreign languages	11.4%
Special education classes	7.1%
Other	30.0%

Most participating general education teachers reported using technology daily in their instruction. Seven general education K-12 teachers reported having 1:1 technology in their schools, while 10 more reported having access to classrooms sets of devices (e.g., MacBooks, iPads, Chromebooks). Only two teachers explicitly stated that they did not have an easy access to technology. Overall, teachers reported regularly using such tools as Smartboards, learning management systems, Google Docs/Classroom, Google Read and Write, QR codes, web quests, Class Dojo, Khan acad-

emy, Aurazma, calculators, graphing software, Photoshop, remind101, and more. Special education teachers and AT specialists reported using AT tools such as speech-to-text or dictation programs, screen enlarging software and screen reader, text-to-speech, Bookshare, word prediction, Ginger editing program, Clicker 6, augmentative and alternative communication, and FM systems. Low-tech AT devices were also mentioned including pencil grips, highlighters, and sticky notes.

At the very beginning of the semester (during Module 1), educators were asked about their understanding of UDL prior to taking the course. This question was incorporated into the Introduction Forum, where educators responded to, "What is the first thing that comes to mind when you hear UDL?" as an open-ended question. The majority demonstrated basic understanding of the UDL concept. Most educators defined UDL as "ways to create learning environment that ALL students can benefit from" (61%); "ways to differentiate instruction/make instruction accessible" (16%); or "the need to present information in multiple flexible ways (13%). One teacher shared the metaphor of having a buffet dinner party, where everyone can choose what they want/can eat. Seven educators admitted that even thought they had heard the word, they did not have knowledge of UDL (10%).

Study Context: Asynchronous UDL Course

The study was conducted across three different sections of a three-credit-hour graduate course. The main objectives of the course focused on (a) describing the foundations of UDL, (b) identifying no technology to high technology tools and strategies to facilitate flexibility, and (c) applying UDL principles in various educational environments. The course was delivered primarily in an asynchronous online format; however, optional synchronous interactions were built-in. The course was logically divided into 11 learning modules in a learning management system with weekly readings, activities, formative and summative assessments. The module topics included (1) Foundations and principles of UDL; (2) UDL standards and guidelines for research and practice; (3) Multiple means of representation: Providing access to print text; (4) Multiple means of action and expression: Enhancing writing process; (5) Multiple means of engagement: Enhancing math instruction; (6) Review of all UDL principles across content areas; (7) UDL in postsecondary (higher) education; (8) UDL in online environments; (9) UDL and progress monitoring; (10) Designing UDL curriculum; (11) Final project presentations. The course was designed with UDL principles in mind in order to address the anticipated variability of learners in the gradu-

ate online course. Among 70 educators, three were with identified disabilities (e.g., learning disabilities, ADHD, visual impairments) and for four others English was not a primary language. Table 2 lists specific UDL strategies that were used to support UDL implementation.

Table 2
UDL Strategies Incorporated in Online Course Design

UDL Principles	Online Course Elements
Multiple means of engagement	Consistent course organization; Ongoing written and video feedback to students; Timely responses to students' emails; FAQ blog; Virtual office hours; Choice to complete activities individually or in small groups; Weekly Are you on track? self-monitoring checklists; Using real classroom for final project; Learning objectives for each module clearly identified; Exemplars of projects; Intermitted reflective blog entries
Multiple means of representation	Content in text, audio, video formats (each lecture in four formats: video presentation, regular PowerPoint for note taking, MP3, & text transcript); Readings in digital format; Captioned videos; Additional simulations, interactive websites; Optional and recorded synchronous sessions; Weekly video messages highlighting previous and upcoming content
Multiple means of action/expression	Flexibility in how weekly activities and major assignments to be completed (allowing for various formats: written, multimedia presentations, video, creating graphic organizer, etc.); Choice to participate in discussions using text, video, etc.; Flexible deadlines on some assignments; Gradual release of learning modules; Final project outline and rubrics; Multiple opportunities to receive feedback on the final project throughout the semester; Peer feedback

Data Collection and Analysis

The data sources used in this study included: educators' UDL Instructional Plan Projects and end-of-course surveys. UDL instructional plan project was the major assignment for the course that was broken into manageable chunks to allow for iterative development based on the instructor and peer feedback. There were several sections in the project including:

(1) Learner Characteristics & Needs – providing general information about the observed classroom and identifying learners' strengths, weaknesses, and preferences/interests;
(2) Observed Curriculum/Lesson Overview – providing detailed description of all the observed activities and identifying UDL guidelines and checkpoints observed; To provide choice, educators could analyze their own lesson or observer somebody else's;
(3) UDL Instructional Plan – including (a) establishing clear and measurable learner outcomes; (b) analyzing learners' variability related to specific lesson goals; (c) deciding how learning is going to be measures; and (4) proposing additional UDL strategies that could enhance learning opportunities for the identified learner variability;
(4) Demonstration – video presentation about UDL strategies;
(5) Reflection – focusing on how suggested UDL strategies can benefit observed students, recognition of the potential impact of UDL, discussion of professional development.

The final UDL instructional plan project had a fixed final due date at the end of the semester, but educators had flexibility in working on its parts throughout the semester. Most educators completed their observations and the initial analysis of existing UDL strategies in Modules 5-6. Thematic analysis (Guest, MacQueen, & Namey, 2011) was used to analyze the sections from 70 final projects that focused on learner characteristics and needs; observed UDL strategies; proposed UDL instructional plan; and reflection. The description of the lessons and demonstration videos were used to assess the accuracy of the observed and proposed UDL strategies but not used in the data analysis. The thematic analysis involved reading and re-reading the projects in order to examine data for patterns. These patterns were compared across educators to develop categories. The categories later merged into overarching themes.

In addition to UDL instructional plan projects; educators completed the end of the year survey. Adapted Web-based Learning Environment Instrument (WEBLEI; Chang & Fisher, 2003) was used to measure educators' feedback across four scales: access, interaction, response, and results. Additional questions were added to the WEBLEI instrument to explore educators' perceptions towards UDL strategies incorporated in the course. Data from responses to the following statements related to the UDL nature of the online course were analyzed in this study:

- The structure of each module was clear and kept me focused on what was to be learned.

- There is a value in having course materials available in multiple formats.
- Having options throughout the semester (in engagement, representation, and action) provided nice examples of how to incorporate UDL strategies into my own teaching.
- At the end of the course, I am more confident in my understanding of UDL for Learning than I was prior to taking the course.
- I am planning on incorporating UDL strategies in my environment.

Sixty-five educators (93%) provided answers to the end-of-semester survey. The answers to aforementioned Likert-scale questions were analyzed using frequencies and descriptive statistics (e.g., mean and standard deviation). Finally, the answers to an open-ended question, "What have you learned about UDL that you did not know before taking this class?" were analyzed using thematic analysis as described earlier.

Credibility and Trustworthiness

Conducting reliability reviews and triangulation of data ensured the credibility and trustworthiness of findings in this study. First, a doctoral student with expertise in qualitative research reviewed the coding of all qualitative data and any disagreements were discussed until resolved. In addition, another researcher reviewed 21 UDL instructional plan projects (30%) to assess the accuracy of the proposed UDL strategies based on the learning outcomes and learner variability. The agreement between two reviewers was 97%. Finally, the data were triangulated across different educators, different sections of the projects, and different data sources.

RESULTS

As part of their final assignment, 70 educators observed a variety of lessons/units. The grade levels varied from Pre-K to college courses including 35.7% of lessons observed in pre-school/elementary grades; 22.9% in middle grades; 27.1% in high school; and 14.3% in higher education. The latter included both regular college courses (n = 8) and courses in the post-secondary program for students with disabilities (n = 2). There was also a great variability in subjects observed including language arts (28.6%); math and algebra (20%); social studies (14.3%); foreign language (8.6%); science (7.1%); art and music (5.7%); and other subjects as independent liv-

ing, Braille reading and writing, etc. (15.7%). Many topics were covered in the observed lessons such as argumentative writing; exploring equality with equations; Westward expansion; cancer; introduction to Chinese; Georgia O'Keeffe; and others.

The majority observed their own classrooms (66%). Across the educators the class sizes ranged from 2 to 30 students (M = 17.24; SD = 6.35). Those were inclusive (including at least one student with disabilities; 52.9%); general education (35.7%); and special education (11.4%) settings. Students with various abilities and needs were present in inclusive classrooms (e.g., learning disabilities, autism, ADHD, visual and hearing disabilities, emotional disorders, anxiety). Special education classrooms included students with more severe intellectual and developmental disabilities. In addition, 20% of educators explicitly noted in their UDL plans having multiple students who were English Language Learners, while 40% noted having students struggling with learning and receiving supports.

Observed and Proposed Additional UDL Strategies

In each lesson, educators could observe teaching with UDL strategies. After the analysis of barriers and learner characteristics in each class, they were also able to propose additional UDL strategies to make the instruction accessible to all learners. Table 3 provides frequencies of the observed and proposed additional strategies across UDL principles, guidelines, and checkpoints. Overall, while all UDL guidelines and checkpoints were present in the instruction during the original observations, the most frequently used checkpoints (present in more than 50% of lessons) included: (1) activating or supplying background knowledge (70%) and (2) fostering collaboration and community (60%). In response to the intentional analysis of learning outcomes, learners' strengths, weaknesses, and preferences, the frequency of all UDL guidelines and checkpoints increased, when educators were asked to propose additional UDL strategies. When analyzing the increase rate, checkpoints under "multiple means of action/representation" principle, "provide options for physical action" guideline showed the highest increase (38% increase across two checkpoints). Most frequently the following UDL checkpoints were proposed in addition to the originally observed ones: (1) offer ways of customizing the display of information (74%); (2) clarify vocabulary and symbols (70%); (3) optimize access to tools and assistive technologies (69%); (4) optimize individual choice and autonomy (67%); (5) use multiple tools for construction and composition

(67%); (6) offer alternatives for visual information (64%); (7) foster collaboration and community (63%); (8) use multiple media for communication (63%); (9) vary the methods for response and navigation (59%); (10) optimize relevance, value, and authenticity (56%); (11) offer alternatives for auditory information (56%); (12) develop self-assessment and reflection (56%); (13) illustrate through multiple media (54%); (14) highlight patterns, critical features, big ideas, relationships (54%); (15) enhance capacity of monitoring progress (51%).

Table 3

Frequencies of Observed and Proposed UDL Guidelines and Checkpoints

Multiple Means of Engagement		
Provide options for recruiting interest:		
• Optimize individual choice and autonomy	49%	67%
• Optimize relevance, value, and authenticity	39%	56%
• Minimize threats and distractions	26%	44%
Provide options for sustaining effort and persistence:		
• Heighten salience of goals and objectives	16%	39%
• Vary demands and resources to optimize challenge	19%	43%
• Foster collaboration and community	60%	63%
• Increase mastery-oriented feedback	24%	37%
Provide options for self-regulation:		
• Promote expectations and beliefs that optimize motivation	23%	41%
• Facilitate persona coping skills and strategies	13%	40%
• Develop self-assessment and reflection	20%	56%
Multiple Means of Representation		
Provide options for perception:		
• Offer ways of customizing the display of information	27%	74%
• Offer alternatives for auditory information	41%	56%
• Offer alternatives for visual information	39%	64%
Provide options for language, mathematical expressions, symbols:	44%	70%
• Clarify vocabulary and symbols	11%	31%
• Clarify syntax and structure	19%	34%
• Support decoding of text, mathematical notation and symbols	14%	32%
• Promote understanding across language	43%	54%
• Illustrate through multiple media		
Provide options for comprehension:	70%	46%
• Activate or supply background knowledge	49%	54%
• Highlight patterns, critical features, big ideas, relationships	41%	49%
• Guide information processing, visualization, manipulation	26%	37%
• Maximize transfer and generalization		
Provide options for physical action:	26%	59%
• Vary the methods for response and navigation	26%	69%
• Optimize access to tools and assistive technologies		

Multiple Means of Action/Expression		
Provide options for expression and communication:	17%	63%
• Use multiple media for communication	26%	67%
• Use multiple tools for construction and composition	27%	40%
• Build fluencies with graduated levels of support		
Provide options for executive function:	19%	33%
• Guide appropriate goal setting	26%	49%
• Support planning and strategy development	24%	39%
• Facilitate managing information and resources	20%	51%
• Enhance capacity for monitoring progress		

Note: Educators could suggest additional strategies for UDL guidelines and checkpoints already present in the lesson during the original observation.

Specific UDL Strategies to Address Learner Strengths, Weaknesses, and Preferences

To model the intentionality of the UDL design, educators identified strengths, weaknesses, and preferences of the students they had observed. Each participant developed a revised lesson plan that included a plethora of UDL strategies used to address those characteristics. The thematic analysis elicited many similarities in both (a) learners' variability experienced by the educators and (b) in the ways to addressed learners' characteristics with various UDL principles, guidelines, and checkpoints. Table 4 presents overarching strategies across three UDL principles proposed to address students' variability and barriers to learning. While some strategies proposed by the educators relied on the use of technology, others could be achieved without the technology.

Table 4
UDL Strategies Proposed by the Educators

UDL Principles & Guidelines	Overarching UDL Strategies Proposed by Educators	Examples of Students' Variability
	Multiple Means of Engagement	
Provide options for recruiting interest:	• Allow choose a partner/group, roles, jobs in a group	Students do very well engaging in conversations with peers; get along.
	• Provide choice of homework type, centers, end product, topic to study, book to read, prompts to write about, problems to solve, materials to use, etc.	
	• Use real-world examples (e.g., fractions)	Students enjoy being independent.
	• Ask to rewrite problems relevant to everyday lives	
	• Offer noise-canceling headphones, dividers, visible timers, visual schedules	Students are receptive to feedback and positive reinforcement
Provide options for sustaining effort and persistence:	• Post goals and agenda	
	• Make goals available on a sticky note	
	• Differentiate level of difficulty (e.g., Newsela)	Students don't hesitate to ask questions
	• Offer exemplars projected or as posters	
	• Use collaborative learning games (board or digital)	
	• Work with partners or in small groups; rotate groups	Students become off-task or unengaged, especially during a longer task.
	• Use programs with instant feedback (e.g., Socrative)	
Provide options for self-regulation:	• Conduct teacher-student conferences	
	• Use motivational apps, timers, incentives (e.g., Dojo)	Students exhibit behavior problems; too social.
	• Allow short breaks; Use stress balls	
	• Use self-assessment of understanding, exit surveys	
	• Ask students to reflect on the process and final product (e.g., reflective journal)	
	• Ask students what they would do differently if they could re-do	
	Multiple Means of Representation	
Provide options for perception:	• Provide digital note sheets, guided notes	Students are very engage, especially when video/ sound clips are involved.
	• Offer digital magnification and contrast	
	• Increase the copy size	
	• Provide captioned video and audio; transcript	
	• Use tools to show the process (e.g., ShowMe)	Students can independently read and follow directions.
	• Provide descriptions to images, photographs	
	• Use narrated/digital versions of books and sources	
	• Orally discuss written directions	
	• Use accessibility features built into technology	Students like using highlighters and sticky notes.
Provide options for language, mathematical expressions, and symbols:	• Offer guided notes with text and images	
	• Offer simplified or annotated notes of key points	
	• Display lesson vocabulary (e.g., word walls; anchor charts, vocabulary cards)	Students have good listening comprehension.
	• Use built-in read-aloud features or recordings	
	• Develop documents with hyperlinks to outside dictionaries and websites explaining vocabulary	Students don't speak English.
	• Offer word banks supported by images	
	• Provide visualizations of concept; act out terms	Students have reading difficulties (both decoding and comprehension).
	• Use sticky notes, flashcards (e.g., Quizlet)	
	• Incorporate translation tools (e.g., Google Translate)	
Provide options for comprehension:	• Use bilingual "peer tutor" partner for ELL	Students have limited receptive language skills.
	• Show video, use Poll Everywhere, engage in discussion to activate background knowledge	
	• Start with KWL, Think Puzzle Explore, or another warm-up activity	Students have processing difficulties.
	• Use visuals and manipulatives (e.g., geoboards)	
	• Connect content to bigger ideas; across curriculum	Students cannot see or hear.
	• Use clear sequential processes (e.g., for editing; solving math problems)	
	• Use scavenger hunts (e.g., Creturepedia); mnemonics; graphic organizers (e.g., Popplet, Padlet)	
	• Engage in role plays mirroring real life actions	

UDL Principles & Guidelines	Overarching UDL Strategies Proposed by Educators	Examples of Students' Variability
	Multiple Means of Action/Expression	
Provide options for physical action:	• Use simulations • Provide e-Book version of the text • Write on printed copy or take notes in different formats (e.g., digital, handwritten) • Ask students to act out, retell, or debate the problem • Use dictation programs, word processors, spelling and grammar checkers, other assistive programs • Use calculators and other supports • Use gradual release model of instruction	Students enjoy making and creating (e.g., pictures, presentations, videos, etc.) Students can independently solve problems (e.g., with and without calculator)
Provide options for expression and communication:	• Ask students to create video (e.g., iMovie, Seesaw, Animoto), podcase (e.g., Podbean); website (e.g., weebly.com), graphic organizer (e.g., Popplet, Padlet, Boxes-and-Bullets), multimedia (e.g., Prezi, Glogster) or oral (e.g., Voki) presentation, journal entry, song, 3-D and other models, picture, diagram • Use concrete and virtual manipulatives; prompts • Offer assignment sheets, rubrics; heterogeneous grouping to allow for scaffolding	Students are comfortable with technology. Students have difficulty writing (both mechanics and organization).
Provide options for executive functions:	• Provide print-out, an outline, planning sheet • Model the process through think-aloud • Break the assignment into chunks • Create teacher's blog, class website, Google Class • Provide directions/explanations via audio, how-to video, multimedia (e.g., VoiceThread) • Give students a minute to "Stop & Think" • Circulate to provide feedback; use peer feedback • Check off tasks as they are completed; create charts to report progress (e.g., individual or class)	Students have poor fine motor skills. Students take long time to complete the task. Students have limited expressive language skills.

Recognition of UDL's Potential as a Support

Overall, all educators recognized UDL as the way to support learning of diverse students. The overarching themes that emerged from educators' reflections focused on (a) the value of UDL for all learners; (b) the importance of intentional planning, implementation, reflection, and revising; (c) the significance of choice for students' autonomy; and (d) the need for more professional development for all teachers.

The value of UDL for all learners. After taking the time to match UDL strategies to their learner characteristics and barriers they might experiences, followed by redesign and reflection on the process, all educators agreed that UDL is very valuable for all students. One general teacher stated, "UDL strategies help support the learning environment by capitalizing on students' strengths while supporting students' weaknesses." Both special and general education teachers agreed on the value of UDL. One teacher noted the importance of UDL for students with disabilities by saying,

> UDL components are essential in order to ensure every student is able to access instruction in a way that meets their need. Thus

> implementing these components can help my students [with disabilities] access instruction; but it can even take a step further and help students strive in the learning environment (special education teacher).

Another general teacher added, "Having many ways in which kids can learn the content allows for the "ah ha" moments to happen more frequently." Overall, as one general education teacher summarized:

> By adding in the options of technology use, partner work, manipulative use, etc. higher needs students no longer feel that they are in a separate group from the rest of the class. Instead of special education students being the only students approaching the learning in different ways, now all of the students will be, regardless of their level of ability.

The importance of intentional planning, implementation, reflection, and revising. Several educators noted that UDL planning "brought to light the unintended barriers that exist in a typical lesson (general education teacher)." All educators recognized the need to remove or at least reduce those barriers to learning for all students to "create a learning environment that is flexible, giving all learners equal access to learning opportunities (general education teacher)." Five educators had an opportunity to implement their revised lesson plans or at least parts of lesson plans during the semester. Others were prepared for implementation and refinement. In their reflections, many started to brainstorm hypothetically how they could have changed the plan if they were to have different learning environment and different students' needs. The iterative nature of UDL was acknowledged. As one student noted,

> I always learn a lot when implementing plans and know that I will find adjustments to be made. To that I believe this process is not a one-time planning activity. In order to fully embrace UDL in the classroom, the planning and revising would need to be ongoing, especially since my students change from year to year (general education teacher).

The significance of choice for students' autonomy. Educators were eager to take it to the next level and incorporate UDL in their daily teaching efforts. One of the most frequently cited reasons included a transfer of responsibility from the teacher to the students "by providing appropriate supports to aid success, while building in appropriate challenges as well (general education teacher)." Indeed, most educators commented on the need to incorporate choice and allow students to become more active in their learning process. One participating teacher shared,

> I want to incorporate some of what I implemented in the observed lesson into my daily teaching efforts. For example, I want to incorporate in all my teaching the addition of student choice. I have done this on some assignments, and have found great success with it. I feel by incorporating more on all levels will ensure students feel they have some autonomy in their classroom experience (general education teacher).

The need for more professional development for all teachers. While using UDL to design curriculum might be a daunting task, the educators in this study learned to do it in a manageable way. As one participant shared,

> Through this planning activity I have learned that while time-consuming, it is not difficult to plan for UDL using the guidelines. I have even laminated a color copy of the guidelines and plan on having it out as a reference when planning in the future (general education teacher).

However, all educators were also in agreement that there needs to be more professional development (PD) on UDL in their schools. As one teacher said, "I have never actually attended or even heard of UDL used in my current district (special education teacher)." That includes both PD on the UDL process as well as separate opportunities to learn how to use various technology-based tools. UDL is a mindset shift. As one teacher said, "With UDL comes a lot more flexibility, extra planning, and more student freedom. That can be difficult for a lot of teachers who like to have control over everything in their classroom (general education teacher)." As the first step in advocating for UDL, many educators chose to share their UDL instructional plans with their colleagues. As one participant stated, "I was so excited to share this plan with my fellow math teachers and they agreed that we should all try to use these activities in the future (general education teacher)." Several others, especially educators in leadership roles, noted the importance of including UDL principles in their training. As one school administrator summarized,

> Planning lessons through the UDL lens is extremely beneficial and proactive as it is harder to adapt to learners on the spot or in retrospect. UDL is powerful, so providing instruction to teachers, and then allowing them time to reflect on their own instruction as I did for this lesson. UDL can be an effective way for teachers to enhance their instruction for all learners.

Learning About UDL While Experiencing UDL

In addition to their reflections, educators expressed their appreciation of being able to experience UDL firsthand in an UDL-based asynchronous learning environment. Based on their end-of-year survey responses, the structure of each course module was clear and kept educators focused on what was to be learner (M = 4.79; SD = 0.47). Educators recognized the value in having course materials available in multiple formats (e.g., narrated presentations, regular PowerPoints, audio, and transcript in Word) (M = 4.92; SD = 0.27). Even if they did not choose to complete module activities in creative ways, having options throughout the semester (in engagement, representation, and action/expression) provided nice examples of how to incorporate UDL strategies into their own teaching (M = 4.91; SD = 0.37). At the end of the course, educators were more confident in their understanding of UDL than prior to taking the course (M = 4.89; SD = 0.36). Specifically, educators noted learning about the implementation process "rather than just a trending buzzword." Those who were familiar with broader UDL principles appreciated learning the specifics and applying them to different content areas. Educators also noted learning about a variety of no technology and high technology options to make learning accessible to all students. More importantly, the majority of educators indicated that they planned to incorporate UDL strategies in their teaching, regardless of the grade, content area, and learning environment (M = 4.83; SD = 0.42). As one general education teacher stated,

> I am a different teacher than I was before taking this class. I now look at my curriculum and daily lessons with the view of how to reduce barriers and increase access for all my students.

Finally, a general education teacher supported this sentiment by saying, "Moving forward, I will always use UDL rather than an outdated approach to differentiation."

DISCUSSION

This study explored how educators can learn about UDL from an online course designed using UDL principles. In addition, it provided the thematic analysis of UDL strategies proposed by the educators to address the learning outcomes, learner variability, and barriers in their contexts. Finally, educators' understandings about UDL in the context of serving diverse learners were elicited. All educators successfully completed the course and

demonstrated mastery in understanding the UDL principles, guidelines, checkpoints, and processes. A great variety of settings, grade levels, subject areas, and job titles were represented in this study. All educators applied the UDL framework to lesson planning regardless of the learning environment. Indeed, it is possible to implement UDL regardless of the learners' age (e.g., K-12, college, adult learners); subject they study (content areas, unique topics); or abilities and needs they have (e.g., general, inclusive, special education). Everyone can benefit from UDL (Castleberry & Evers, 2010; Coyne et al., 2012; Hall et al., 2015; Marino et al., 2014; Rao & Tanners, 2011; Rao et al., 2014).

Most of the educators in this study had their own classrooms and chose to analyze their own lessons. These observations happened mid semester and the educators were already aware of the basic UDL principles. Thus, all the educators observed some UDL strategies in the lessons. In addition, teachers might use UDL without knowing it, as checkpoints are derived from the best practices in the research literature (Israel et al., 2014). It is not surprising that the two most frequently checkpoints addressed in the original observations included: (1) activating or supplying background knowledge and (2) fostering collaboration and community; strategies shown by research to be effective for diverse learners and widely used by teachers (e.g., Strangman, Hall, & Meyer, 2004). However, after intentionally thinking about learning outcomes, learner strengths, weaknesses, and preferences, all educators could propose additional UDL strategies. The "unintentional barriers" that existed in the observed lessons were surprising to many. Intentionality is the most important part of the UDL design process. It is imperative to consider what needs to be taught and how to address existing students' variability and existing barriers (Rao & Meo, 2016). More so, the supporting technology should be selected intentionally. It might not be possible to adequately provide all desired components of UDL in the first iteration (Lock et al., 2016); but it should not stop educators from applying UDL in small steps, adding more and more components with time.

In response to Research Question 2, the thematic analysis of specific UDL strategies proposed by the educators was conducted to explore overarching ways to support learners' variability. Table 4 offers a wide range of no technology to high technology strategies. In fact, each UDL principle was supported by this blended approach. Additional ideas can be found on the National Center on Universal Design for Learning website (CAST, 2017). Educators actively incorporated the tools introduced in the course in their UDL instructional plans. Following the premise of UDL, students with various abilities and needs could benefit from the strategies proposed

by the educators. For example, providing a digital version of all reading materials may be beneficial for a student who is blind and uses screen reading software; a student with dyslexia who relies on text-to-speech for reading comprehension; an English language learner who might benefit from seeing and hearing the same text multiple times; or anyone who might have better listening comprehension or prefer reading on a device while traveling or otherwise multitasking. For many educators this became a surprising discovery, as they traditionally thought that digital materials were only for students with disabilities.

Once again, based on the intentionality of the UDL design, different learning environments call for different UDL guidelines and checkpoints, which can be supported by blended learning. Technology can provide "on-the-fly" individualization of instruction (CAST, 2011, p. 9). It offers different modalities (Black et al., 2014). In this study, the easy access made it possible to use the technology. Only two teachers reported not having any access to technology, while 17 teachers had either 1:1 technology initiatives or readily available classroom sets. Everybody else reported using technology regularly, in most cases, daily. Indeed, prior to taking the class, educators were already using a wide range of assistive and instructional technologies. However, after the class, technology-based recommendations addressed the specific goals and matched the specific students' characteristics (Rao & Meo, 2016). At the same time, it is important to remember that technologies should not be considered as the only way to implement UDL; neither the use of technology automatically qualifies as UDL (CAST, 2011; Dell et al., 2015; Nelson, 2014).

Overall, educators were very positive about UDL and eager to incorporate it in their learning environments. As one general education teacher summarized,

> Implementing UDL in future lessons is something that will become a necessity for me. Differentiation occurs with every move educators make in the classroom; but not all students can benefit by the same differentiation. So UDL is my answer!

Although UDL originated in special education, it is implemented in general education classrooms and makes all students approach learning in different ways (Edyburn, 2013; Israel et al., 2014). While UDL allows students with disabilities strive in their learning environments without standing out, it should be implemented for the sake of all learners. It was rewarding to see how much general education teachers recognized the value of UDL in this study. As one general teacher said, "After taking this course, I learned that UDL is more than just providing accessible materials, it's about recognition of diversity and allowing all students to learn in their preferred ways."

Data revealed that it was beneficial for the educators to learn about UDL by experiencing flexible learning environment firsthand. Consistent with previous research (Engleman & Schmidt, 2007; He, 2014; Rao & Tanners, 2011), educators in the current study appreciated how the online course was built, empowering them to be active learners and make choices; just like what they wanted for their own students. This also reinforced the notion that UDL is not just about special education. As one general education teacher stated:

> I can understand the value of UDL because I am experiencing it in this class. While I don't have any learning or other disabilities, I am seeing tremendous benefit from the UDL approach to offering variety of choices to the student.

Providing UDL experiences makes the process less intimidating. Overall, to summarize using one educator's words, "UDL framework helps educators think about removing barriers and provide scaffolding and supports to ALL students in terms of how materials can be presented to them, how they express their understanding, and how they will be motivated and engaged (general education teacher)."

Implications for Research and Practice

Since this study was largely qualitative in design and had a single-program focus, there was no intent to generalize. Further, after the educators analyzed their learning environments, revised the lesson plans, and proposed the additional UDL strategies, they were not required to implement the revised lessons. Partially, this was due to the time constraints with the school year finishing shortly after the end of the course. Only five educators took the initiative to try their plans. Thus, the study does not address the multiple iterations a plan must pass through to be ready for students with disabilities.

Future research should focus on the ability of teacher candidates and in-service educators to fully implement a UDL unit, rather than just to plan for it. In addition, a follow-up study with the same educators would be important to see if they implemented UDL in their teaching after finishing their programs. This study also provides practical ideas on UDL implementation in many different classrooms. All strategies presented in this study are designed by practicing teachers taking into consideration the available resources. It is important to note that educators proposed many no technology or readily available technology applications, making UDL an affordable solution for addressing the diverse needs of their learners.

Conclusion

This study contributes to the limited research investigating the implementation of UDL in various learning environments across grade levels and subject areas. In addition to exploring the change in perceptions of in-service general and special education teachers, this study is a stepping-stone for research on application of UDL principles in authentic classrooms. Experiencing UDL firsthand in an online course resulted in educators' willingness to use technology to ensure UDL instruction. Both attitudes and lesson plans in this study have demonstrated educators' strong inclinations to include diverse learners in meaningful learning experiences.

References

Ashman, A. (2010). Modeling inclusive practices in postgraduate tertiary education courses. *International Journal of Inclusive Education*, *14*, 667-680.

Basham, J. D., Meyer, H., & Perry, E. (2010). The design and application of the digital backpack. *Journal of Research on Technology in Education*, *42*, 339–359.

Black, R. D., Weinberg, L. A., & Brodwin, M. G. (2014). Universal design for instruction and learning: A pilot study of faculty instructional methods and attitudes related to students with disabilities in higher education. *Exceptionality Education International*, *24*, 48-64.

Castleberry, G. T., & Evers, R. B. (2010). Incorporating technology into the modern language classroom. *Intervention in School and Clinic*, *45*, 201-205.

CAST: Center for Applied Special Technology. (2011). *Universal design for learning guidelines version 2.0*. Wakefield, MA: Author.

CAST: Center for Applied Special Technology. (2017). *What is universal design for learning*. Retrieved from http://cast.org/udl/index.html

Chang, V., & Fisher, D. (2003). The validation and application of a new learning environment instrument for online learning in higher education. In M. S. Khine & D. Fisher (Eds.), *Technology-rich learning environments: A future perspective,* (pp. 1–18). Singapore: World Scientific.

Courey, S. J., Tappe, P., Siker, J., & LePage, P. (2012). Improved lesson planning with Universal Design for Learning (UDL). *Teacher Education and Special Education*, *36*, 7-27. doi: 10.1177/0888406412446178

Coy, K., Marino, M. T., Serianni, B. (2014). Using universal design for learning in synchronous online instruction. *Journal of Special Education Technology*, *29*, 63–74. doi: 10.1177/016264341402900105

Coyne, P., Pisha, B., Dalton, B., Zeph, L. A., & Smith, N. C. (2012). Literacy by design: A universal design for learning approach for students with significant intellectual disabilities. *Remedial and Special Education*, *33*, 162–172. doi: 10.1177/0741932510381651

Dell, C. A., Dell, T. F., & Blackwell, T. L. (2015). Applying universal design for learning in online courses: Pedagogical and practical considerations. *The Journal of Educators Online*, *13*, 166–192. doi: 1547-500X

Edyburn, D. L. (2010). Would you recognize universal design for learning if you saw it? Ten propositions for new directions for the second decade of UDL. *Learning Disability Quarterly*, *33*, 33–41.

Edyburn, D. L. (2013). Critical issues in advancing the special education technology evidence base. *Exceptional Children*, 80(1), 7-24.

Engleman, M., & Schmidt, M. (2007). Teaching an experimental universally designed learning unit in a graduate level online teacher education course. *MERLOT Journal of Online Learning and Teaching*, *3*, 112-132.

Guest, G., MacQueen, K. M., & Namey, E. E. (2011). *Applied thematic analysis*. Thousands Oaks, CA: SAGE Publications

Hall, T. E., Cohen, N., Vue, G., & Ganley, P. (2015). Addressing learning disabilities with UDL and technology: Strategic reader. *Learning Disability Quarterly*, *38*, 72-83. doi: 10.1177/0731948714544375.

He, Y. (2014). Universal design for learning in an online teacher education course: Enhancing learners' confidence to teach online. *MERLOT Journal of Online Learning and Teaching*, *10*, 283–298.

Israel, M., Ribuffo, C., & Smith, S. (2014). Universal Design for Learning: Recommendations for teacher preparation and professional development (Document No. IC-7). Retrieved from http://ceedar.education.ufl.edu/tools/innovation-configurations/

Kennedy, M. J., Thomas, C. N., Meyer, J. P., Y Alves, K. D. (2014). Using evidence-based multimedia to improve vocabulary performance of adolescents with LD: A UDL approach. *Learning Disability Quarterly, 37*, 71-86. doi: 10.1177/0731948713507262

King-Sears, M. E., Johnson, T., Berkeley, S., Weiss, M., Peters-Burton, E., Evmenova, A., Hursh, J. (2015). An exploratory study of universal design for teaching chemistry to students with and without disabilities. *Learning Disabilities Quarterly*, *38*, 84-96. doi: 10.1177/0731948714564575

Kumar, K., & Wideman, M. (2014). Accessible by design: Applying UDL principles in a first year undergraduate course. *Canadian Journal of Higher Education*, *44*, 125–147.

Lock, J., Altowairiki, N. F., Hill, S. L., & Johnson, C. (2017). A journey through the development of online environments: Putting UDL theory into practice. *Handbook of Research on Innovative Pedagogies and Technologies for Online Learning in Higher Education*. Hershey, PA: IGI Global.

Mace, R. (1997). What is universal design? Center for Universal Design, NC State University, USA. Retrieved from http://www.design/ncsu.edu/cud/univ_design/ud.htm

Marino, M. T., Gotch, C. M., Israel, M., Vasquez, E., Basham, J. D., & Becht, K. (2014). UDL in the middle school science classroom: Can video games and alternative text heighten engagement and learning for students with learning disabilities? *Learning Disability Quarterly*, *37*, 87-99. doi: 10.1177/0731948713503963.

Meyer, A., Rose, D. H., & Gordon, D. (2014). *Universal design for learning: Theory and practice*. Wakefield, MA: CAST.

Navarro, S. B., Zervas, P., Gesa, R. F., & Sampson, D. G. (2016). Developing teachers' competences for designing inclusive learning experiences. *Educational Technology & Society*, *19*, 17-27.

Nelson, L. L. (2014). *Design and deliver. Planning and teaching using Universal Design for Learning*. Baltimore: Paul S. Brookes

Parker, D. R., Robinson, L. E., & Hannafin, R. D. (2008)."Blending" technology and effective pedagogy in a core course for preservice teachers. *Journal of Computing in Teacher Education*, *24*, 49-54.

Rao, K., & Tanners, A. (2011). Curb cuts in cyberspace: Universal instructional design for online courses. *Journal of Postsecondary Education and Disability*, *24*, 211–229.

Rao, K., Edelen-Smith, P., & Wailehua, C. (2015). Universal design for online courses: Applying principles to pedagogy. *Open Learning: The Journal of Open and Distance Learning*. *30*, 35-52. doi**:**10.1080/02680513.2014.991300

Rao, K., & Meo, G. (2016). Using Universal Design for Learning to design standards-based lessons. *SAGE Open*, *6(4)*, 1-12. doi: 2158244016680688

Rao, K., Ok, M., & Bryant, B. R. (2014). A review of research on universal design educational models. *Remedial & Special Education*, *35*, 153-166. doi:10.1177/0741932513518980

Robinson, D. E., & Wizer, D. R. (2016). Universal Design for Learning and the Quality Matters Guidelines for the design and implementation of online learning events. *International Journal of Technology in Teaching & Learning*, *12*,17-32.

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal Design for Learning*. Retrieved from the Association for Supervision and Curriculum Development http://www.ascd.org/publications/books/101042.aspx

Rose, D. H., Meyer, A., & Hitchcock, C. (2005). *The universally deigned classroom: Accessible curriculum and digital technologies*. Cambridge, MA: Harvard Education Press

Scott, L., & Temple, P. (2017). A conceptual framework for building UDL in a special education distance education course. *Journal of Educators Online*, *14*, 48-59.

Smith, F. (2012). Analyzing a college course that adheres to the Universal Design for Learning (UDL) framework. *Journal of the Scholarship of Teaching and Learning*, *12*, 31–61.

Spooner, F., Baker, J. N., Harris, A. A., Ahlgrim-Delzell, L., & Browder, D. M. (2007). Effects of training in universal design for learning on lesson plan development. *Remedial and Special Education*, *28*, 108-116. doi:10.1177/0741932507028002010 1

Strangman, N., Hall, T., & Meyer, A. (2004). *Background knowledge instruction and the implications for UDL implementation.* Wakefield, MA: National Center on Accessing the General Curriculum. Retrieved from http://aem.cast.org/about/publications/2004/ncac-background-knowledge-udl.html

Van Laarhoven T. R., Munk, D. D., Lynch, K., Bosma, J., & Rouse, J. (2007). A model for preparing special and general education preservice teachers for inclusive education. *Journal of Teacher Education*, *58*, 400-455. doi: 10.1177/0022487107306803