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# Universal Design for Learning in K-12 Educational Settings: A Review of Group Comparison and Single-subject Intervention Studies

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This literature review on Universal Design for Learning (UDL) included articles from January 1984 through June 2014. We (a) investigated the UDL educational framework without the inclusion of other major K-12 educational frameworks in learning environments, (b) reported researchers' scope and depth of use of the UDL principles, and (c) focused our investigation on two research methods: group comparison and single-subject. We used the quality indicators for evidence-based practices (EBPs) in special education to review, not rate, the final pool of five peer-reviewed articles. Results included analyses of the incorporation of UDL principles in all identified studies, highlighting the need for caution in promoting conceptual frameworks until sufficient empirical evidence is available to validate pedagogical utility in educational environments. We conclude that the UDL framework has merit but researchers must conduct studies that use group comparison and single-subject studies to independently test the UDL principles, guidelines, and checkpoints to increase the likelihood of causation in treatment outcomes.

*Keywords:* access, evidence-based practice, instructional design, universal design for learning.

Estimated population trends indicate that as a nation we will continue to become more diverse (Mackun & Wilson, 2011). Educators have traditionally addressed the academic and social needs of diverse students well over the years; however, educators need access to more high-quality research studies to understand the nuanced academic and social needs of diverse student populations (Council for Exceptional Children, 2014). In terms of recent educational conditions, there was an increase in student enrollment for Hispanics, Asians/Pacific Islanders, and English-language learners, and a decrease in students categorized as Black and White in U.S. public schools (Kena et al., 2014). In 2011-2012, the number of students receiving special education services was 13 percent or 6.4 million with 36 percent of this population categorized as students with learning disabilities (LDs; Kena et al., 2014). The large percentage of diverse students with LDs may be an indicator that warrants

a critical investigation of professional practices and students' interactions with variables associated with the social dynamics and instructional designs within learning environments that do not support student variability (Gage, Gersten, Sugai, & Newman-Gonchar, 2013; Waitoller, Artilles, & Cheney, 2009). The changing demographics in the United States indicate to researchers and educators that one of the challenges of a diverse populace is to appropriately address the learning needs of their students in order to increase access, participation, and progress, especially for students with disabilities within the general education curriculum.

Researchers and educators have been encouraged to offer students with disabilities greater educational opportunities through legislative provisions related to access, participation, and progress in the general curriculum, which were initially reflected in the Individuals with Disabilities Education Amendments Act (IDEA) of 1997 and subsequently included in the Individuals with Disabilities Improvement Act (IDEIA) of 2004 (also see Hitchcock, Meyer, Rose, & Jackson, 2002). In our review of the extant literature base on topics related to universal design (UD), the meaning and operationalization of access, participation, and progress piqued our interests to investigate the complexities associated with student variability and universally-designed environments, curricula, or instructional practices. Therefore, the goal of this paper is to illustrate the merits of UD principles within the educational framework Universal Design for Learning (UDL) while highlighting the need for caution in promoting conceptual frameworks or strategies until sufficient empirical evidence is available to validate pedagogical utility in educational environments (see Kennedy, Thomas, Meyer, Alves, & Lloyd, 2014; McGuire, Scott, & Shaw, 2006).

**Universal Design**

There has been an increased legislative focus on universal design (UD) principles to improve curricular and instructional access for students with disabilities. For example, in IDEA 1997, the term UD was mentioned once in the following context: "Supporting research, development, and dissemination of technology with universal-design features, so that the technology is accessible to individuals with disabilities without further modification or adaptation" (111 Stat. 155). Subsequently in the Assistive Technology Act (ATA) of 1998 and 2004 and in IDEIA 2004, UD was defined as:

> a concept or philosophy for designing and delivering products and services that are usable by people with the widest possible range of functional capabilities, which include products and services that are directly accessible (without requiring assistive technologies) and products and services that are interoperable with assistive technologies. (ATA, 1998, 112 Stat. 3634-3635)

The scope of the definition of UD now includes the design and delivery of products and services, whether effectuated with or without assistive technologies, to meet the widest range of individuals. Although the application of the UD architectural concept from the Center for Universal Design (CUD) to educational environments seemingly has the potential to increase learning opportunities for students with disabilities (CUD, 1997), researchers and educators must systematically test the effects of the various elements of universal design frameworks (e.g., Universal Instructional Design [UID],

Universal Design for Instruction [UDfI], Universal Design of Instruction [UDoI], and Universal Design for Learning [UDL]) with diverse student populations in K-12 and postsecondary educational contexts to establish strong empirical research bases. For a detailed description of the various applications of UD frameworks in educational environments, please see McGuire, Scott, and Shaw (2006). The need for additional research is a call to researchers and educators to explore the implementation of UD principles in educational environments for students who demonstrate seemingly intractable learning characteristics (Edyburn, 2010).

**UDL and Evidence-based Practices in Special Education**

As currently expressed, the Higher Education Opportunity Act (HEOA) of 2008 provisions indicate that to improve K-12 students' educational opportunities and success at postsecondary institutions, faculty in teacher preparation programs can incorporate the principles of Universal Design for Learning (UDL) in the preparation of teachers in such areas as the (a) application of research-based instructional methods and strategies, (b) integration of technology into curricula and instruction, and (c) incorporation of accessible curricula and instructional practices to increase academic achievement. UDL has been defined in the HEOA (2008) as: a scientifically valid framework for guiding educational practice that—

> (a) provides flexibility in the ways information is presented, in the ways students respond or demonstrate knowledge and skills, and in the ways students are engaged; and
>
> (b) reduces barriers in instruction, provides appropriate accommodations, supports, and challenges, and maintains high achievement expectations for all students, including students with disabilities and students who are limited English proficient. (122 Stat. 3088)

The UDL framework is comprised of three principles developed in alignment with the affective, recognition, and strategic brain networks: (a) provide multiple means of engagement (the "why" of learning), (b) provide multiple means of representation (the "what" of learning), and (c) provide multiple means of action and expression (the "how" of learning; CAST, 2011). The ultimate goals for all education stakeholders in using the UDL principles in K-12 learning environments are to address student variability and develop students who are (a) purposeful and motivated, (b) resourceful and knowledgeable, and (c) strategic and goal-oriented (CAST, 2011). Researchers and educators may use the three guidelines under each principle and the 31 checkpoints as signposts to address students' interests and academic needs. For example, for students who demonstrate difficulties with vocabulary, researchers and educators may consider using checkpoint 2.1 (clarify vocabulary and symbols) of guideline two (language, expressions, and symbols) to improve accessibility to content by providing graphic symbols with alternative text (low tech) to embedding supports for vocabulary through hyperlinks of previous content, definitions, explanations, illustrations, or translations into other languages (high tech). The UDL framework was designed to provide education stakeholders guidance in proactive design or redesign of curricula and learning experiences by encouraging stakeholders to maximize the supports embedded in curricula and instructional practices so that they address students' proclivities, experiences, resources, and engagement (Meyer, Rose, & Gordon, 2014).

Although the HEOA (2008) mandates stipulate which practices to implement to reform teacher preparation programs and learning environments (e.g., UDL) to "enable kindergarten through grade 12 students to develop learning skills to succeed in higher education and to enter the workforce" (122 Stat. 3155), more clarity is needed on utilizing frameworks such as UDL and testing the effects of educational practices. Recently, the Council for Exceptional Children (CEC; 2014) developed standards for evidence-based practices (EBPs) in special education to provide individuals who possess the knowledge, experiences, and skills to appraise educational research designs and methods clarity on which research methods have an increased likelihood to effectively increase students' learning growth rates. The two research methods currently listed in the CEC (2014) standards are experimental group comparison (randomized, quasi-, and regression-discontinuity) and single-subject. Under the CEC (2014) standards for EBPs, studies can be classified as one of the following: (a) evidence-based practice, (b) potentially evidence-based practice, (c) mixed evidence, or (d) insufficient evidence. The criteria used for classifying EBPs in special education may also benefit educators in K-12 learning environments. When K-12 educators couple EBPs with a recommended practice such as UDL in learning environments, the assumption is that the educators are more likely to produce positive educational outcomes for students with disabilities at the classwide, small-group, and individual-learner level.

**Purpose of the Literature Review**

The authors of recent preK-12 and postsecondary literature reviews of experimental studies of various UD frameworks (i.e., UID, UDfI, UDoI, and UDL) (a) described how researchers are implementing universal design principles and (b) provided recommendations for establishing a research base (Rao, Ok, & Bryant, 2014; Roberts, Park, Brown, & Cook, 2011). In the present literature review we (a) investigated the UDL educational framework without the inclusion of other major educational frameworks or design features, (b) reported researchers' scope and depth of use of the UDL principles, and (c) focused our investigation on two research methods. We used the quality indicators for EBPs in special education to review, not rate, group comparison (e.g., experimental, quasi-experimental, and regression discontinuity) and single-subject (e.g., Acceptable: ABAB/reversal, multiple-baseline, changing-criterion, and alternating treatment; Unacceptable: AB) intervention studies, because researchers are better able to infer causality from these types of methods (CEC, 2014). We also explored whether researchers indicated or measured the UDL principles as contributing factors in treatment effects. The purpose of this K-12 literature review on UDL is to explore the logic behind using the principles, guidelines, and/or checkpoints of this education framework to increase learners' access to the curricular content of group comparison and single-subject interventions.

**Research Questions**

We used three research questions to investigate the logic for conceptualizing the intent for using, incorporating, and determining possible treatment effects from UDL principles:

1. Do researchers indicate the purpose for using elements of the UDL educational framework?
2. How do researchers incorporate UDL principles in interventions to increase access for learners?
3. Do researchers indicate or measure

whether they believe UDL principles contributed to treatment effects?

## Method

### Search Criteria and Terminology

We used a systematic process to search for intervention studies that included UDL as an instructional design feature in K-12 educational settings. Four searches were initially conducted in January 2014 and updated in July 2014. We searched eight electronic databases within the EBSCOHost interface (i.e., Academic Search Complete, Education Source, ERIC, Professional Development Collection, PsycARTICLES, PsycINFO, Social Sciences Full Text, and Teacher Reference Center). Keyword searches included the use of double-quotation marks, boolean (AND & OR), and truncation (i.e., asterisk) searches to increase the relevance of search hits in education, psychology, and social science fields. The primary keywords entered in all four searches were "*universal design for learning" OR "universal design*" with the latter keywords used to capture authors who may have included universal design as a possible synonym for UDL. Next, the primary keywords were used in conjunction with four sets of secondary keywords: (1) *"elementary school*" OR "elementary education" OR "elementary grade*"*, (2) *"secondary school*" OR "secondary education" OR "secondary grade*"*, (3) *"middle school*" OR "middle grade*"*, and (4) *"high school*"*. The four searches of the eight databases also included the limiters "scholarly (peer-reviewed) journals" and search months and years January 1984 through June 2014. The year 1984 was used as the initial search year for the literature review because it aligned with the year education researchers established CAST (formerly the Center for Applied Special Technology). Any article that met criteria included UDL as an instructional design feature in K-12 group comparison or single-subject intervention studies, or as one of the methods in a mixed-methods study. We included K-12 as a search criterion to align with the language in the HEOA of 2008, but recognize the importance of prekindergarten instructional practices on the future educational outcomes of students.

### Selection Process for Coding and Interrater Reliability

In January 2014, all four authors participated in a training session that coincided with instructional support from the first author in the second of a two-part research course sequence in spring 2014. All authors were randomly assigned into dyads and then randomly assigned to search eight EBSCOHost databases (i.e., Academic Search Complete, Education Full Text, Education Research Complete, Education Source, ERIC, PsycARTICLES, PsycINFO, and Social Sciences Full Text). The ninth database, Teacher Reference Center, was the first database searched independently by each author and subsequently reviewed as a research team to operationalize search criteria procedures; we used this discussion opportunity to clarify misunderstandings and to answer questions. Interrater reliability was not calculated for the training session for the database Teacher Reference Center, since it was considered a learning and competency-building activity. Interrater reliability for the remaining eight databases and for the updated July 2014 search was calculated by dividing the number of agreements by the number of agreements plus disagreements and then multiplying by 100. Throughout the spring 2014 semester, the quality indicators for coding group comparison or single-subject research methods were reinforced both in

the research course and in research team meetings.

All four authors individually used a five-step article selection process before comparing findings in dyads and as a research team in January 2014. First, we screened the titles, keywords, and abstracts of all peer-reviewed articles for criteria relevant to the search parameters. If necessary, we also screened the narrative bodies and methods sections of articles to dispel ambiguities and to confirm whether articles met criteria. Second, the United States was the geographical location for K-12 educational settings and English was the sole language of instruction for all participants. Fourth, acceptable evidence-based practices in special education studies would include randomized or quasi-experimental group, regression-discontinuity, or single-subject research methods. Last, researchers and/or educators in identified articles incorporated UDL principles in the design of curricula and/or instructional practices. In this literature review, we did not focus on whether dependent variables included UDL features; rather, our focus was on the curricular and instructional implementation of UDL in K-12 educational environments. Articles were excluded from consideration if a comparison or control group was not used in a group comparison study or if any other research method was not used in conjunction with a group comparison or single-subject research method. Interrater reliability for each of the two dyads for the remaining eight databases resulted in 94% agreement. A clarification discussion on disagreements resolved article all selection discrepancies.

In July 2014, two of the first three authors were randomly assigned to a dyad and independently updated the search using the same five-step selection process, resulting in over 315[1] article hits. The EBSCOHost databases (i.e., Academic Search Complete, Education Source, ERIC, Professional Development Collection, PsycARTICLES, PsycINFO, Social Sciences Full Text, and Teacher Reference Center) included a feature that removed duplicate articles within each of the four searches for the initial pool of articles, resulting in a total of 191 articles eligible for review. By July 2014, we no longer had access to two originally searched databases (i.e., Education Full Text and Education Research Complete) and added one database (i.e., Professional Development Collection) to the pool of previously searched databases.

We also reviewed the findings of the Rao, Ok, and Bryant (2014) preK to postsecondary literature review of empirical studies on universal design educational models to confirm our searches included all available intervention studies that met our criteria through January 2012. Our final pool of articles included two of the 13 articles included in the Rao et al. (2014) literature review (i.e., Browder, Mims, Spooner, Ahlgrim-Delzell, & Lee, 2009; Dolan, Hall, Banerjee, Chun, & Strangman, 2005), and one article not meeting our criteria because the design did not include a comparison group (i.e., Marino, 2009). Three other articles also nearly met criteria with the exception of including comparison or control groups or UDL was not the sole framework used in the instructional design (i.e., Kennedy et al., 2014; Marino et al., 2014; Okolo, Englert, Bouck, Heutsche, & Wang, 2011); therefore, these articles were not included in the final pool of articles. The randomly assigned members of the dyad coded UDL intervention studies as

[1] Total number of middle school hits was 20 without duplicates—total number with duplicates not listed in the database.

group comparison or single-subject research methods, including those in mixed-method studies, with 100% interrater agreement. The unassigned author randomly selected articles and agreed with dyad members' coding of articles. The final pool of articles resulted in five peer-reviewed articles (see Table 1).

**Results**

Findings from our literature review of K-12 intervention studies that incorporated UDL as an instructional design feature in group comparison, single-subject studies, or those in mixed-method studies are presented in three areas within the results section: (a) overview table (Table 1); (b) narrative summaries of group comparison, single-subject, or either within mixed methods studies; and (c) instructional design of implemented UDL principles related to the research questions. In totality, the three areas that comprise the results section capture the quality indicators of EBPs in special education. Our primary objective was to delineate why and how for the incorporation of UDL in the final pool of articles. We used the eight quality indicators for EBPs in special education as a general guide to report on the final pool of peer-reviewed articles but did not rate articles. The eight CEC (2014) quality indicators cover the following areas: (a) context and setting, (b) participants, (c) intervention agent, (d) description of practice, (e) implementation fidelity, (f) internal validity, (g) outcome measures, and (h) data analysis.

**Group Comparison Studies**

The purpose of the Proctor et al. (2009) 16-week quasi-experimental study was to investigate the effects of an Internet-based intervention designed to enhance vocabulary breadth and depth. The study focused on 240 fifth-grade English-speaking as well as Spanish-English speaking students; one hundred twenty-nine of these students received the intervention (Improving Comprehension Online [ICON]) while the remainder (*n* = 111) received the traditional literacy curriculum. Twelve teachers were assigned to the treatment group or the business-as-usual group. Through the ICON program, students in the intervention group read eight multimedia texts, which included additional instruction on 40 words (5 per text) along with support through reading strategies. The support provided by the program included human read-alouds of each text in both languages along with student work logs, multimedia glossaries, and pictures illustrating events from the texts. Furthermore, students receiving the intervention could access the texts and accompanying activities in Spanish as well as English. In order to complete the program, students receiving the intervention were not required to use any of the support features provided by the program; rather, they were free to use them as their individual abilities and needs rendered them necessary. Fidelity of implementation was not reported. The following dependent variables were used to measure the effects of the intervention:

The Gates McGinitie Reading Achievement Test (pre and post intervention), an experimenter-developed test of vocabulary breadth (post intervention) and test of vocabulary depth (post intervention).

Table 1

*K-12 Group Comparison, Single-Subject, or Mixed-Method Intervention Studies with Group Comparison That Incorporated UDL Principles*

| | | Participants | | | | |
|---|---|---|---|---|---|---|
| Study (year) / Research Design | Context / Setting | *N* | Grade/ Age | Population | Focus of IV | Focus of DVs |
| Dolan, Hall, Banerjee, Chun, and Strangman (2005)<br><br>/ Mixed-Methods: Quasi-experimental Group and Case Study/Survey | 1 suburban public high school | 9 | 11th & 12th | Classrooms (*n* = NR)<br>Ethnicity: NR<br>Gender: NR<br>SES: NR<br>Language status: NR<br>Disability status: 100%<br>with IEPs & LD classification | Paper-and-pencil testing accommodations vs. computer-based testing<br>with text-to-speech accommodations (two released NAEP multiple-choice test forms)<br>Reading composite scores<br>Investigated flexible and individualized assessment based on UDL principles<br>Treatment, *n* = 9<br>No Control, *n* = 0 | Usage tracking<br>Field observations<br>Student surveys<br>Structured interviews |
| Browder, Mims, Spooner, Ahlgrim-Delzell, and Lee (2009)<br><br>/ Single-subject | 1 special education classroom within a large southeastern urban school | 3 | 7, 7, & 10 years old | Classrooms (*n* = 1)<br>Ethnicity: NR<br>Gender: Male (*n* = 2), Female (*n* = 1)<br>SES: NR<br>Language status: NR | Three adapted elementary picture books that included each student's name as main | Task analysis (active responding and comprehension): Number of independent student |

| | | | | | | |
|---|---|---|---|---|---|---|
| (Multiple-probe across participants) | district in the United States | | | Disability status: 100% of students with IEPs & profound intellectual disabilities classification | character<br>Sensory materials and objects<br>Repeated storyline<br>Surprise element added near end of story | responses during the reading of the story (out of 16 possible steps) |
| Proctor et al. (2009)<br><br>/ Quasi-experimental Group | 4 schools within three northeastern school districts in the United States | 240 | 5th | Classrooms (*N* = 12)<br>Treatment, *n* = 6<br>Control, *n* = 6<br>Ethnicity: 49% Minority<br>Gender: Balanced<br>SES: Range 35.4% to 89.9%<br>Language status: 49% Spanish-English Bilinguals<br>Disability status: NR | Improving Comprehension Online (ICON):<br>An Internet delivered intervention designed to increase students' vocabulary depth and breadth<br>Treatment, *n* = 129<br>Control, *n* = 111 | Experimenter-Developed:<br>Measures of vocabulary, both for depth and breadth<br>Gates-McGinitie Reading Achievement Test (Forms S and T) |
| Coyne, Pisha, Dalton, Zeph, and Smith (2012)<br><br>/ Quasi-experimental Group | 7 schools within two New England states in the United States<br><br>State One:<br>Suburban school, | 16 | K-2nd | Classrooms (*N* = 9)<br>State One (separate classrooms):<br>Suburban treatment, *n* = 1; Suburban control, *n* = 1; Urban treatment, *n* = 1; | Literacy by Design (LBD):<br>A technologically-based UDL aligned approach to literacy instruction (Four scaffolded e-books: 2 animal | Woodcock Johnson Test of Achievement III (WJ-III):<br>Seven Subtests:<br>Letter-Word ID; Understanding Directions;<br>Passage |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *n* = 1; Urban school, *n* = 1<br><br>State Two:<br>Rural schools, *n* = 5 | | | Urban control, *n* = 1<br>State Two (inclusive classrooms):<br>Rural treatment, *n* = 3; Rural control, *n* = 2<br>Ethnicity: 12.5% Minority, total, and within each condition Gender: Treatment: Male, *n* = 5; Female, *n* = 3; Control, Male, *n* = 6; Female, *n* = 2<br>SES: NR<br>Language status: NR<br>Disability status: 100% with IEPs & significant intellectual disability classification | fantasies, 1 folktale, & 1 contemporary fiction)<br>Treatment, *n* = 8<br>Control, *n* = 8<br><br>Complementary software programs: WiggleWorks (1997) (supplemented LBD inventory); Island Adventure (1997) & Ocean Adventure (1997; interactive exercises and games for phonemic awareness and phonics) | Comprehension; Word Attack; Picture Vocabulary; Oral Comprehension; Sound Awareness<br>Two Composite scores: Listening Comprehension (Understanding Directions & Oral Comprehension); Basic Reading (Letter-Word ID & Word Attack)<br><br>Two Criterion-Referenced Tests: Letter Identification (Clay, 2000a); Concepts About Print (Clay, 2000b) |
| Rappolt-Schlichtmann et al. (2013) | 8 schools within a southeastern United States | 621 | 4th | Classrooms (*N* = 28)<br>Ethnicity: 35% Minority | Universally Designed for Learning Science Notebook (UDSN): | ASK Survey (Ferguson, Long, & Kennedy, 2009): |

| | | | | |
|---|---|---|---|---|
| / Mixed-Methods: Experimental Group, Student Focus Group, and Teacher Interviews | school district (District included rural, suburban, and urban schools) | Gender: NR (Focus groups: Boys, *n* = 42; Girls, *n* = 42)<br>SES: NR<br>Language status: NR<br>Disability status: 10% with IEPs or Section 504 | lower construct-irrelevant barriers; access to learning via contextual support; teacher prompts for feedback<br>Treatment (range in analyses), *n* = 346 to 411<br>Control, *n* = 168 | Content knowledge for magnetism & electricity<br>Experimenter-Developed: Motivation for science<br>Teacher Background<br>Academic progress (Northwest Evaluation Association, 2005): Reading & writing proficiency – computerized adaptive tests<br>UDSN electronic usage log |

*Note*. IV = independent variable; DVs = dependent variables; NR = not reported; Free/reduce-priced lunch was used as a proxy for socio-economic status (SES); IEPs = Individualized Education Programs; See reference lists of articles for citations of measures

The vocabulary breadth test was designed to measure students' knowledge of 20 of the 40 target words while the vocabulary depth test measured two areas of vocabulary depth: written definitions of the words and drawing and captioning of the words. Data analyses included one-way analyses of variance, hierarchical linear modeling. Major findings indicated enhanced breadth and depth of vocabulary for students who received the intervention in comparison to students in the control group who received the traditional literacy curriculum. Although the effects for vocabulary were quite impressive, the results for reading comprehension were not as significant. The findings seem to indicate support for vocabulary breadth and depth development through interventions aligned with certain UDL principles. Further research could substantiate this claim by expanding the number of students receiving this type of intervention.

The purpose of the Coyne, Pisha, Dalton, Zeph, and Smith (2012) seven-month quasi-experimental study was to investigate the effects of a technologically-based UDL instructional approach to literacy instruction (i.e., Literacy by Design [LBD]) on a group of students in grades K-2 with significant intellectual disabilities. A group of 16 students who met the criteria for selection (subaverage intellectual ability, identified need for additional reading instruction, could communicate verbally) were selected for the study. Eight students received reading instruction via LBD and the remaining eight received reading instruction, which did not include the technologically-based UDL program. The control and intervention group teachers attended seminars on best practices literacy instruction. A total of 9 teaches attended the seminars and 5 of them received formal instruction on how to implement LBD during literacy instruction. The independent variable of this study (i.e., the Literacy by Design program) included instructional strategies focusing on the following elements of literacy: reading comprehension, fluency, phonemic awareness, phonics, and vocabulary development. Furthermore, the program focused on reading for meaning and provided students with scaffolded UDL based e-books along with word recognition exercises. Fidelity of implementation was conducted on a weekly basis for LBD group and on a monthly basis for control groups. Data analyses included analysis of co-variance and multivariate analysis of variance. The pre- and posttest differences between the control and intervention group favored the intervention group (see Table 1 for the 11 quantitative reading and language tests). Overall, the intervention group's reading comprehension was significantly higher than the control group. The results of this study support the inclusion of the three UDL principles in the design of reading instruction for students with significant intellectual disabilities. However, additional studies with larger samples would be necessary to support these findings.

**Single-subject Study**

The purpose of the Browder, Mims, Spooner, Ahlgrim-Delzell, and Lee (2009) three and a half month single-subject study was to demonstrate a method for planning and implementing shared readings for three students with multiple disabilities by using a 16-step task analysis in conjunction with literacy team planning utilizing the principles of Universal Design for Learning (UDL). Students from a self-contained special education classroom were chosen for this multiple-probe design across participants study based on several criteria: (a) few or no responses during literacy

lessons, (b) inconsistent use of augmentative and alternative communication (AAC) devices, and (c) difficulty interpreting the students' intentionality of responses (e.g. movements or sounds). All three students had intellectual quotients below 20 and developmental levels below one year and were classified as intellectually disabled. These students were largely unresponsive to shared stories and participated in an intervention that consisted of three adapted, popular elementary storybooks. The intervention agent was a doctoral student in special education with seven years experience as a formerly licensed special educator of students with multiple disabilities. Two research-team members calculated procedural fidelity by scoring whether the interventionist presented the 16-step task. During story reading (out of a possible 16 responses as part of the task analysis), the dependent variable was the number of independent student responses. The interventionist recorded all responses and reactions (e.g. vocalizations, reaching for objects, opening closed eyes, etc.). The results of this study indicated that all students improved independent responses to adapted stories when the interventionist applied the principles of UDL to increase engagement and systematically taught the task analysis with prompting and feedback. These results support the literature base that shared stories lead to increased literacy engagement and promote communicative skills in children. While there is some research about the use of shared stories for students with severe intellectual disabilities, the focus of this study was a population with very limited communicative abilities. Thus, the learning targets were more foundational (e.g. choosing a book, focusing on story-based objects, etc.). Future research could investigate potential next steps to extend this population's access to literacy instruction.

**Mixed-Methods Studies Including Group Comparison Methods**

The purpose of the Dolan, Hall, Banerjee, Chun, and Strangman (2005) three-week mixed methods study was to investigate the potential of computer-based read-aloud testing accommodations for eleventh and twelfth grade students with learning disabilities compared to traditional paper-and-pencil testing accommodations. In this quasi-experimental group and case study/survey, 15 students were initially recommended by resource-room teachers and volunteered to be part of the study with nine students comprising the final sample of participants. All students had individualized education programs with a classification of Specific Learning Disability, and were either partially or fully included in general education classes. The students were administered two versions of equivalent U.S. history and civics exams from the National Assessment of Educational Progress on two separate days. One test was administered using traditional paper-and-pencil testing (PPT), while the other was administered using computer-based testing with text-to-speech (CBT-TTS). Teachers did not serve as intervention agents and fidelity of implementation was not recorded. Quantitative data analyses included statistical difference between means, including effect sizes. Qualitative analyses included student surveys, structured interviews, field observations, and usage tracking of test-taking strategies. Specifically, after completing exams, students completed a survey about their experiences with the CBT-TTS system, strategies in test-taking, and prior experience with computers, and testing accommodations. Six of the nine students

also participated in interviews and gave more extensive feedback and impressions about the use of the different testing accommodations. Findings indicated significant increase is students' scores on the CBT-TTS version when responding to longer passages (more than 100 words) compared to the PPT version. Student impressions overall of the CBT-TTS system were largely positive; researchers associated this reaction with the independence and flexibility provided while completing a test. Usage tracking indicated that students who self-reported feeling very comfortable using computers utilized many of the accommodations available in the CBT-TTS version, such as a "Review Later" flag. This study sought to extend the ways in which principles of UDL are applied to testing for students with learning disabilities, and findings suggest that use of CBT-TTS may be one effective way to improve accessibility for this population of students.

The purpose of the Rappolt-Schlichtmann et al. (2013) 8-10 week mixed-methods study was to investigate the effects of the web-based Universal Design for Learning Science Notebook (UDSN) intervention on student learning and teacher experiences using a fourth-grade web-based science notebook. For the randomized experimental group method, students were randomly assigned to either a treatment (UDSN) or control (traditional paper/pencil science notebook) group (see Table 1 for breakdown of sample). Teachers were randomly assigned to either treatment ($n$ = 11) or control ($n$ = 11) via a two-step process (i.e., matched-pairs by experience and classroom demographics) to deliver a research-based magnetism and electricity unit. Six students selected and counterbalanced by ability, disability status, and gender from each of the 14 treatment classrooms ($N$ = 84) participated in focus groups. All treatment interventionists participated in interviews. Focus groups and teacher interviews were conducted within two weeks of the completion of the intervention, using the same set of open-ended semi-structured questions. The UDSN independent variable included all the features of a traditional pencil and paper science notebook but differed in design by including a focus on (a) lowering construct irrelevant barriers, (b) embedding contextual supports to increase student access to learning, and (c) incorporating instructor prompts to support the teacher's role in providing student feedback. Fidelity of implementation was not reported. Quantitative data analyses were conducted with a multilevel modeling approach and qualitative analyses were used to determine perceptions through student focus groups and teacher interviews. Major findings indicated similar positive educational outcomes in science learning for students in the UDSN group, regardless of pretest reading and writing proficiency or motivation, compared to students in the pencil and paper group. Students who frequently used the embedded contextual supports and had teachers with more experience using science notebooks had greater positive outcomes. The implication for this study supports the integration of technology in content learning for diverse students when the design of the intervention includes features that lower construct-irrelevant barriers, support contextual learning, and align interventionists' skills (i.e., greater experience) with intervention content.

**Instructional Design of Implemented UDL Principles**

We provide a purpose for investigating each research question and delineate the instructional design of each

study associated with the respective research question. This section is different from the article summaries in that, we provide additional information and analyses on the incorporation of UDL principles for all the identified studies.

**Research Question 1: Do researchers indicate the purpose for using elements of the UDL educational framework?**

The purpose of the first research question (Do researchers indicate the purpose for using elements of the UDL educational framework?) was to investigate why researchers wanted to incorporate UDL principles in the instructional design of interventions.

**Proctor et al. (2009).** In this study, one emphasis was to utilize the UDL principles to undergird effective instructional design within the intervention with the desired effect of improving access to embedded vocabulary supports to increase the development of breadth and depth of knowledge.

**Coyne et al. (2012).** In this study, the authors indicated that a potentially promising approach to providing students with significant intellectual disabilities access to research-based literacy is the integration of UDL principles and technology. Of note, the authors emphasized scaffolding as being a key instructional design feature and a core feature of UDL.

**Browder et al. (2009).** In this study, the researchers capitalized on previous findings from a study that investigated the incorporation of UDL principles in lesson plans for preservice general education teachers (Spooner, Baker, Harris, Ahlgrim-Delzell, & Browder, 2007). Although the study was conducted in a special education classroom, the principles of UDL were discussed by both general and special education teachers in team planning meetings to ensure all students would benefit by participating fully in shared story readings.

**Dolan et al. (2005).** The authors in this study emphasized the issue of construct-irrelevant factors and wanted to increase the likelihood students would be able to access content and demonstrate their learning. Specifically, barriers tend to mask students' knowledge and skills and therefore affect how well teachers are able to design targeted instruction and/or reduce or eliminate barriers in curricula, materials, or instruction. All three UDL principles were addressed and provided students: (a) options to better understand representations (e.g., flexibility to read questions before passages, complete test in a preferred order, etc.); (b) options to express their knowledge and skills in multiple ways that physically and mentally challenged students in a just-right type of ways (e.g., promoted the development of learner strategies to complete tasks); and (c) options to recruit interests, sustain effort, and help students self-regulate their learning (e.g., promoted motivation).

**Rappolt-Schlichtmann et al. (2013).** UDL principles were incorporated into the overall design of the Universal Design for Learning Science Notebook to address the potential pitfalls in using science notebooks, which were expressed as being traditionally and primarily used in a mechanical way to record data, procedures, or definitions. The authors indicated that the term universal does not equate to a one-size-fits-all approach to the conceptualization and design of curricula and materials for the widest range of learners and their preferences. UDL was described as a "transdisciplinary framework that facilitates interaction between researchers from the learning sciences and professionals within education" and can be used to innovatively

work towards solutions and "to reach a holistic understanding" (Rappolt-Schlichtmann, 2013, p. 1211).

**Research Question 2: How do researchers incorporate UDL principles in interventions to increase access for learners?**

The purpose of research question two (How do researchers incorporate UDL principles in interventions to increase access for learners?) was to investigate how researchers conceptualized and implemented UDL principles into interventions.

**Proctor et al. (2009).** While testing the effects of an Internet-based strategic digital reading environment (i.e., Improving Comprehension Online [ICON]), the researchers attempted to complement research-based strategies for improving vocabulary development with native-language options in a universally designed digital reading program. The incorporation of UDL principles were noted as (a) Spanish and English, images, audio-recorded and written language for representation (Principle 1); (b) Spanish and English, audio-recorded, and written language for action and expression (Principle 2); and (c) choice, feedback, and multimedia for engagement (Principle 3).

**Coyne et al. (2012).** The Literacy by Design digital e-books included embedded supports based on the UDL principles. A detailed list of the types of supports is noted in the Coyne et al. (2012, p. 166) study. For example, one feature for multiple means of representation (Principle 1) is video and photo essays to build background information. Varied response options (e.g., visual multiple choice, sentence starters, etc.) may represent multiple means of action and expression (Principle 2), and multiple means of engagement (Principle 3) may include the option to decide when to click on embedded supports (e.g., navigation).

**Browder et al. (2009).** Although all aspects of the study address all three UDL principles, the focus for implementing the principles into the intervention emphasized student engagement. During research team meetings, questions revolved around customizing learner experiences with the shared storybooks so that there was a match between each of the three principles with learner needs. In other words, the research team members addressed learner variability. Example questions listed for the principles representation, action and expression, and engagement were, respectively: (a) is there a better way to present this opportunity to respond so it is clearer to the student (Principle 1), (b) is there an alternative way the student could respond (Principle 2), and (c) What prompt could be used to get the student to make the response? How should it be faded (Principle 3)?

**Dolan et al. (2005).** Conceptualized beyond traditional media and instructional approaches, the design of the assessment tool (i.e., computer-based testing text-to-speech [CBT-TTS]) in this study included flexibility and customization options for assessment tasks. Students engaged with the testing environment on their own terms. In other words, the features provided multiple, flexible options for representation, action and expression, and engagement (e.g., individually select words, sentences, or passages to read and reread; mark individual questions for review; view progress, etc.). These types of embedded features do not affect the construct of the assessment and enhance students' interactions in the assessment environment.

**Rappolt-Schlichtmann et al. (2013).** The authors refined the features of their web-based science notebook through design-based methodology and embedded

flexibility beyond that available to students in traditional paper-and-pencil science notebooks. Specifically, the authors established learning experiences that "allow for the creation of accessible, highly effective apprenticeship environments where students are actively guided in the process of constructing meaning through the provision of just-in-time feedback and contextual supports that can be gradually withdrawn as student expertise increases" (p. 1211).

**Research Question 3: Do researchers indicate or measure whether they believe UDL principles contributed to treatment effects?**

The purpose of the third research question (Do researchers indicate or measure whether they believe UDL principles contributed to treatment effects?) was to investigate whether researchers were able determine any treatment effects from incorporating UDL principles into interventions. This research question was less about the efficacy of UDL principles in interventions and more about a cursory review of researchers' possible beliefs for incorporating UDL principles.

**Proctor et al. (2009).** The authors noted that there were large and significant effects after taking variance into consideration, but these effects are inconclusive and require additional investigations. In fact, Proctor et al.'s (2009) findings are consistent with other research findings on the possible efficacy of UDL principles. The authors did not use measures conceptualized with the UDL principles. The authors expressed caution, even thought there were encouraging findings.

**Coyne et al. (2012).** In this study, no direct tests were used to measure UDL treatment effects. However, the authors do provide commentary on their beliefs that embedded UDL principles in LBD show promise for improving reading comprehension. In studies that incorporated UDL principles, regardless of research method, one of the interesting facts is the scope and depth of use of the UDL principles. Unfortunately, this liberal use of the principles may indeed result in positive effects but makes it difficult for researchers to parse the contributions of the various aspects of the UDL frameworks (i.e., Which one was it? Was it a principle, guideline, or checkpoint that positively contributed to or more that than one that made causation that much more difficult to pinpoint in treatment effects?).

**Browder et al. (2009).** In terms of procedural fidelity, there was 100% agreement for all steps of the 16-step task analysis with the three UDL principles during team planning meetings. This indicated that all research team members similarly conceptualized the implementation of UDL principles. In addition, when UDL principles were included as an instructional design feature in the intervention to increase engagement, all students increased independent responses.

**Dolan et al. (2005).** Overall, quantitative and qualitative findings indicated that there are benefits to incorporating UDL principles in a computer-based test text-to-speech (CBT-TTS) tool compared to traditional paper-and-pencil test (PPT) version. The most noticeable quantitative finding was statistically significant differences favoring the CBT-TTS condition to that of PPT condition for passages that were longer than 100 words. Qualitatively, students favored TTS features and the authors noted it was difficult to determine the specific contributions of navigation and accessibility features, and TTS effects may be attributable to it being a novelty.

**Rappolt-Schlichtmann et al. (2013).** Quantitative and qualitative data supported the authors' commentaries for overall UDL effects for students and teachers. For example, students who participated in the UDL treatment group had minimal exposure to UDL principles (i.e., an average of one time per week across 10 weeks) but demonstrated better outcomes than the paper-and-pencil group. Even though the researchers were unable to disaggregate which features of the UDL web-based science notebook primarily contributed to treatment effects, commentaries focused on the inclusion of options and contextual supports being available for all students being the likely influences for treatment outcomes. An emphasis on reducing construct-irrelevant barriers (e.g., accessing a keyboard to mitigate handwriting difficulties or recording data with audio to mitigate low reading abilities) and embedding contextual supports enhanced the level of challenge for students while engaging students with content (e.g., UDL Principle 3). Future research may benefit from an investigation of the identified themes competence and autonomy for both students and teachers as students were more apt to demonstrate their knowledge and skills and teachers were able to provide critical feedback. Coincidentally, teachers with higher levels of expertise benefited students.

**Discussion**

The findings from this literature review, albeit a small body of evidence, support the incorporation of UDL as an instructional design feature in interventions. Although both researchers and educators must move forward with caution in how they plan and execute the implementation of the UDL framework (i.e., principles, guidelines, and checkpoints; Edyburn, 2010; Kennedy et al., 2014; McGuire et al., 2006), there is an increased likelihood that construct-irrelevant barriers in curricula and instruction can be reduced or eliminated when UDL principles are incorporated in the design of interventions.

For the first research question (Do researchers indicate the purpose for using elements of the UDL educational framework?), researchers from all five studies in the literature review consistently highlighted issues related to access and participation, which were often associated with learner variability, flexible options, integration of the principles with complementary variables (e.g., technology), and a focus on construct relevant factors in instruction and assessment to engage students with tasks. These consistencies undergird effective and efficient instructional design and emphasize the term universal as not equating to a one-size-fits-all approach, but a conceptual shift to meeting the curricular and instructional needs of the widest range of learners. Interestingly, one study included highlights on the benefits of establishing blended research planning teams comprised of general and special education teachers to ensure the full participation of learners in learning environments (Browder et al., 2009).

The second research question (How do researchers incorporate UDL principles in interventions to increase access for learners?) overlapped in meaning with key terms from research question one; the terms encountered in answering research question two included complementary, embedded supports/flexibility, customization (i.e., addressing variability), and engagement. When attempting to implement UDL, researchers overwhelmingly incorporated as many of the guidelines and checkpoints as possible

from the three principles, but tended to not overtly indicate which guidelines and/or checkpoints they were addressing in the principles to increase access to the general education curriculum for students with disabilities and other diverse learners.

The last research question (Do researchers indicate or measure whether they believe UDL principles contributed to treatment effects?) was underemphasized as a whole in the findings of this literature review. Researchers seemed to primarily focus on instructional design and less on measuring the effects of instructional designs that incorporated UDL principles. In general, it was difficult to determine the specific contributions of UDL principles, the contextual or embedded supports, the number and frequency of use of options, and the scope and depth of the principles. These hard-to-pinpoint areas made conclusions difficult to determine.

**Limitations**

Although we reviewed a recent literature review on universal design educational models that included UDL (Rao et al., 2014), we did not conduct a hand-search of articles. We also did not include pre-kindergarten as one of our search terms. It is possible that primary grades could have been included as a package in some studies, thereby, increasing the possibility of us not identifying and reviewing those types of studies with our search criteria. Another limitation is participant variability (i.e., age, knowledge, backgrounds, skills, etc.), which on one hand should not be of significant concern since the UDL framework was conceptualized to address learner variability. On the other hand, with such a small final pool of EBP articles, finding overlaps and convergence in the literature was difficult to determine. Last, we did not include any studies of researchers who did not utilized group comparison or single-subject research methods. We recognize that valuable information may have been overlooked in other empirical studies.

**Implications for Future Research**

Five areas related to specificity should be considered. Researchers should describe the learning environments (i.e., context and setting) and participants in detail. Detailed descriptions would assist other researchers and educators to understand variables associated with linking principles, guidelines, or checkpoints with learner characteristics. Third, with a detailed description of learners, researchers would be able to customize individual guidelines and checkpoints, thereby, refining and narrowing the possible variables associated with treatment effects. Fourth, using the EBPs quality indicators in special education as signposts to review articles may be insufficient. Future research studies may need to rate group comparison and single-subject research methods to provide insight on whether causation can be reasonably inferred. If studies are rated as evidence-based practices, then there is an increased likelihood that the connections among the UDL principles, guidelines, and checkpoints might influence treatment effects to a greater degree. Last, researchers of future investigations should consider measuring isolated aspects of the UDL framework. In other words, for every guideline or checkpoint embedded into the design of interventions, researchers should also consider assessing the possible effects (e.g., disentangling embedded technological features used/not used).

**Conclusion**

UDL is an educational framework that has promise. The findings from this literature review support the continued use of the framework to reduce or eliminate construct-irrelevant factors in curricula, assessments, instructional methods, and materials. Although CAST was established in 1984, the passing of the 2008 Higher Education Opportunity Act and the 2010 National Educational Technology Plan has seemingly invigorated the interest of researchers and educators to incorporate UDL in their research and school-based practices.

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