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Lisa Finnegan  
*University of Central Florida*



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EXAMINING THE EFFECT OF THE UNIVERSAL DESIGN FOR LEARNING-  
EXPRESSION PRINCIPLE ON STUDENTS WITH LEARNING DISABILITIES IN SCIENCE

by

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A dissertation submitted in partial fulfillment of the requirements  
for the degree of Doctor of Philosophy  
in the College of Education and Human Performance  
at the University of Central Florida  
Orlando, Florida

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2013

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## ABSTRACT

The significance of students being able to express and demonstrate their knowledge and understanding in all content areas has always been important especially in the sciences. Students under the Next Generation Science Standards will be required to participate in science discourse through a variety of approaches. This study examined student engagement and student demonstration of content knowledge in inclusive science classrooms through a quasi-experimental research design which included four case study participants with a learning disability. The researcher also evaluated student content knowledge through the implementation of Universal Design for Learning-Expression (UDL-E) through a non-replicated control group design. Data were collected through a variety of sources including: researcher observations, review of student academic records, interviews, surveys, UDL-E products, and pre-test and posttest scores. Researcher observations spanned over a 10 week period and were coded and analyzed quantitatively. Findings from a Repeated ANOVA demonstrated no statistical significance, however based on interviews with students; findings show that the students did enjoy exploring the opportunity to express their knowledge using the Expression principle of Universal Design for Learning. Student time-on-task did remain equally as high during UDL-E and students' inattentive behaviors decreased.

This dissertation is dedicated to my sons, Riley and Bennett Finnegan. It is never too late to accomplish anything you set your mind to.

## ACKNOWLEDGMENTS

In the words of Buddha, “I never see what has been done; I only see what remains to be done”. While much work has gone into this research product, it is just the beginning of what I hope to be my life’s work and a product that demonstrates the support and devotion in the preparation of the teaching that my committee lives every day. My most humble and sincere thank you and acknowledgement of great respect goes to Dr. Lisa Dieker, Dr. Wilfred Wienke, Dr. Rebecca Hines, and Dr. Robert Everett. Without your guidance, support, direction, and inspiration this would not have come to fruition nor would I truly come to understand the knowledge and experience I have is something to be shared with young educators. Dr. Dieker, additional thanks and appreciation are yours for the hours of mentorship and support you have provided me. To know you as a professional is as great an honor as your friendship. My achievement would not have been attained without the support of Donna Leinsing, Director of the Toni Jennings Exceptional Education Institute and the staff and support system that Toni Jennings Exceptional Educational Institute offers. A special thank you to Linda Alexander who made course registration and comp exams survivable. Dr. Larry Wexler and Dr. Renee Bradley, thank you for the opportunity to witness the massive efforts that you and the staff at OSEP play in the workings of the implementation of the educational policies that are established for students with special needs and for all students. Fr. John Bluett, thank you for your prayers and steadfast faith in my ability to reach this goal even when it seemed a daunting task. Special thanks go to Katie Miller and Dennis Garland, fellow cohort members and adopted family members, who without

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## LIST OF ACRONYMS/ABBREVIATIONS

CBA- Curriculum-based Assessment

FCAT-Florida Comprehensive Assessment Test

EBS- Eyes on the board or screen

ESEA-Elementary and Secondary Education Act

ETS- Eyes on Teacher or Student

IDEA-Individuals with Disabilities Education Act

LBD-Literacy Based Design

LD-Learning Disability

LRE-Least Restrictive Environment

LRT- Looking or Reading Text

MSLQ- Motivated Strategies for Learning Questionnaire

NAEP-National Assessment of Educational Progress

NCLB-No Child Left Behind

PI- Peer Interaction

SD-Students with Disabilities

SDE- Student is disengaged

SGA- Student or Group Activity

SI- Student is inattentive

SR- Student Response

SW- Student Writing

TOT-Time-on-Task

UDL-Universal Design for Learning

UDL-E-Universal Design for Learning-Expression



## CHAPTER ONE: INTRODUCTION

### Background: Need for the Study

Over 50% of students ages 6 through 21 served under the Individuals with Disabilities Education Act (IDEA), Part B, today spend 80% of their day in the general education classroom (USDOE, 2011). Students with learning disabilities (LD) make up one-third of the increasing number of students with disabilities currently being educated in the general classroom (USDOE, 2011). At the same time, 47 states are moving forward with developing and implementing curriculum resources that align with the Common Core State Standards as well as determining the types of assessments that will measure student understanding of these more complex standards. This chapter provides an introduction to existing research and issues that have led to the need for this study. Research questions will be presented, as well as an overview of the procedures and research design. Finally, terminology used in this study will be defined for clarification.

Given that students with disabilities (SD) are in the general education setting the majority of their academic day, their inclusion should be about learning (Kaufman, Nelson, Simpson, & Mock, 2011) by finding ways to support all learners through principles such as Universal Design for Learning (UDL) (Meyer & Rose, 2005; Rose & Meyer, 2006). However, with the necessities of inclusion arises the need for accountability, which typically in the United States (U.S.) translates into local and state assessments. Under the Individuals with Disabilities Education Improvement Act (IDEA) 2004 and the No Child Left Behind Act (NCLB) of 2001, SD are required to participate in their district and state accountability assessments.

Despite the push for inclusion and accountability of students with LD, of considerable concern today at the local, state, and national levels is the status of the unmet educational goals set by President George H.W. Bush and the nation's governors in the year 2000 of NCLB. Specifically, the four-year high school graduation rate remains stagnant at about 70%; the achievement gap between minority and White students in reading and math is larger than ever; and U.S. performance on international tests has continued to decline, with the U.S. ranking 22nd in science on the 2009 Programme in International Student Assessment (PISA) (The Organisation for Economic Cooperation and Development (OECD), 2013) tests (Darling-Hammond, 2006, 2011; Fleischman, Hopstock, Pelczar, & Shelley, 2010; Harris, Schumaker, & Deshler, 2011; Kennedy & Deshler, 2010; Schumaker et al., 2002). Furthermore, between 2009 and 2011, students have shown little or no improvement in science on the National Assessment of Educational Progress (NAEP), an important source of information on the performance of U.S. students in reading, mathematics, science, U.S. history, writing, and other subjects (USDOE, 2012a). All of these areas are issues of concern for U.S. educational leaders, but specific purpose to this study is the need to address the gap in science education and specifically the assessment outcomes in this content area for students with LD.

#### Statement of the Problem

The state of science education for all learners is currently an issue of great challenge. Current data from 2011 shows that 62% of students taking the NAEP science assessment performed at a Basic level (34%) or Proficient level (28%), while only 2% scored at an advanced level, leaving 36% of students nationwide performing below the Basic level (USDOE, 2012a). Students with disabilities average scores (124 points) were 36 points below students without

disabilities (155 points). While in the state of Florida, student performance on the Florida Comprehensive Assessment Test (FCAT), which tests students on the current Next Generation Sunshine State Standards, remained stagnant from 2011 to 2012 (Florida Department of Education (FLDOE), 2012). Current FCAT science scores for eighth-grade show that 46% of students taking the FCAT scored at a proficient level of three or above leaving 54% of eighth-grade students below a proficient level (FLDOE, 2012). Students averaged 9 out of 15 possible points on all three science content areas: Physical, Life, and Earth and Space Science while also scoring only an average score of 6 out of 11 possible points on the Nature of Science concepts (FL DOE, 2012). Given that a greater categorical range of students with disabilities are included in high stakes national and state assessments, these dismal outcomes will not change without a change in the approach to science education. The Next Generation Science Standards (NGSS) require students to think differently and learn deeply critical science content (Achieve, Inc., 2013). This level of thinking for students with disabilities may need to be paired with current and emerging practices presented through the concept of UDL principles, of which one aspect focuses on students expressing their knowledge and affirming their understanding of the science content in multiple ways. Universally designed assessments that allow for knowledge expression, although a complex potential resolution, support the learning needs of the individual, particularly the individual student with LD, who may not be fully able to demonstrate their knowledge on a standard assessment due to barriers in test media, meaning, paper and pencil (Rose, Meyer, Strangman, & Rappolt, 2002).

Since students with disabilities continue to perform well below the average of students without disabilities the need for this population of students to have opportunities to participate in

additional courses in the sciences is critical. Currently, only 12% of students with disabilities make up the 30% of 2009 graduates who took biology, chemistry, and physics in high school (USDOE, 2012a). According to Scruggs, Mastropieri, Berkely, and Graetz (2010) access to content area curriculum improves students' knowledge of human society, the world, and how it works. Students can assimilate the knowledge they learn from content area curriculum and apply it to their aspirations both academically and as citizens. However, if students with LD experience difficulty in assimilating content area curriculum, frustration can result along with academic failure and the loss of opportunities to access additional content area curriculum and future fields of study (Scruggs et al., 2010).

In order to remain competitive in the global economy, have a better educated citizenry, and attend to a delayed agenda for social justice , a far larger proportion of American students need to receive the substantive, challenging education that once was reserved for those bound for college and challenging careers. (Lynch & Taymans, 2004, p. 21)

The need to be college and career ready requires students to be prepared for the “information-age workplace,” have strong literacy skills, as well as, mathematics and scientific reasoning skills (Lynch & Taymans, 2004, p. 21).

The current influence of standards-based learning and high-stakes assessment forges the mile-wide, inch-deep textbook-based approach to teaching and learning that indications suggest students with disabilities may struggle with, particularly with text comprehension and the independent study strategies that text-based learning approaches use (Scruggs & Mastropieri, 1994a; Scruggs, Mastropieri, & Okolo, 2008). Yet, students with LD could ultimately benefit from hands-on approaches such as those found in a two-year qualitative study where students

expressed their enjoyment in the science activities and the opportunities to interact with their peers. Additionally, Scruggs, Mastropieri, and Wolfe (1995) adjusted instruction in activity-based science classrooms for students with more significant cognitive disabilities when they displayed difficulty with some of the aspects of activity-based learning such as independent reasoning. Scruggs and Mastropieri (2000, 2007) also have reported that mnemonic strategies have been extremely effective in assisting students with LD to recall science content. Summarization strategies (Nelson, Smith, & Dodd, 1992), differentiating main idea, list, and sequence text structures (Bakken, Mastropieri, & Scruggs, 1997), and text enhancements such as graphic organizers (Bergerud, Lovitt, & Horton, 1988; Lovitt, Rudsit, Jenkins, Pious, & Benedetti, 1986; Scruggs et al., 2010) also have been used as approaches to assist students with LD with content comprehension.

A two year study of inclusive classrooms identified seven variables that promote effective inclusive education in science. Outstanding inclusive classrooms include an open and accepting environment; administrative support for inclusion; highly effective general education and special education teachers (Smith, Robb, West, & Tyler, 2010); peer mediation and cooperative learning; appropriate interactive, hands-on curriculum; and specific disability instructional strategies (Scruggs & Mastropieri, 1994b). Differentiating curriculum enhancements such as class-wide peer tutoring can maximize learner engagement and promote learning at appropriate levels to assist students with LD in gaining content understanding (Mastropieri et al., 2006; Scruggs et al., 2008) and ultimately improve student outcomes.

The percentage of eighth-grade students identified as students with disabilities excluded in the NAEP science was significantly small, ranging from 1% to 2% for most states, indicating a

high percentage of students with disabilities participating in national assessments

([http://nationsreportcard.gov/science\\_2011/exclusion.asp?tab\\_id=tab2&subtab\\_id=Tab\\_1#chart](http://nationsreportcard.gov/science_2011/exclusion.asp?tab_id=tab2&subtab_id=Tab_1#chart)).

Consensus has not been reached on best practices for assessment and accommodations for students with LD when considering state and national assessments, however due to legislative requirements students with LD are a part of the accountability system (Fiester, 2012). Fiester (2012) contended that “technology can influence the educational outcomes of children with LD by creating a barrier-free learning environment (as does UDL) and by enabling students to bypass or compensate for their disabilities (as assistive technology does)” (p. 9). Wissick and Gardner (2011) maintained that technology can assist teachers in differentiating instruction to meet the needs of all learners. As early as the 1980s, Ann Meyer and David Rose (2005), who lead the Center for Applied Special Technology (CAST) began exploring how technologies could be used to expand the educational opportunities for learners of all levels of ability. Meyer and Rose (2005) explained that UDL was based on over two decades of research on the nature of learning as well as the capacities of new media, effective teaching practices, and assessments that are based on high standards but are fair while accurately measuring student learning. “UDL’s basic premise is that barriers to learning occur in the interaction with the curriculum—they are not inherently solely in the capacities of the learner” (Meyer & Rose, 2005, p. 20).

A similar premise could be made regarding assessments. Most traditional assessments maintain “print-based assumptions and practices” and often tend to measure things teachers are not trying to measure such as decoding skills leading to inaccurate inferences about student content understanding (Kennedy & Deshler, 2010; Meyer & Rose, 2005; Rose & Gravel, 2009). The use of UDL principles have

found traction nationally, and its premise that all barriers to learning should be absent from the get-go—rather than relying on accommodations to level the playing field—provides a framework for changing the learning environment in a very fundamental and positive way. (Fiester, 2012, p. 8).

The UDL principle framework promotes evidence-based, promising and innovative practices that enhance the learning environment and engage learners. King-Sears and Mooney (2004) stated that

teachers who develop and use the design elements of UDL are more likely to reach and teach more learners who have varied learning abilities and that UDL elements are essential for some students but also may be beneficial for others. (p. 231)

#### Purpose of the Study

The purpose of this study was to evaluate learner engagement and understanding of content in inclusive science classrooms, as well as, the impact UDL-E has on student curriculum-based assessment (CBA) outcomes and engagement in demonstrating science content understanding through the use of UDL-E in a Performance-based assessment (PBA) type product. This study evaluated student expression of science content understanding and transfer of knowledge to a CBA.

Upon acceptance by the researcher's university Institutional Review Board (IRB) (see Appendix A), permission to conduct the research was requested from the local school district (see Appendix B), the school principal (see Appendix C), the teacher (see Appendix D) and permission for participation was requested from the students (Appendix E). As outlined in Table 1, participants in this study were comprised of students from four inclusive science classes in this

school and were grouped into two participant groups (Group A and Group B) taught by the same science teacher. Group A consisted of students in Period 2 (a.m.) and Period 5 (p.m.) and Group B consisted of the students in Period 3 (a.m.) and Period 7 (p.m.). This study required a research procedural checklist (see Appendix F) and procedural timeline (see Appendix G) which included four physical science content lessons. All participants in this study took a CBA (see Appendix H) pretest for each content lesson prior to content instruction beginning. Additionally, a CBA posttest (same test as the pretest) was also administered for each of the four content lessons when instruction for the lesson was completed.

Participants in each group used the UDL-E intervention as an opportunity to express their science content learning in a PBA product for one lesson while the other group acted as a control during that lesson. The PBA product was evaluated using a Science Vocabulary Checklist (see Appendix I) by the researcher and an inter-rater for the number of correct science words expressed. No intervention was done to either Group A or Group B during Lesson 1 and Lesson 4, however students in both Group A and Group B took the Motivated Strategies Learner Questionnaire (MSLQ) learner engagement survey (see Appendix J) after Lesson 1 posttest. In Lesson 2, Group A received the UDL-E intervention while Group B acted as a control. In Lesson 3, Group B received the UDL-E intervention and Group A acted as a control. During Lesson 2 and Lesson 3, prior to the UDL-E intervention, students in both Groups A and Group B took a CBA pretest. Students viewed the UDL-E tool tutorials and completed a UDL-E Tool Evaluation Form (see Appendix K) on their comfort level with the web-based tools for the intervention phase. Students in the intervention received a copy of the directions for the UDL-E intervention procedure (see Appendix M).



In addition to the UDL-E intervention, the researcher observed four case study participants, one participant from each class. The participants were students with LD who also had the lowest reading score of all the students in each class. Detailed observations were made for Time on Task (TOT) (Appendix L) during science instruction and lab. The TOT data were coded for various on-task and off-task sub-behaviors (Appendix L).

After the Lesson 4 posttest, students were randomly selected from both Groups A and B to participate in a focus group interview along with Case study participant to share their thoughts and perceptions about the UDL-E tools and UDL-E PBA product.

**Table 1: Research Interventions and Activities for Lessons of Study for Group A and Group B**

	Group A	Group B
Lesson 1	CBA pretest	CBA pretest
	TOT observation	TOT observation
	CBA posttest	CBA posttest
	Student Engagement Survey	Student Engagement Survey
Lesson 2	CBA pretest	CBA pretest
	TOT Observations	TOT Observations
	UDL-E Intervention & TOT observation during UDL-E PBA product	CBA posttest
	CBA posttest	
Lesson 3	CBA pretest	CBA pretest
	TOT Observation	TOT Observations
	CBA posttest	UDL-E Intervention & TOT observation during UDL-E PBA product
		CBA posttest
Lesson 4	CBA pretest	CBA pretest
	CBA posttest	CBA posttest
	Focus Group Interviews	Focus Group Interviews

## Research Questions

The questions addressed in the study are as follows:

1. How do students with LD demonstrate learner attention or engagement during instruction in inclusive science classrooms?
2. How do students with LD demonstrate their understanding of the material learned in science in inclusive science classrooms?
3. Does the implementation of UDL- E principle impact student understanding of science content as measured by the number of correct vocabulary words used from the lesson?
4. Does the use of UDL-E principle impact the curriculum based assessment outcomes for students with LD in science?

## Research Design

The research for this study was conducted using mixed methods with a focus on a quasi-experimental replicated nonequivalent control group design, multiple case studies of students with LD and focus group discussions all grounded in UDL-E interventions. A nonequivalent control group design was used to determine the outcome of the implementation of the UDL-E interventions. Multiple case studies were conducted to enhance the “empirical inquiry that investigates a contemporary phenomenon in-depth and within its real-life context” (Yin, 2009, p. 18). These cases were chosen to look at the specific behaviors and outcomes for students with LD that were within each of the classes in the replicated nonequivalent control group design. Case studies help to explain presumed causal links in real-life interventions, describe

interventions in a real-life context, illustrate specific topics, or can be used to clarify situations where an intervention may not have clear outcomes (Yin, 2009). For this study, looking at the specific approach to UDL-E and the impact on individual cases within each classroom will further enhance the overall study outcomes. One benefit of using multiple case studies is the “possibility of direct replication” when using similar cases (Yin, 2009, p. 61). A nonequivalent control group design requires that a pretest and a posttest be given to both an experimental group and a control group; both of which do not have pre-experimental sampling (Campbell & Stanley, 1963). The Motivated Strategies for Learning Questionnaire (MSLQ) is a self-reporting survey on student engagement used to measure motivational beliefs and self-regulated learning strategies developed and validated by researchers at the University of Michigan. Case study observations and focus group interviews (see Appendix N) were transcribed, and evaluated for themes to connect and further support the results of this study.

#### Independent Variables

The independent variable in this study was the implementation of UDL-E tools for students’ expression of knowledge.

#### Dependent Variables

The dependent variables in this study consist of:

- a. CBA Pretest and posttest scores
- b. UDL-E PBA product (correct science word record)
- c. MSLQ scores
- d. Time-on-task (TOT) Record form for Case Study observations

## Reliability

Test scores and survey scores were maintained anonymously for each participant throughout the study (Brantlinger, Jimenez, Klingner, Pugach, Richardson, 2005; Gast, 2010; Kazdin, 1982). Students received the same CBA test for the CBA pretest and CBA posttest. The researcher and an inter-observer attained an 83% agreement on 25% of the observations completed in the classroom. Inter-rater agreement on 30% of the coded observations was at 91%. Thirty percent of UDL-E PBA products were evaluated by an inter-rater with 80 % agreement. Qualitative data from the focus group interviews were coded by themes. Inter-rater agreement of the coded data was completed through point-by-point or response-by-response basis (Kazdin, 1982).

## Validity

Previously validated instruments were used in all phases of this study. The CBA pretest and posttest were created with direction of the teacher using the district approved validated curriculum assessments. The UDL-E PBA product form used was created from a list of the science vocabulary words and definitions in the curriculum resources and student textbook materials. The CBA pretest and posttest and the vocabulary word form demonstrated face validity and content validity as the instruments demonstrated a high degree of measuring what they appear to assess (Slavin, 2007), which is science content knowledge and science vocabulary.

The MSLQ survey was used to evaluate learner motivation and engagement during UDL-E intervention. The MSLQ was validated using a sample of 173 seventh grade students across 15 classrooms. The Middle School MSLQ contains five subscales, two of which are relevant for engagement. The MSLQ reported Cronbach's alphas of .83-.88 for cognitive strategy use scale and .63-.73 for self-regulation scale (Pintrich & DeGroot, 1990). Additionally, construct validity is reported from correlational studies and criterion-related validity was also demonstrated through correlations of strategy use and self-regulation with indicators of academic performance (Pintrich & DeGroot, 1990). Predictive validity or "the degree to which the scores on a scale or test predict later behavior or other scores" (Slavin, 2007, p. 182) could be assumed through the effect between the UDL-E PBA product and the CBA score, as well as, TOT report forms as a part of engagement.

#### Treatment Fidelity

Treatment fidelity was maximized through the cross-over or replicated treatment design due to the counterbalancing of the treatment groups. The researcher utilized a research procedure checklist (see Appendix F) to ensure that the same procedures are used for each phase of the study. Statistical power was maximized in a within-subjects design allowing for fewer needed participants.

#### Definitions of Terms

For the purpose of this study the following terms are defined as:

Universal Design: 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 interoperative with assistive technologies” (Assistive Technology Act of 1998).

Universal Design for Learning Framework: “set of principles for curriculum development that gives all individuals equal opportunities to learn. UDL provides a blueprint for creating instructional goals, methods, materials, and assessments that work for everyone--not a single, one-size-fits-all solution but rather flexible approaches that can be customized and adjusted for individual needs” (CAST, Inc., 2012b)

Universal Design for Learning-Action & Expression (UDL-A&E) Principle: based on the philosophy that “learners differ in the ways that they can navigate a learning environment and express what they know” (CAST, Inc., 2012c).

Universal Design for Learning- Expression (UDL-E): focuses on learners expressing or sharing what they know by being provided options from which they can choose to express themselves such as written work or explanation, audio-recorded response, visually recorded or downloaded image and explanation, drawn diagrams, songs or other alternative ways or approaches to sharing their knowledge (CAST, Inc., 2012c)

Performance-based Assessment (PBA): Tasks that measure how students construct and apply their understanding about content material

Performance-based Assessment (PBA) product: A model or product that the student creates that reflects the knowledge of the all of the vocabulary words from a lesson of study.

Vocabulary Usage: Science vocabulary words are used and explained accurately.

**Inclusive Setting:** Teaching and learning classroom environment which includes students with and without disabilities.

**High Tech Tools:** Computer-based software programs that allow students to upload video, diagrams, and audio/video record their responses to demonstrate science knowledge such as VoiceThread, Voki, etc.

**Mid-Tech Tools:** Computer-based software programs that allow students to build concept maps and presentations to demonstrate science knowledge such as PowerPoint.

**No Tech Tools:** Paper and pencil, poster type approaches used to demonstrate science knowledge.

**Web-based Tools:** Technological tools that are accessible using the World Wide Web.

**Students with Specific Learning Disability/Learning Disabilities (LD):** Students who do not achieve adequately for their age or to meet State-approved grade-level standards in one or more of the following areas, when provided with learning experiences and instruction appropriate for their age or State-approved grade--level standards: oral expression, listening comprehension, written expression, basic reading skills, Reading fluency skills, reading comprehension, mathematics calculation, or mathematics problem solving (IDEA, 2004).

**Time-on-task (TOT):** The time that a student is fully engaged in an activity whereby they are writing, talking, looking, and participating in the designated activity being observed for on-task behavior and not an unrelated activity.

**Interobserver:** An observer in addition to the researcher who objectively assists in the validity of the data.



Interrater: A research assistant in addition to the researcher who objectively assists in the validity of the data through evaluating data based on strict guidelines for consistency.

## CHAPTER TWO: LITERATURE REVIEW

### Chapter Overview

#### Introduction

Approximately, 54% of students, ages 6 through 21 served under the Individuals with Disabilities Education Act (IDEA, 2004) Part B, spend 80% of their day in the general education classroom (USDOE, 2011). Students with autism, other health impairment, traumatic brain injury, emotional disturbances, hearing impairment, and learning disabilities (LD) represent the largest increases in disability categories of students educated in the general education classroom, with LD alone representing one-third of this increase (USDOE/NAEP, 2011). As the nation moves toward developing and implementing curriculum resources that align with the Common Core State Standards, the need to include the framework for 21<sup>st</sup> century skills within the teaching and learning environment, particularly within assessment, becomes even more critical. Universal Design for Learning (UDL) is a set of principles for curriculum development that provides a blueprint for creating instructional goals, methods, materials, and assessments that work for every learner and can be customized and adjusted for individual needs (CAST, Inc., 2012a), especially the needs of students with disabilities included in the general education classroom.

The purpose of this chapter is to provide an overview of the literature that is relevant to the assessment of the science content knowledge of students with LD. The narrative begins by tracing the history of the identification of students with LD, the evolution of science education, and the movement toward inclusive science classrooms. Next, the current national and state

assessment outcomes of students with LD in science are presented. Lastly, a summary of research studies are provided to demonstrate the need for alternative options in assessment of science concepts for all students, but specifically, for students with LD.

## History of Science Education for Students with Learning Disabilities

### The Road to Identification

Special education legislation has been the driving force behind the current status of the field of special education. The current legislation however emerged as the result of strong advocacy by medical and educational professionals as well as parents and families of individuals with disabilities. This activism has helped to move students from environments of isolation and seclusion to more inclusive classroom environments of today. A summary of the key legislation that has led to setting a platform for one of the newest and largest categories served today, students with LD is provided.

The educational legislation movement in America began with early laws which required parents to educate their child in religion, capital laws, and some sort of trade and were eventually broadened and strengthened by the Old Deluder Satan Law of 1647 (The Laws and Liberties of Massachusetts, 1929) which required communities of 50 or more households to appoint a teacher for those children and communities of 100 or more households to build a grammar school. By mandating school attendance, the Massachusetts Bay School Law and the Old Deluder Satan Law marked the beginning of school attendance for students to learn to read (Dunn, 1929).

Historically, individuals with disabilities were deemed inferior and often less than human. Prior to the 1800s, a disability was considered to be due to some type of deviance or to

have been caused supernaturally. Over decades and decades, persons who were different from what society considered to be normal often found themselves subject to abuse, isolation, and even death (Kellogg, 1897). A shift in thinking about the treatment and potential for learning for people with disabilities started to occur due the research being done in Europe with veterans who had received brain injuries (Brockert, 1855).

A well-documented example of this shift in America can be seen in Dorothea Dix's petition in 1843 to the Massachusetts Legislature to financially support an expansion to the state insane asylum in Worcester, Massachusetts. Dix expressed concern that "regulated" almshouses that were established to care for the mentally insane were incapable of such outcomes.

Poorhouses converted into madhouses cease to effect the purposes for which they were established, and instead of being asylums for the aged, the homeless, and the friendless, and places of refuge for orphaned or neglected childhood, are transformed in perpetual bedlams. (Dix, 1843, para. 58)

Dix's concern extended not only to almshouses but also to prisons housing the mentally insane and the "idiotic in descending states from silly and simple, to helpless and speechless, within the same walls as criminals" (Dix, 1843, para. 59). In 1908, Elizabeth Farrell forged a movement from society to the classroom when she initiated an advocacy movement for individual students that did not fit in with their age equivalent peers. Farrell's advocacy resulted in Public School 1, in Manhattan, to house the first special class of students who needed further classification (Farrell, 1908-1909). Farrell notably advocated for the children that struggled with learning and

were placed in ungraded classes, as well as for teachers being prepared to support the learning needs of these students (Farrell, 1908-1909, 1921).

Edward Seguin, a Frenchman who worked with Jean Marc Gaspard Itard, further influenced practice and policy as he learned about moral treatment of the mentally insane through Itard's work with Victor, the wild boy of Aveyron. As well noted by Sequin (1856), Itard worked with Victor in his home continuously attempting to teach for understanding. Seguin elaborated that Itard bestowed upon him the gift of his practical experience, that which guided Seguin to his desire to morally treat and educate those individuals identified as 'idiots' at that time (Seguin, 1856, para. 19). As an outcome of his work with Itard, Sequin influenced policy and practice by leaving Europe and establishing the Pennsylvania School for Idiots at Germantown (Brockett, 1855).

In 1877, a formal agency for advocacy was formed to impact both practice and policy. The Association of Medical Offices of American Institutions was formed to discuss "all questions relating to the causes, conditions, and statistics of idiocy, and to the management, training, and education of idiots and feeble-minded persons (Wilbur, 1877, para. 5). This group of medical professionals determined the importance of assessment "to show the starting point in the pupil's career, to which reference can be made from time to time to test their absolute or relative progress" (Wilbur, 1877, para. 34). Additionally defining some form of classification, in relation to the growth and development of the student and established through "the general order of development of the mental faculties even in the case of idiots" (Wilbur, 1877, pp. 34-35), would allow for the progress of students to be tracked.

The advocacy of these pioneers was not without effort as their work was often met with ignorance, prejudice, and simple fear by people in society at all levels. Sir Francis Galton (1909) himself wrote about the need to sterilize and institutionalize individuals with disabilities believing that their disability stemmed from immorality and genetics. Goddard (1912) also believed that

people whom physicians tell you are partially demented properly belong in an institution for the feeble-minded because unenlightened people do not recognize the difference when someone has lost their mind and someone who has never had one to begin with.  
(pp. 56-57)

As legislation began to increase in supporting the isolation and sterilization of individuals considered feeble-minded or insane; contrasting support for legislation began for veterans with disabilities. The National Defense Act (1916), Smith-Hughes Vocational Act (1917), Smith-Sears Veterans Rehabilitation Act (1918), Social Security Act (1935), and the Randolph-Shepard Act (1936) all supported veterans chiefly related to their employment (McMurthie, 1918; Samuels, 1918). Legislation passed in support of veterans and soldiers with disabilities began to lead the way for similar legislation related to non-veterans and non-soldiers with disabilities.

The emergence of advocacy for students with specific learning needs began in the early 1900s. One exemplar, Samuel Orton (1929), made significant contributions to understanding LD, noting a potential incidence level as high as 10% of the student population. Orton (1989) initially thought that reading disabilities were often inherited, but also stated that reading is a very complex activity requiring the involvement of several areas of the brain. Orton linked cerebral dominance to reversals which led him to the term 'strephosymbolia' (p. 13) and

suggested phonics instruction for reading. He later added an additional strategy, letter blending, and eventually introduced the concept of multi-sensory training using kinesthetic tracing of letters while sounding them out for students who struggled to read and write (Orton, 1929). Marion Monroe, a student of Orton's, further contributed to the field for students who struggled with learning by developing diagnostic tests that were used to inform instruction. Well trained teachers worked with students who were struggling either individually or in small groups by providing intensive interventions and phonics based instruction (Monroe, 1932). Monroe (1932) analyzed the specific types of reading errors students made on tests to further guide instruction. Techniques for working with students with LD continued the development of identification tools to assess learning such as the Illinois Test of Psycholinguistic Abilities (ITPA). Monroe and Kirk were instrumental in initiating the paradigm of providing teachers who were prepared with instructional strategies to meet the reading and learning needs of students with LD. Kirk (1962) moved the field of special education from thinking of children as "brain injured" to today's inclusion of LD in federal disability legislation. Even with Kirk (1962, 1977) leading the development of the definition of LD, he expressed concern that while labels gave some satisfaction to adults, they are of little help to children. In the first edition of his textbook, *Educating Exceptional Children*, Kirk (1962) first defined LD as a retardation or delayed development in one or more of the processes of spelling, language, reading, speech, writing, or arithmetic resulting from possible cerebral dysfunction and/or emotional or behavioral disturbance and not from mental retardation, sensory deprivation, cultural, or instructional factors (p. 263 ). Kirk's use of the term *learning disabilities* moved the designation of LD as a disability forward and therefore in need of funding to support research and preparation programs.

## The Legislative Movement

Legislation initially slated for returning soldiers forged a pathway for advocates of individuals with disabilities. These advocates initiated the establishment of policy creation that generated funding and research for practices that support individuals with disabilities. The timeliness of the introduction of the term LD and the evolution of its definition, closely aligns with the federal mandate passing of The Education for All Handicapped Children Act of 1975 (EAHCA) . Public Law 94-142, provided federal funds to states to assist in educating students with disabilities. In order to receive the federal funding, each state has to submit an action plan of how services will be provided to students with disabilities. Under IDEA, the Individualized Education Program (IEP) is the focal point of EAHCA whereby goals and objectives of the student's program, educational placement, length of school year, and evaluation are documented. The EAHCA was a huge step forward toward impacting the education of all students and students with LD in public schools today.

A component of this federal legislation mandated that students were to be educated in the least restrictive environment (LRE) with the intent that they remain in the general education setting when possible. For students with LD, this emphasis on LRE often ensures that services are provided in general education settings. The LRE component of the law is central to the placement of students today and is the impetus for students increasingly being educated in inclusive settings.

Over time EAHCA was continuously amended, however changes for students with LD were limited after the initial passage. The 1990 revision of P.L. 94-142 renamed EAHCA to the Individuals with Disabilities Education Act (IDEA) and required the use of person-first language



when addressing individuals with disabilities (Yell, Rogers, & Rogers, 1998). The intent of use of person-first language was to enable students with disabilities to be students first and therefore included with their peers by removing the negative context of a label.

The IDEA Amendments of 1997 (P.L. 105-17) added several major provisions that still impact students who are LD today. An increased emphasis on parent participation and shared decision making; inclusion of the regular education teacher as a member of the IEP team; access to the general education curriculum; student access to their IEP at age 14; inclusion of positive behavior support plans in IEPs when appropriate; inclusion of students with LD in state or district wide testing programs; the addition of orientation and mobility services to the list of related services; and protection for students whose disability manifests itself in behavioral issues that result in change of placement, suspension or expulsion for more than 10 days, requiring a manifestation determination by the IEP team confirming that the student's conduct was not related to his or her disability. The amendments required states to collect and review data on racial disproportionality and gave students the right to attend their own IEP meetings. Allowing students with LD to participate in structuring their IEP gives them the right to be heard especially with respect to their future independence, options for skills training, and postsecondary college or careers.

At the same time revisions in special education law at the federal level were occurring, other federal laws were being revised that had an impact on students with LD. The wide-sweeping revision of the Elementary and Secondary Education Act (ESEA) of 1965 occurred in 2001 that being the changing of ESEA to what is now known as No Child Left Behind Act (NCLB, 2001). This revised legislation held schools accountable for student achievement levels

and provided penalties for schools that did not make adequate yearly progress toward NCLB goals. For the first time, meeting these goals included nation-wide testing of students with disabilities on standardized assessments. Additionally, NCLB set the precedent that all teachers, including special education teachers, must be highly qualified.

The issue of accountability brought forth the need for inclusion and cooperative teaching practices for those teaching students with disabilities. The IDEA reauthorization in 2004 included: a model of support for identifying students with LD through their response to evidence-based teaching practices rather than the discrepancy model, support for parental involvement and student self-advocacy, and increased professional development support for teachers aligning with NCLB's drive for highly qualified teachers. Overall, these changes have continued to shape the definition of LD initially generated by advocates for these students with disabilities. This group of students is the largest category of individuals with disabilities being served in our nation's schools (USDOE, 2012a). Advocates for and researchers of students with LD have had a significant impact on both general education and special education through interventions such as Response to Intervention (RtI), Positive Behavioral Supports and Interventions (PBIS), and UDL (O'Connor & Sanchez, 2011; Rose et al., 2002; Yell, Katsiyannis, & Bradley, 2011).

#### Where We Stand Today for Students with Learning Disabilities

Currently, ESEA is being re-evaluated as the U.S. Department of Education's Blueprint for Reform. Under the Blueprint for Reform efforts are being made to move students towards college and career readiness and acquisition of 21<sup>st</sup> century skills. In addition, the Blueprint

includes an approach to supporting all learners through common standards and the UDL framework (USDOE, 2010).

Our ESEA reauthorization will help ensure that teachers and leaders are better prepared to meet the needs of diverse learners, that assessments more accurately and appropriately measure the performance of students with disabilities, and that more districts and schools implement high-quality, state- and locally-determined curricula and instructional supports that incorporate the principles of UDL to meet all students' needs. (U.S. DOE, 2010, p. 20)

Additionally, "priority will be given to states that have adopted common, state developed, college and career ready standards and to states that use technology to address student learning challenges, which may include the principles of universal design for learning" (U.S.DOE, 2010, pp. 26-27).

Subsequently, Senator Harkin (D-IA), Chairman of the Senate Health, Education, Labor and Pensions Committee has also released his proposed ESEA reauthorization bill, Strengthening America's Schools Act. Under the Strengthening America's Schools Act a teacher evaluation section has been added under Science, Technology, Engineering, and Mathematics , early childhood education is a priority, preparation of teachers to meet the diverse needs of the students in their classrooms particularly SD and accountability of all sub-groups of students (U.S. Senate Committee on Health, Education, Labor, & Pensions, 2013).

Under either of these prospective reauthorizations, the need to design instruction to meet the needs of all students, a fundamental principle of UDL, is particularly important for students with LD who are being served in the general education classroom. The number of children and

youth with disabilities receiving services under IDEA increased from 4.1 million in 1980 to 6.7 million in 2005 (USDOE, 2012a). In contrast, from 2005 to 2009, the number of students receiving services declined to 6.5 million which corresponds to approximately 13% of the total population of public school enrollment (USDOE, 2012a). Although a decline has occurred, 38% of 6.5 million students have been identified as having LD. The National Center for Education Statistics (USDOE, 2012a) states that approximately 95% of school-aged children and youth ages 6-21 served under IDEA, Part B attend regular schools. Over 50% of students with specific LD spend the majority of their school day in general education classrooms (USDOE, 2011). This large number of students served in this category creates a critical need for interventions to support this population in general education settings, including core content areas.

### Serving Students with Learning Disabilities in the Sciences

#### Science Education Evolves for All Students

With a movement toward students with disabilities being served in the general education setting, finding ways to more effectively educate the 13% of the school population that has a disability has been an ongoing need in schools. The history of supporting students with LD has evolved as has the way students learn within and across various content areas. One content area that has greatly evolved that parallels the evolution of the category of LD is science education.

Science education in the U.S. has endured a thrust of changes initiated by space exploration. “At the time of the *Sputnik* crisis at least three competing views about the nature, purposes, and emphases of school science could be identified:

- 1) A practical, technical, applied emphasis.

2) A liberal, generalist, humanistic emphasis.

3) A specialist, theoretical, disciplinary emphasis” (Matthews, 1994, p. 15).

“In the early 1950’s American academics, scientists, professional associations, with physicists at the forefront, led the activism for the reform of U.S. science education. These groups were “concerned about the decline of science and mathematics” in the nation (Matthews, 1994, p. 16). As *Sputnik* brought the claims of reformers of science education to the national forefront, the National Defense Education Act of 1958 (P.L. 85-864; 72 Stat. 1580) provided funds to state educational agencies for the purposes of improving the teaching of science, mathematics, and foreign languages such as Russian, German, and other languages while the National Science Foundation (NSF) attempted to professionalize the development of school science curriculum (Matthews, 1994).

Moreover, due to the idea of a national assessment plan gaining impetus, the National Assessment of Educational Progress (NAEP) test began in 1964 with a grant from the Carnegie Corporation. The plan started with setting up an Exploratory Committee for the Assessment of Progress in Education in conjunction with a Technical Advisory Committee to facilitate the first national assessments in 1969. (USDOE/NAEP, 2012).

The 1970s introduced challenges to NSF through its curriculum programs and the idea of fashioning a national curriculum. Funding reductions due to the lack of perceived threat by the Soviet Union, the landing on the moon by the US, declining school enrollment, and states in arms against a national curriculum triggered NSF to withdraw from school curriculum development. In the 1980s, policy makers examined K-12 student achievement rates and declared the nation “at risk” of economic catastrophe. They

prescribed ramping up high school graduation requirements, especially in science and mathematics, a recommendation that was a precursor to the standards-based reforms of the 1990s. These crises and the reforms they stimulated are milestones that have defined and redefined the landscape of K-8 science education. They continue to influence the practices and attitudes of educators, researchers, policy makers, and the public (Duschl, Schweingruber, & Shouse, 2007, p. 12).

Coincidentally, Project 2061 was developed by the American Association for the Advancement of Science (AAAS) in 1985, to overhaul science education in schools and promote scientific literacy of all American high school students (American Association for the Advancement of Science, 1989; Matthews, 1994). The authors of Project 2061 stated that:

the scientifically literate person is one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural works and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. (American Association for the Advancement of Science (AAAS), 1989, p. 4)

In 1983, *A Nation at Risk* was published and provided an opportunity for the creation of standards for content, instruction, assessment, and professional development that would provide a framework for coordinated efforts toward a common goal: offering all students a sufficient level of knowledge and skills across the core academic subjects (Duschl et al., 2007). After the report of *A Nation at Risk*, several federal reports were published stating a need for stronger and more effective science instruction for all students. For example, the *Benchmarks for Science*

*Literacy* (AAAS, 1993) \*\*\*and *The National Science Education Standards* (National Research Council, 1996) provided the K-12 subject matter frameworks developed by education researchers, curriculum developers, scientists, teacher educators, and teachers for the development of each state's science frameworks (American Association for the Advancement of Science, 1993; Duschl et al., 2007; National Research Council, 1996). These revised frameworks were to reflect the changes discovered through scientific research in this century.

The majority of these transformations in science education occurred prior to the passage of IDEA. Similar to the teaching and learning of students with disabilities, the teaching and learning of science education was still evolving. O'Sullivan and Weiss (1999) discovered that typical classroom activities tend to convey a narrow view of science learning or an activity-oriented approach that is lacking the type of question-probing that leads to deep conceptual understanding for all students. Additionally, U.S. textbooks often fail to guide teachers in the process to build students' understanding, to contextualize science in meaningful problems, or to treat complex ideas other than superficially (Kesidou & Roseman, 2002; Schmidt, Houang, & Cogan, 2004).

A review of pedagogy in classrooms support the findings about curriculum and standards as teachers often attempt to cover a wide array of scientific concepts broadly and superficially eliminating opportunities for deep and real understanding (Weiss & Pasley, 2004; Weiss, Pasley, Smith, Banilower, & Heck, 2003). The typical textbook format requires students to read sections of content, take notes on and define science vocabulary, and respond to information-recall type summative assessment questions. This array of activities often leaves students with a vacant understanding and without a sense of what it means to know and do the kind of science thinking

requiring analysis, discussion, and debate (Carey & Smith, 1993; Smith, Maclin, Houghton, & Hennessey, 2000). For students who struggle with a learning disability in reading or for that matter in writing as well, they often find themselves struggling with the traditional text and worksheet type of science instruction and curriculum used in classrooms today.

Beyond textbooks, a variety of science approaches are used that might be beneficial to all students, but especially to students with LD. One alternative approach is through the use of science kits. Each individual science concept kit may provide students with a six or eight week unit of study that provides activities that build upon each other. These kits while creating coherent connections within the unit may sometimes be disconnected to the next science kit or unit of study or the ‘big idea’ to be learned in science. Another approach to science as practice is through teaching students to design and conduct scientific experimentations. These experimentations provide opportunities for students to make hypotheses, design methods for investigation, gather evidence, and evaluate the evidence in comparison to their hypotheses; building their understanding of scientific phenomena (Crawford, Krajcik, & Marx, 1999; Geier, Blumenfeld, Marx, Krajcik, Fishman, & Soloway, 2008; Lehrer & Schauble, 2002; Schneider, Krajcik, Marx, & Soloway, 2002). A third approach to science as practice is teaching science through opportunities for students to engage in other aspects of argumentation, explanation, and model building. As scientists, students investigate empirical regularities in the world and attempt to explain these regularities with theories and models, and then apply those theories and models to new science phenomena through evidence supported explanations (McNeill Lizotte, Krajcik, & Marx, 2006; Sandoval, 2003; Sandoval & Reiser, 2004). A fourth approach to consider is problem-based or project-based science, which has found to be particularly successful



in the middle school grades (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Edelson, Gordin, & Pea, 1999; Edelson & Reiser, 2006; Kolodner, Camp, Crismond, Fasse, Gray, & Holbrook, 2003; Krajcik, Blumenfeld, Marx, Bass, Frederick, & Soloway, 1998; Singer, Marx, Krajcik, & Chambers, 2000). Typically students learn the science content through investigating a compelling research question about a problem to which they can identify an authentic purpose for real-world application (Edelson, 2001). These types of approaches are not textbook based and reflect the thinking suggested by the NSTA. The position of NSTA on *Scientific Inquiry* is, “that all K-16 teachers embrace scientific inquiry and (NSTA) is committed to helping educators make it the centerpiece of the science classroom. The use of scientific inquiry will help ensure a deep understanding of science and scientific inquiry” (National Science Teachers Association, 2013b) and allows for the scaffolding that students with LD require.

#### The Science Classroom Moves Toward the Future

The Next Generation Science Standards (NGSS) (Achieve, Inc., 2013) release defines learning science as a three dimensional view of science and engineering practices, crosscutting concepts, and disciplinary core ideas. Given that “most people in this country lack the basic understanding of science that they need to make informed decisions about many scientific issues affecting their lives’ (National Research Council, 2006, p. 1), it is understandable that Achieve, Inc. (2013), developers of the NGSS determined that the demand of the scientific and engineering practices will require students to engage in classroom science discourse that will present opportunities and challenges for students with disabilities who must listen, speak, read, write, and visually observe and represent ideas and explanation (Achieve, Inc., 2013).

Additionally, the) draft report showed that the eighth grade gap on the National Assessment of Educational Progress (NAEP) continually decreased from 38 points in 1996, to 34 points in 2000, to 32 points in 2005 indicating continuous improvement although small (Achieve, Inc., 2013).

The NAEP data includes students with disabilities with an IEP or 504. Test accommodations under the NAEP are twofold, first being that the attest accommodation must be identified on the student's IEP and secondly that the accommodation is one allowed by the NAEP (National Assessment Governing Board, 2010). NAEP data for 2011 shows that 62% of students taking the NAEP performed at a Basic level (34%) or Proficient (28%), while 2% scored at an advanced level leaving 36% of students nationwide performing below the Basic level. Forty-six percent of Grade 8 students taking the Florida Comprehensive Assessment Test (FCAT) in 2012 scored at a proficient level while an even greater 54% of students taking the FCAT scored below proficient, demonstrating a lack of success on the current Next Generation Sunshine State Standards in science. For the three science content areas; Physical, Life, and Earth and Space Science, students averaged 9 out of 15 points and scored an average score of 6 out of 11 possible points on the Nature of Science concepts. Given that the inclusion of greater variety of students with disabilities are included in high stakes national and state assessments finding other methods to assess learning may be needed (Florida Department of Education, 2012).

In the May 16, 2012 edition of Education Week, Sparks' wrote, "fewer than one-third of American eighth graders are proficient in science" (Sparks, 2012, p. 6). Spark's indicated that although scores are improving gaps still exist for students from minority backgrounds and for

students with disabilities. In fact, Sparks states that eighth graders with disabilities and English Language Learners saw no growth from 2009 to 2011 (Sparks, 2012, p. 6).

The implementation of the Common Core State Standards will aid in addressing the need for consistency in the big ideas that all children nationally should be learning at some point during that academic year. The rigorous Common Core State Standards apply to all students, including students with disabilities so that they will be college or career ready. According to the Common Core State Standards Initiative (2012a), “students with disabilities, that is, students eligible under the Individuals with Disabilities Education Act (IDEA) must be challenged to excel within the general curriculum and be prepared for success in their post-school lives, including college and/or careers” (p. 1). The Common Core State Standards Initiative contends (2012a) that these common standards will provide improved access to rigorous academic content standards for students with disabilities and that how the standards are taught and assessed will be of the utmost importance in reaching this diverse group of students.

Furthermore, the Common Core State Standards Initiative (2012a) includes statements that in order for students with disabilities to meet high academic standards and to fully demonstrate their conceptual and procedural knowledge and skills their instruction must incorporate supports and accommodations, including:

- supports and related services designed to meet the unique needs of these students and to enable their access to the general education curriculum (IDEA 34 CFR §300.34, 2004).
- An Individualized Education Program (IEP), which includes annual goals aligned with and chosen to facilitate their attainment of grade-level academic standards.

- Teachers and specialized instructional support personnel who are prepared and qualified to deliver high-quality, evidence-based, individualized instruction and support services.

Promoting a culture of high expectations for all students is a fundamental goal of the Common Core State Standards. In order to participate with success in the general curriculum, students with disabilities, as appropriate, may be provided additional supports and services, such as:

- Instructional supports for learning— based on the principles of UDL--which foster student engagement by presenting information in multiple ways and allowing for diverse avenues of action and expression.
- Instructional accommodations (Thompson, Morse, Sharpe, & Hall, 2005) —changes in materials or procedures— which do not change the standards but allow students to learn within the framework of the Common Core State Standards.
- Assistive technology devices and services to ensure access to the general education curriculum and the Common Core State Standards (pp. 1-2).

Proficient individuals possess subject matter knowledge that is connected, related and cohesive; whereas less proficient students will have disconnected and isolated pieces of information. As a proficient student acquires new knowledge or develops a deeper understanding, their responses demonstrate the interconnectedness and complexity of their knowledge. Less proficient students continue to respond with simple, fragmented justifications (Baxter, Glaser, & Raghavan, 1993; Pellegrino, Chudowsky & Glaser, 2001). As the push for greater and improved thinking, information gathering, understanding, reasoning, evaluation, and problem solving occurs within educational reform so too does the need to develop measures of

student achievement that align with educational goals and meaningful learning experiences (Baxter et al., 1993).

### Teaching Science to Students with Learning Disabilities

The NSTA's position and support for instruction to occur through scientific inquiry lends well to the needs of students with LD. Correspondingly, NSTA is committed to developing strategies to overcome barriers to make certain that all students have the advantage of a good science education and can attain scientific literacy through overcoming educational and physical barriers, selecting science curriculum, overcoming barriers in the way assessment tools are developed and used with students with disabilities, overcoming attitudinal barriers and educating science teachers about what is involved in teaching students with disabilities, and helping students with disabilities prepare for careers in science and science-related fields (<http://www.nsta.org/about/positions/disabilities.aspx>).

Science is a content area that is typically taught with two differing approaches: traditional textbook approach or hands-on approach. Textbooks can be used both as the primary source or as a supplemental resource for instruction. Although textbooks tend to be the primary source for science content information, they can be often be considered a barrier to learning when students with LD commonly have readability levels below that of many of their peers in the class. Alternatively, a hands-on approach to learning science stresses the use of inquiry and processing skills rather than an accumulation of knowledge that textbooks provide. Inquiry science helps teachers to meet students where they are in their learning, provides opportunities for authentic learning tasks and independent thinking, capitalizes on learning by doing through hands-on investigations with teacher demonstrations and facilitation, and guides students to make

connections to the textbook (McFarland, 1997; Pearce, 1999; Shymansky, Chidsey, Henriques, Enger, Yore, Wolfe, & Jorgensen, 1997). Either approach without some accommodations can be difficult for students with LD.

Basically, students with LD are likely to encounter a number of problems relative to science instruction that are the direct result of their primary characteristics and other issues that may be secondary or tertiary problems. For example, students with LD may have difficulty acquiring critical information from lectures, class discussions, textbooks, and media presentations along with demonstrating difficulty working with numeric data from a science experiment. These same students may also demonstrate difficulty with the verbal or written expression that they expected to demonstrate to show their competence in understanding the science content learned (Scruggs & Mastropieri, 1993; Scruggs, Mastropieri, Bakken, & Brigham, 1993; Scruggs, Mastropieri, Levin, & Gaffney, 1985). Students with LD may face problems with memory and recall of information (Scruggs & Mastropieri, 2000; Scruggs, Mastropieri, Sullivan & Hesser, 1993; Swanson & S´aez, 2003), have difficulty with their attending to tasks and struggle with appropriate behavior (Cutting & Denckla, 2003; Scruggs & Mastropieri, 1995), as well as issues of self-concept and motivation (Elbaum & Vaughn, 2003; Spencer, Scruggs, & Mastropieri, 2003).

Scruggs and Mastropieri (1994a) studied outstanding inclusive science classrooms in a school district well known for excellence in science learning. These elementary classrooms contained students with a range of disabilities, including students with visual impairments, physical disabilities, hearing impairments, LD, and autism. From an analysis of the observations, interviews, curriculum materials and classroom products collected during this

study, the researchers identified seven variables that were highly significant in promoting effective inclusive education in science. An open and accepting classroom environment, administration that supports inclusion, effective teaching skills by the general education teacher, consultative support by the special education teacher, peer learning activities, supportive hands-on curriculum, and instructional strategies specific to a student's disability were found to be necessary for a highly effective inclusive science learning environment (Scruggs & Mastropieri, 1994b). These very same variables that impact a highly effective inclusive environment for students with LD align with the UDL framework (Rose et al., 2002).

Mastropieri, Scruggs, and Marshak (2008) also share that this constructivist approach to teaching science has many advantages for students with LD: An emphasis on concrete and meaningful experiences, an emphasis of scaffolded learning for depth of understanding, a de-emphasis on rote learning, and a method where students demonstrate their knowledge through projects and materials rather than paper and pencil worksheets and tests. Potential challenges with a constructivist approach for students with LD include appropriate peer interactions, overreliance on learner discovery, and insight into concept acquisition. Vocabulary demands in science are particularly challenging as grade levels increase. Learning and memory strategies for academic content, strategies for studying, adapted hands-on activities, and teacher support for inquiry learning all support student learning for students with disabilities. Research has shown that students with LD benefit from many evidence based strategies (Scruggs & Mastropieri, 2007). Mastropieri and Scruggs (1992) reviewed research on science instruction with students with LD from 1954 to 1992. Twenty-five studies were identified that focused on text adaptations, including study guides and graphic organizers, use of mnemonic strategies for recall

of science content, research on hands-on or activities oriented approaches to instruction, and even the inclusion of virtual/reality labs. These approaches to learning have had positive outcomes in recalling text-vocabulary and concept acquisition (Mastropieri, et al., 2008). Scruggs, and colleagues (1993) discovered that students, general education and students with LD, scored higher when they were taught with activity/inquiry-oriented methods and materials similar to methods and materials utilized in UDL rather than strictly through a textbook method. In addition, Mastropieri, Scruggs, and Butcher (1997) found that students with LD performed just slightly below students without disabilities when given explicit prompts during activities that required inductive thinking. Research on outcomes from peer tutoring, enhanced with differentiated curriculum resources, increased engagement and performance for all students (Mastropieri, Scruggs, & Graetz, 2005; McDuffie, Mastropieri, & Scruggs, 2009).

Knowing that pre-teaching vocabulary, using mnemonics and graphic organizers, supporting or guiding student learning in project based activities has had positive outcomes for students with LD in an inclusive classroom environment provides insight into the student's acquisition of knowledge. Bybee (2002) stipulates that informal discourse provides students with a forum for exploring their own ideas and considering those of their peers, whereas, more formal presentations are opportunities for students to organize and defend their thoughts and ideas. Furthermore, "valid assessment provides samples of behavior that allows the classroom teacher to observe and evaluate student responses indicating conceptual knowledge of a scientific topic and "the critical evidence of valid assessment is the appropriate match between what has been taught and what is being tested" (Bybee, 2002, p. 54). Standardized tests continue to play a major role not only in language arts and math, but science as well. Not only is the traditional



summative assessment considered a valuable tool in science assessment but also of value are alternative forms of assessment such as science journals, teacher observations, performance assessments, and discussion that can be a part of the valuable on-going formative assessment tools that should be part of a comprehensive assessment program (Bybee, 2002).

The research presented in Table 2 displays research on specific instructional strategies and technologically-enhanced assessment tools that have been found to improve outcomes for students with LD. However these studies are void in demonstrating depth in individual student understanding of science content therefore also void in meeting with the National Academies of Science (NAS) Framework for K-12 Science Education assessment standards (National Research Council, 2012).

**Table 2: Studies in Assessment in Science with Middle School Students with Disabilities**

Article	Participants	Methods	Results	Notes
<p>Borsuk, E. R. (2010). Examination of an administrator-read vocabulary-matching measure as an indicator of science achievement. <i>Assessment for Effective Intervention, 35</i>(3), 168-177.</p>	<p>63 Sixth &amp; Seventh Grade students from northeastern US middle school All students from two inclusive classrooms and some students were in pull-out English language arts class were included</p>	<p>Custom-made computer program generated 24 alternate versions of vocabulary-matching measures Students were asked to select the term matching the presented definition given six potential answers Study employed an administrator-read version of the vocabulary-match measure—both vocabulary word and definition choices were read aloud Data was collected for 24 weeks</p>	<p>Hierarchical Linear Modeling was used to determine the significance of the mean growth rate of participants, the variability in growth rate of participants, and the difference in growth rate between students without disabilities and students with disabilities .05 priori alpha level Initial estimated mean score of 10.67 Predicted growth rate of 0.26 correct answers/week was significantly different from 0 (<math>p &lt; .05</math>) Slope reliability estimate .62 Disability status was a significant predictor (<math>p &lt; .05</math>) of the intercept and rate of growth Coefficient of -1.90 (<math>\beta_{01}</math>) related to the intercept in Level 1 model signifies a lower score for those without disabilities and a coefficient of -0.15(<math>\beta_{11}</math>) related to students with disabilities</p>	<p>Data were statistically significant –when put into practical application based on 9.5 month school year at rate of improvement of 0.26 items per week translates into 10 items across the school year Impact on student achievement is unknown and author recommends formative, progress monitoring measures be developed Focus on vocabulary lends to memorization of content</p>

Article	Participants	Methods	Results	Notes
<p>Olsen, J. K. &amp; Slater, T. F. (2009). Impact on modifying activity-based instructional materials for special needs students in middle school astronomy. <i>Astronomy Education Review</i>, 7(2), 40-56.</p>	<p>Middle school students from 50 science teacher's classes Each student identified by anonymous code number assigned to Lawrence Hall of Science (LHS) modified curriculum and other students used Great Explorations in math and Science (GEMS) curriculum</p>	<p>Four group pretest/posttest quasi-experimental study Group 1- regular education students in unmodified curriculum Group 2- students with special needs in unmodified curriculum Group 3- regular education students in modified (computer-mediated instructional approaches) curriculum Group 4- students with special needs in modified (computer-mediated instructional approaches) curriculum</p>	<p>Most students with special needs demonstrated substantial gains with a 7% gain for students with special needs and 9% gain for general education students. Special education students not in the modified curriculum showed a 7% decrease in gain scores whereas general education students showed an average 8% gain</p>	<p>Study focuses on instructional practices for improvement in standard, typical, classroom assessment</p>

Article	Participants	Methods	Results	Notes
<p>Tindal, G. &amp; Nolet, V. (1996). Serving students in middle school content classes: A heuristics study of critical variables linking instruction and assessment. <i>The Journal of Special Education</i>, 29(4), 414-432.</p>	<p>2 Seventh Grade science classrooms in a large (4,000 students) district 74 participants (Low Performing (LP) Students = 16 students who received services from Ch. 1) or special education (n=11, all identified with LD) males=34 females=40 Students' scores were slightly above average on SAT Students were taught by two teachers (one teacher had a Masters degree and one teacher had a Bachelors degree)</p>	<p>Study completed during 2 week unit on biomes Teacher taught and audio-recorded their lesson Near end of unit teachers were directed to administer three performance outcomes (perception probe, one criterion referenced test (focused on facts) generated by curriculum book and a problem-solving prompt (focused on concepts and principles) generated by researchers. Perception probes were scored according to percentage of students selecting each of the target words. Criterion-referenced test was analyzed for concept easiness by calculating percentage of students passing items focused on specific target concepts. Problem solving task was analyzed quantitatively by counting number of words, concepts, though units and concept-specific through units on their essay and qualitatively by rating it holistically on a 5 point scale and analytically on two 5 point scales</p>	<p>Little disparity between students who were LP and general education students. Students who were LP included targeted concepts on perception probes were not much lower than general education students. In all but multiple choice facts subtest, students who were LP had significantly lower scores than general education students</p>	<p>Study attempted to identify three variables that may be important in developing successful interventions: curriculum materials, verbal interactions, and performance outcomes (student perception and learning) Authors state that this study can be considered within the context of Scruggs and Mastropieri (1993) effort to match student characteristics with educational environments in general education science classes</p>

Article	Participants	Methods	Results	Notes
<p>Mastropieri, M. A., Scruggs, T. E., Norland, J. J., Berkley, S., McDuffie, K., Tornquist, E. H., &amp; Connors, N. (2006). Differentiated curriculum enhancement in inclusive middle school science: Effects on classroom and high-stakes tests. <i>The Journal of Special Education</i>, 40(3), 130-137.</p>	<p>13 8<sup>th</sup> Grade science classes (213 students of which 44 were classified as students with disabilities -37 LD &amp; 7 EBD) – 109 males 104 females  44% Caucasian  27% Black  17.4% Latino  4.4 % Asian  5.2% Multi-racial  5 classes were co-taught General Education Teacher (GET) &amp; Special Education Teacher (SET), 8 taught by GET, and 2 by SET.  Classes were matched by classroom teacher and then randomly assigned to either control or experimental condition</p>	<p>Control Condition: Teachers directed all aspects of instruction. Lessons began with daily review, presented new information, offered guided and independent practice and led laboratory activities.  Experimental Condition: Teacher presentations were identical to control condition, but time typically spent completing worksheets was devoted to peer-assisted learning with differentiated science activities, roles, rules and materials were covered, and students worked with one another using the hands-on curriculum enhancement materials. Students were grouped in dyads or groups of three based on ability. Students needing assistance were paired with higher achieving students. Teacher selected level of materials with differentiation  Pretest/posttests of science content</p>	<p>Unit Tests: Data was entered into a 2 condition experimental vs. control) x 2 group (special education vs. general education) ANCOVA with pretests as a covariate and classrooms treated as a nested factor within condition. Significant effects were observed for condition <math>F(1192) = 8.93, p=.003</math>. High-Stakes Test: Data was entered into a 2 condition (experimental vs. control) x 2 group (special education vs. general education) ANCOVA with pretests as a covariate (correlated score <math>r=.417</math>) with high stakes test score with classrooms treated as a nested factor within condition which had a significant effect for condition <math>F(1185)=5.56, p=.018</math>. Survey on Student Attitudes &amp; Teacher Perceptions—students reported variable attitudes toward the individual activities—students with disabilities reported more positive attitudes than did students without disabilities though the differences were not statistically significant</p>	<p>Study supports differentiated learning activities with peer partners in inclusive science classes Authors indicate that inclusive classroom teachers have an ongoing challenge to meet the needs of all learners, especially when content is challenging and when students needs are diverse</p>

The developers of the NAS Framework propose three purposes for educational assessment: formative assessment in the classroom to assist learning and guide the instructional process; summative assessment for classroom, school, and district levels to understand individual student achievement; and program evaluation assessment to evaluate the effect of different instructional programs. The NAS Framework author's further purport that "a "one-size-fits-all" notion of assessment is demonstrably inadequate. The NAS Framework, like the UDL Principles Framework, supports the concept that no single assessment, regardless of how well it might be designed, can possibly meet the range of information needs that operate from the classroom level on up . The NAS Framework writers indicate that computer-based assessments offer a promising alternative however, high-quality science assessments must be consistent with the framework and meet the different purposes of assessment while being accessible to all levels of learners.

### Universal Design for Learning

One approach to assessing student knowledge incorporating the NAS Framework is through the implementation of an UDL assessment approach. The UDL framework centers on providing options for students and supporting the learning needs of all learners (Meyer & Rose, 2005; Rose & Meyer, 2006). "The term universal design means 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 inter-operative with assistive technologies" (P.L.110-315). The concept of universal design began with Marc Harrison, an industrial design engineer, who suffered a severe brain injury as a child from a sledding accident.

Marc Harrison was an instructor at Rhode Island School of Design (RISD) where he was instrumental in establishing the Division of Architecture and Design as well as owning his own design consulting firm. There he changed the idea of designing for the average person to designing products for all people of all abilities. His design direction or philosophy became known as Universal Design (UD), a term coined by Ron Mace, an internationally known architect, product designer, and educator (Burgstahler, 2008). Mace (1998) stated that “UD goes far beyond the minimum specification and limitations of legislated mandates for accessible and barrier-free facilities” (p. 21). Public buildings have been mandated by building codes and laws since 1961 when the American National Standards Institute published the first national accessibility standard, A117.1 Making Buildings and Facilities Accessible to and Usable by people with Disabilities (Mace, 1998). The UD accommodations established for public buildings and property, such as ramps and curb cutouts, was used not only by individuals with disabilities but by all individuals. At the Designing for the 21st Century: An International Conference on Universal Design, Mace defined UD as “a consumer market driven issue. Its’ focus is not specifically on people with disabilities, but all people (The Center for Universal Design, 2008).

The foundational UD concept of accessibility was the inspiration for the founders of the Center for Applied Special Technology (CAST) as they looked to designing instructional materials and strategies that are flexible to meet the needs of all learners through a UDL framework (Coyne, Pisha, Dalton, Zeph, & Cook-Smith, 2006). This flexibility could be a pathway to assist students with LD in science curriculum using many of the research-based practices (Scruggs & Mastropieri, 2007). The unique aspect of combining UDL and science

instruction for students with LD is the added assumption that technology will be a tool integrated into instruction. The directors of the CAST share that:

The CAST began in 1984 when a group of clinicians from North Shore Children's Hospital in Salem, MA collaborated on idea of to create the CAST. The focus at the CAST was on how computer technology can enhance the learning for students with LD and later children with sensory issues and physical disabilities. In 1988, CAST developed the Equal Access program with the goal of equalizing access to the curriculum through technology and in doing so generated their new mission of adapting the curriculum to fit all learners rather than addressing individual student needs to fit into the curriculum, thus sowing the seeds for UDL (CAST, Inc. (2012b).).

“UD principles have been applied to many educational products, (e.g., Websites, curricula, scientific equipment) and environments, (e.g., classrooms, student union buildings, libraries, online courses)” (Burgstahler, 2008, p. 14), yet limited application has occurred to date in the literature in science. However, these principles more recently were applied to the Higher Education Opportunity Act (HEOA). The UD and UDL provisions under the HEOA, P.L. 110-315 (Higher Education Opportunity Act, 2008), are defined as a scientifically valid framework for guiding educational practices 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.

“UDL represents a shift in how we look at learner differences. It emphasizes the need for curriculum that can adapt to student needs rather than require adaptation from the learners. It helps us to identify and remove barriers” (Coyne et al., 2006, p. 2). This approach could address many of the barriers found in traditional science textbooks (Wissick & Gardner, 2011) for students who struggle with reading. Students with LD specifically need approaches that address different neuro-pathways to learn new concepts (Rose et al., 2002). The concepts within UDL are built on brain based research that focuses on three specific brain networks. The networks are identified based on their functions.

- 1) Recognition networks are specialized to sense and assign meaning to patterns we see; they enable us to determine to identify and understand information, ideas, and concepts.
- 2) Strategic networks are specialized to generate and oversee mental and motor patterns. They enable us to plan, execute, and monitor actions and skills.
- 3) Affective networks are specialized to evaluate patterns and assign them emotional significance; they enable us to engage with tasks and learning and with the world around us (Rose et al., 2002, p. 12).

Coyne and colleagues (2006) describes the recognition network, located at the back of the brain, as the “what” of learning. The NGSS focuses specifically on the “what and how” of science learning. Using UDL concepts the recognition network could allow students with LD to gather facts and develop understanding through multiple means of representation. Providing

differing ways to acquire information for students with specific information processing needs. The strategic network is described as the “how” of learning. The strategic network allows individuals with LD to plan and perform tasks and share their knowledge through the support of providing multiple means of action and expression (Coyne et al., 2006). The affective network determines our interest and engagement and is described by Coyne et al. (2006) as the “why” of learning. The affective network provides individual learners with meaningful, varied, and interesting learning opportunities through UDL’s principle of providing multiple means of engagement. UDL supports and facilitates the interaction between the learner and the curriculum. When the support and facilitation is missing, learning difficulties arise particularly for students with LD. Therefore, if the curriculum can be flexibly designed, the material and tools created can meet more learners where they are. Flexibly designed curriculum can challenge and support the varied needs, interests, skills, and learning styles that teachers find within their classroom walls every day (Meyer & Rose, 2005) and improve the educational outcomes of students with LD particularly in the science classroom where vocabulary can be of significant challenge and the ability to make inferences is required (Scruggs & Mastropieri, 2007).

In an interview by Christina Samuels in Education Week, David Rose said, “True UDL requires that educators think deeply about what each lesson is about. Those goals then guide how UDL is implemented” (p. 12). Rose was also quoted in the interview saying:

“lessons should be designed with accessibility in mind, instead of retrofitting existing materials in an attempt to accommodate students learning differences. While the early days of UDL focused on helping students with disabilities, supporters say it has benefits for any student, including those who are learning English , gifted students, or students

who simply learn better through methods other than a teacher's lecture such as through technology" (Samuels, 2007, p. 12).

With accountability in mind large-scale assessment in public education has expanded significantly. Rose, Hall and Murray (2008) contend that there is no separation between instruction and assessment and that assessment is an integral part of instruction and without it instruction is actually disabled in science. UD's primary goal in large-scale assessment is to ensure accurate measurement and educational accountability for all participating students. This goal can be accomplished through accurately assessing the right constructs across the full spectrum of students for which the instruction and assessment is intended (Rose et al., 2008). Utilizing the power of UDL to generate assessments in science that are accessible for all learners can be done through the application of the principles of UDL, namely the means for representing information to students, the means by which students will express their knowledge, and the means for engaging learners (Rose et al., 2008). Of particular interest is the provision for providing multiple means of action and expression whereby students can demonstrate their understanding of science concepts as outlined in the NAS Framework through the means that best meets their intelligence and learning style. Effective communication through writing is one of the most difficult and demanding challenges for any student, but for students with writing difficulties the barriers to expressing their knowledge are confounded (National Center on Universal Design for Learning, 2011).

The National Center on Universal Design for Learning (NCUDL) (2011) identifies that one approach to removing writing barriers is to provide alternative media for expression. The NCUDL (2011) states that "the advantages of using a broader range of media – including word-

processing, audio recording, video or film, multimedia, images, drawing, animation, graphics – are that building fluency with a wider range of options prepares all students better for the communication skills they will need in the 21st century and provides valuable alternatives for those students who have persistent difficulties in written expression” (p. 1).

Digital media can open doors to learning for all students but particularly for students with disabilities. Today’s learning environments have changed. Children, including students with LD, learn science from the world around them -- through books, television, the Internet, visits to museums and national parks, the classroom and the scientific and technological world they live in (Duschl et al., 2007, p. 19). “Technology is not a small thing in the lives of people living with disabilities. It can stretch the boundaries of normal access to include them” (DeMers, 2010, p. 33). Digital technology is fast becoming an important part of the learning environment of students today and offers the flexibility that UDL enfolded that makes learning personal and meaningful for each student (Bower, Hedberg, & Kuswara, 2010; Morgan, 2012; Prensky, 2010; Rose et al., 2002; Rose & Gravel, 2009). Rose and colleagues. (2002) state that “digital media offers a remarkable, almost paradoxical set of features in that it can save text, speech and images reliably and precisely over time, and yet they offer flexibility in how those images, text, and speech can be redisplayed” (p. 63). Rose and colleagues (2002) also indicate that digital media has four aspects that make it particularly beneficial for classroom application. The four aspects are:

1. Digital media is versatile. Digital media can be displayed in text, still image, sound image, video image, and combinations within text, sound and video image. It offers the user the option to work in a preferred medium or to interact using multiple media.

2. Digital media is transformable. Digital media allows for content to be displayed in multiple ways enabling students to access information by turning on sound, adjusting the sound volume, dismantling graphics, enhancing images by adjusting or changing the browser. Also, cross-media transformations or transformation from one medium to another are also possible allowing for speech to text or text to speech capabilities through software or access.
3. Digital media can be marked. Hypertext markup language (HTML) is a code for constructing Web pages. HTML allows a Web page designer to “mark up” text, tagging different structural components such as title, subheadings, or main body so that teachers or students can alter content to accommodate needs or preferences such as adjusting fonts size or identifying specific literary components .
4. Digital media can be networked. Digital media can be linked with other media through hyperlinks and embedded supports allowing for rapid navigation (pp.66-67).

Digital media and other web-based learning tools can provide the necessary scaffolding tools for learning and the options to activate or deactivate extraneous information that may overload a student with LD in the science classroom (Bower et al., 2010; Morgan, 2012; Wissick & Gardner, 2011). Wissick and Gardner (2011) state that a wide range of technology considerations can be incorporated into the science learning environment depending on whether they are focused on the representation of the content such as in virtual labs, graphic organizers software, and interactive textbooks or students’ expression of their knowledge in learning activities or on-line assessments. “Allowing students to use graphic organizers, presentation software, podcasting, and word processing, all represent multiple ways students can acquire and

express their knowledge of science content for the purposes of communication or assessment of learning” (Wissick & Garner, 2011, p. 495).

“Designing assessments that allow students to select and use their preferred method to express their content knowledge ensures a more accurate snapshot of their learning by eliminating the potential for unnecessary barriers when one or two teacher-imposed modalities are used” (Staskowski, Hardin, Klein, & Wozniak, 2012, p. 116). Bowen and Rude (2006) state that students with disabilities must have greater opportunities to learn the content, and that it is essential that they have appropriate accommodations to fully participate in the general education curriculum as well as incorporating UDL to support participation especially in schools with limited curricular choices. Universal Design for Learning principles build upon options and flexibility. The UDL Action and Expression Principle focuses on setting goals, monitoring progress, and providing opportunities for students to share what they know, manage the information that they know and identify gaps in learning that they may have.

Although the UDL framework has been around for several decades, a search of key terms related to UDL framework and middle school students with LD in science yields minimal studies. Research that is identified through Eric, Academic Search Premier, Web of Knowledge and Education Full Text center on UDL in instructional technology-based tools is shown in Table 3.

Research on UDL has focused on the principle of representation or instructional practices and curriculum creation through the integration of technology and media within structurally-sound learning experiences that are for students with diverse needs (Pisha & Coyne, 2001; Wehmeyer, Smith, Palmer, Davies, & Stock, 2005). Lopes-Murphy (2012) identify the

importance of developing classroom-based assessments to evaluate students' performance over time as UDL is implemented as an instructional framework for students identified as English Language learners. Acrey, Johnstone, and Milligan (2005) examined the feasibility of using elements of UD in study guides and classroom tests. Study guides were created to increase accessibility of course content for all students and reinforce concepts that they learned (Acrey et al., 2005). Acrey et al. (2005) reported that teachers responses were overwhelming positive related to student engagement and comprehension which was demonstrated by increases in the annual statewide test scores from the previous year. Marino, Black, Hayes, and Beecher (2010) examined the factors affecting achievement when students participate in technology-enhanced Science, Technology, Engineering, and Mathematics (STEM) curricula. The technology-enhanced STEM curricula contained UDL framework components of representation and engagement to provide access to curriculum materials. Results from the study showed that significant gains were made between the pretest and posttest regardless of student's reading level with the implementation of the technology-enhanced STEM curricula. Coyne and colleagues (2012) also assessed reading growth through a Literacy Based Design (LBD) approach to instruction utilizing UDL framework supports. According to Coyne and colleagues (2012), LBD provides students with multiple means of representation, action and expression, and engagement. They discovered that students in the LBD group scored significantly higher than the control group on the Letter Word Identification and Picture Vocabulary subtest of the Woodcock-Johnson III (Coyne et al., 2012).

Table 3 contains studies that demonstrate the positive significant impact of implementing UDL representation and engagement principles as a part of instructional tools. UDL research to

date has focused on instructional strategies and learning environments using UDL representation principles and the impact on standard or curriculum-based assessment rather than UDL principles within the assessment itself.



**Table 3: Studies on UDL and Middle School Students in Science**

Article	Participants	Methods	Results	Notes
<p>Marino, M.T. (2009). Understanding how adolescents with reading difficulties utilize technology-based tools. <i>Exceptionality</i>, 17(2), 88-102.</p>	<p>1153 students from four middle schools in northeast US Students ranged from Sixth to Eighth Grade Students were grouped into three groups based on previous year's Degrees of Reading Power (DRP) score- Group 1 Students with Sever reading difficulties, Group 2 Poor readers and Group 3 Proficient readers</p>	<p>16 General science education teachers in grade level astronomy classes—11 teachers implemented the curriculum in a computer laboratory and 5 teachers used laptop computers Technology-based astronomy curriculum was utilized – curriculum used problem-based instruction and components of UDL (representation &amp; engagement) Students began by watching a video and were charged with learning about aliens, comparing and contrasting the aliens' needs to the planets and moons in the solar system</p>	<p>Categories used during analysis were: 1)tools that share cognitive load, 2) tools that support the cognitive process, 3) tools that support out-of-reach activities and 4) tools that support hypothesis testing. Correlation between students' use of cognitive tools and posttest were obtained—results showed tool use and posttest to have a stronger correlation than tool use and solutions form scores (<math>r=.24</math>). One-way ANOVA was conducted with cognitive tools categories and DRP- DRP groups were significant (<math>F(2,954) = 12.60, p &lt; .001, \eta^2 = .03</math>) 2) tools that support the cognitive process <math>F(2,954) = 4.86, p = .008, \eta^2 = .01</math> 3) tools that support out-of-reach activities <math>F(2,954) = 3.07, p = .047, \eta^2 = .006</math> and 4) tools that support hypothesis testing <math>F(2,954) = 5.567, p = .004, \eta^2 = .01</math>. After controlling for DRP group, students' uses of tools that share cognitive load and tools that support out-of-reach activities were found to be statistically significant predictors of posttest score. Student use of tools that support out-of-reach activities had a significant negative impact on posttest scores</p>	<p>UDL supports within curriculum allowed students to learn at their pace and receive tutorial assistance if needed</p>

Article	Participants	Methods	Results	Notes
<p>Marino, M. T., Black, A. C., Hayes, M. T., &amp; Beecher, C. C. (2010). An analysis of factors that affect struggling readers' achievement during a technology-enhanced STEM astronomy curriculum. <i>Journal of Special Education Technology</i>, 25(3), 35-47.</p>	<p>See study above</p>	<p>See study above</p>	<p>Posttest scores- the intraclass correlation coefficient estimated from the unconditioned model .173 indicating 17% of the variance in the posttest scores was between teachers &amp; classrooms. School indicator variables explained differences in classroom average scores and the effect of being a student with reading difficulties on posttest scores. All students regardless of their reading level made statistically significant pre/posttest gains Effect of being a student with reading difficulties varied significantly across teachers/classrooms (<math>p = .003</math>) – variability explained by school indicators. Student posttest scores increased incrementally as father's education level increased (<math>p = .001</math>) on posttest scores. Being male had a positive and statistically significant (<math>p = .011</math>) effect on posttest scores—male students' scores were higher than females' scores by average of .51 pts. On 25 pt. scale. Having a computer at home also predicted higher posttest scores (2.02 pts. higher on average) (<math>p = .007</math>). Effect of being a poor reader or reader with sever difficulty was statistically significant and negative (<math>p = .026, p &lt; .001</math>).</p>	

Providing students with an avenue to demonstrate or “*express*” their science content knowledge and understanding of concepts can be accomplished through UDL approaches as well as providing options of performance-based assessment activities. Performance-based assessments (PBA) are alternatives such as projects, performances, or self-choice products to traditional paper and pencil tests that assess student knowledge. “Performance-based assessment attempts to apply skills in a manner similar to the method the student uses during the learning process” (Finson, Ormsbee, & Jensen, 2011, p. 180) and provides for the scaffolded experience that students with LD require. The PBA model provides meaningful opportunities for students with LD to demonstrate student learning growth and construction and application of their understanding of course content and conceptual understanding (Krajcik, McNeil, & Reiser, 2008; Lenz & Deshler, 2004; Quellmalz, Timms, Silberglitt, & Buckley, 2007). “It is an active, hands-on form of assessment and allows learners to demonstrate their understanding of concepts and apply acquired knowledge and skills” (Finson et al., 2011, p. 180). Students that are given the opportunity to express their knowledge in a way that fits their learning needs may develop deeper connections and meaning to the content being learned. Utilizing alternative media for the purposes of expression of content knowledge is a performance-based assessment tool that can be used to identify where students are in their understanding of content material.

Federal mandates and policy continue to infuse in today’s educational environment with No Child Left Behind (NCLB), Common Core State Standards, and the reauthorization of the Elementary and Secondary Education Act’s (ESEA) Blueprint for Reform. Additionally, mandates such as the Individuals with Disabilities Act (IDEA), NCLB and the Blueprint have forged ahead the idea that in today’s classroom environment, most students with special needs

can find themselves in an inclusive general education classroom (USDOE, 2012a). The movement toward inclusion in the learning environment lends itself to the movement of students with disabilities being included in both assessment and accountability. The NSTA's stance that the middle school years are a "pivotal time in the understanding of and enthusiasm for science" and "that if educators don't capture students' interest and enthusiasm in science by grade 7, students may never find their way back to science" (<http://www.nsta.org/about/positions/middlelevel.aspx>) is one that leads to the necessity for research to focus on finding a better way to assess the learning and understanding of students with LD in general education science classrooms.

## CHAPTER THREE: METHODOLOGY

### Introduction

The purpose of this study was to evaluate science content understanding and engagement of students with learning disabilities (LD) in inclusive science classrooms through the use of UDL-E tools. This chapter begins with an introduction of the research questions that guide the study, followed by a list of construct definitions, a description of the participants and setting. The methodological research details are presented next, and include: (a) research design, (b) research timeline, (c) research procedures, (d) dependent and independent variables, (e) data collection, and (f) data analysis

### Research Question

In this study, the researcher used a quasi-experimental design anchored in the theoretical framework of Universal Design for Learning (UDL) expression principle through using performance-based assessment, curriculum based assessment, and case study observations. This framework was explored using the following four research questions.

#### Research Questions:

1. How do students with LD demonstrate learner attention or engagement during instruction in inclusive science classrooms?
2. How do students with LD demonstrate their understanding of the material learned in science in inclusive science classrooms?

3. Does the implementation of UDL- E principle impact student understanding of science content as measured by the number of correct vocabulary words used from the lesson?
4. Does the use of UDL-E principle impact the curriculum based assessment outcomes for students with LD in science?

### General Research Hypothesis

#### Null Hypothesis for Question 3:

No statistical significant difference exists in the number of correct vocabulary words used by students who use UDL-E framework tools to express science content understanding.

#### Null Hypothesis for Question 4

No statistical significant difference exists in science chapter pretest and posttest assessment outcomes by students who use UDL-E framework tools to express science content understanding.

### Setting and Population

The population and setting for this study included four eighth grade middle school inclusive science classrooms in the central Florida area. Grades 6, 7 and 8 comprised the middle school setting. The student sample was dependent on the selection of one individual teacher who was selected for the study. The population in this study were students in inclusive science classes taught by the general education science teacher only, where as some inclusive content classes in this school district have the special education teacher in the classroom as a support facilitator. The student to teacher ratio for the participating teacher was 21:1 which was above

the district 15:1 average. Permission to participate in this study was received by the district (see Appendix B), the school principal (see Appendix C), the teacher (Appendix C) and the student participants (see Appendix D).

### Study Participants

The participants for this study were eighth grade middle school students in inclusive science classes taught by one teacher of a four teacher team. One class, held during Period 2 and receiving instruction in the morning and one class held during Period 5 and receiving instruction in the afternoon is hereby known as Group A. Classes held during Period 3 and receiving instruction in the morning and during Period 7 and taught in the afternoon are hereby known as Group B. Data were collected on all students, both students with LD and students without LD. Group A contained 5 students with LD and 36 students without disabilities. Group B contained 8 students with LD and 32 students without disabilities. Period 4 was eliminated due to excessive weekly absences from school for students with LD. In addition to the two groups, a student with LD was chosen from each participating class as participants for case study observations and interviews. Case study students were chosen as students identified with having a LD and also having the lowest FCAT reading score and Lexile score in their particular inclusive science classroom. This purposive sample of participants are noted in Table 4.

**Table 4: Case Study Students Demographics**

	Student 1A	Student 2B	Student 3A	Student 4B
Class Period	A.M.	A.M.	P.M.	P.M.
DOB/Age	5/25/98 14 yrs	5/18/99 13 yrs.	8/14/98 14 yrs.	7/25/97 15 yrs.
Gender	Female	Male	Male	Male
ESE	SLD	SLD	SLD	SLD
FCAT Reading	3	2	1	2
Lexile	1010	935	860	965
Notes	Math FCAT 3 Writing on grade level	Math FCAT 1 Offer scribe for lengthy notes	Math FCAT 2 Writing on Grade level	Math FCAT 1 Writing on grade level

Participant 1, Student 1A, was a 14 year old female student with SLD in Period 2. Her most recent IEP indicated that she was on grade level for Reading, Mathematics, and Writing for the previous academic year. Student 1A's previous FCAT score in Reading was 3 and Mathematics was 3 and Reading Lexile score was 1010. A FCAT score of three indicates that the student has partial success with the content but still demonstrates some inconsistencies (Florida Department of Education, 2008) and a Lexile of 1010 falls in the Lexile range for a reading grade level of seventh grade range from 735 to 1065 to a 11<sup>th</sup>/12<sup>th</sup> grade level at 940-1210 lexile (Metrametrics, 2013). IEP accommodations for Student 1A were extended time during assessments as well as use of the testing center. In addition, she may have had directions



clarified and she also had an accommodation to allow extended time to complete assignments. During the eighth grade year, her schedule consisted of Algebra I, US History, Science, PE-Body Management, Language Arts, Peer Counseling/Study Hall, and Spanish I at the high school. The researcher learned that Student 1A did not pass her Algebra I end of course exam and therefore did not earn the high school credit. Her GPA prior to the end of course and semester exams was 3.6. Student 1A came from a split family, where both biological parents were divorced and remarried. She had two older siblings in high school. She missed 10 academic days during the second semester all at the end of the academic year when her family took a vacation prior to the end of the semester.

Participant 2, Student 2B, was a 13 year old student with SLD in Period 3. Student 2B's IEP indicated that he was currently on grade level for Reading, and Mathematics. His previous FCAT score in Reading was 2 and Mathematics was 1, while Reading Lexile score was 935. An FCAT score of two indicates that the student has limited success with challenging content whereas, a one indicates that the student has little success with challenging content (Florida Department of Education, 2008). A reading Lexile score of 935 falls between a sixth grade level (665 to 1000) through a 12<sup>th</sup> grade level (940 to 1210) (Metrametrics, 2013). The IEP accommodations for Student 2B were extended time during assessments as well as use of the testing center and test items to be read. In addition, he could have a scribe for lengthy writing assignments. Classroom accommodations for Student 2B were for the teacher to provide classroom notes, student needed preferential seating, and allowance for extended time to complete assignments. Other classroom accommodations were for the student to be prompted to use self-advocacy skills, have fewer problems for mastery, teacher-check for understanding

throughout lessons, and use of scribe or computer for lengthy writing assignments. During the eighth grade year, Student 2B's schedule consisted of Pre-Algebra, Intensive Mathematics, Science, Intensive Language Arts, Language Arts, Intensive Reading and U.S. History. At the time of the study he lived with both parents in the home and one younger sibling. Student 2B's GPA to date prior to end of semester exams was 2.39. He missed 19 academic days during the second semester.

Participant 3, Student 3A, was a 14 year old student with SLD in Period 5. Student 3A's most recent IEP indicated that he was below grade level for Reading and Mathematics. His previous FCAT score in Reading was 1 and Mathematics was 1 and Reading Lexile score was 860. A reading Lexile of 860 falls between the range of a fifth grade level of 565 to 910 and a ninth grade reading level range from 855 to 1165 (Metrametrics, 2013). The IEP accommodations for Student 3A, were extended time during assessments as well as use of the testing center and support in reading test items. In addition, classroom accommodations for Student 3B were extended time to complete assignments, remind student to use planner due to weak organizational skills and reminders for homework completion due to history of student not completing assignments. During the eighth grade year, his schedule consisted of Pre-Algebra, Intensive Mathematics, History, Intensive Reading, Science, Language Arts, and Learning Strategies. Student 3A resided with a split family with one younger sibling from parent's second marriage. His GPA to date prior to end of semester exams was 1.5. Student 3A missed 21 academic days during the second semester most occurring during third quarter due to the need to care for a younger sibling. Upon his return to school from his absence Student 3B informed the teacher that "I am here until the end of the year. No more absences."

Participant 4, Student 4B, was a 15 year old student with SLD in Period 7. Student 4B's most recent IEP indicated that he was below grade level for Reading and Mathematics, but on grade level for Writing. His previous FCAT score in Reading was 2 and Mathematics was 1 and Reading Lexile score was 965. A reading Lexile of 965 falls between the sixth grade level range of 665 and 1000 to a 11<sup>th</sup>/12<sup>th</sup> grade range of 940 to 1210 (Metrametrics, 2013). The IEP accommodations for him were extended time during assessments and use of the testing center. Student 4B could also have test items read and used a calculator when needed. In addition, classroom accommodations for him were preferential seating, reminders to use his planner and turn in homework due to difficulty completing assignments. Student 4B had low technology skills and required assistance with Blackboard and a computer. During the eighth grade year, Student 4B's schedule consisted of Intensive Mathematics, Intensive Reading, Pre-Algebra, Language Arts, Science, History, PE-Body Management, and ROTC. Student 4B did have a split family where biological parents are divorced and remarried. His GPA at the end of semester exams was 2.0 and he missed one academic day during the second semester.

### Research Design

This study encompassed a quasi-experimental replicated nonequivalent control group design with the enrichment of multiple case studies. A nonequivalent control group design requires that a pretest and a posttest be given to both an experimental group and a control group both of which do not have pre-experimental sampling (Campbell & Stanley, 1963). The groups in a nonequivalent design are typically already assembled classrooms and the implementation of the intervention is under the researcher's control (Campbell & Stanley, 1963). Both quantitative and qualitative data were collected and analyzed. Qualitative data were collected using a case

study approach. According to Yin (2009), case study research examines a case within a real-life context. Glesne (2011) and Creswell (2013) support Yin's concept of case study through the distinction that case studies tend to involve an in-depth, detailed collection of data and are often a longitudinal examination of bounded data gathered through participant observations, in-depth interviews, document collection and analysis of documents and other data. This study involved a multiple case study approach allowing the researcher to evaluate one issue or concern through multiple cases (Creswell, 2013). A secondary purpose of this study was to examine how students with LD demonstrate learner engagement and understanding in inclusive science classrooms during instruction and to determine how the implementation of the UDL-E principle affected the number of science vocabulary words used correctly, student engagement, time-on-task, and curriculum-based assessment outcomes when implementing the UDL-E principle.

### Procedures

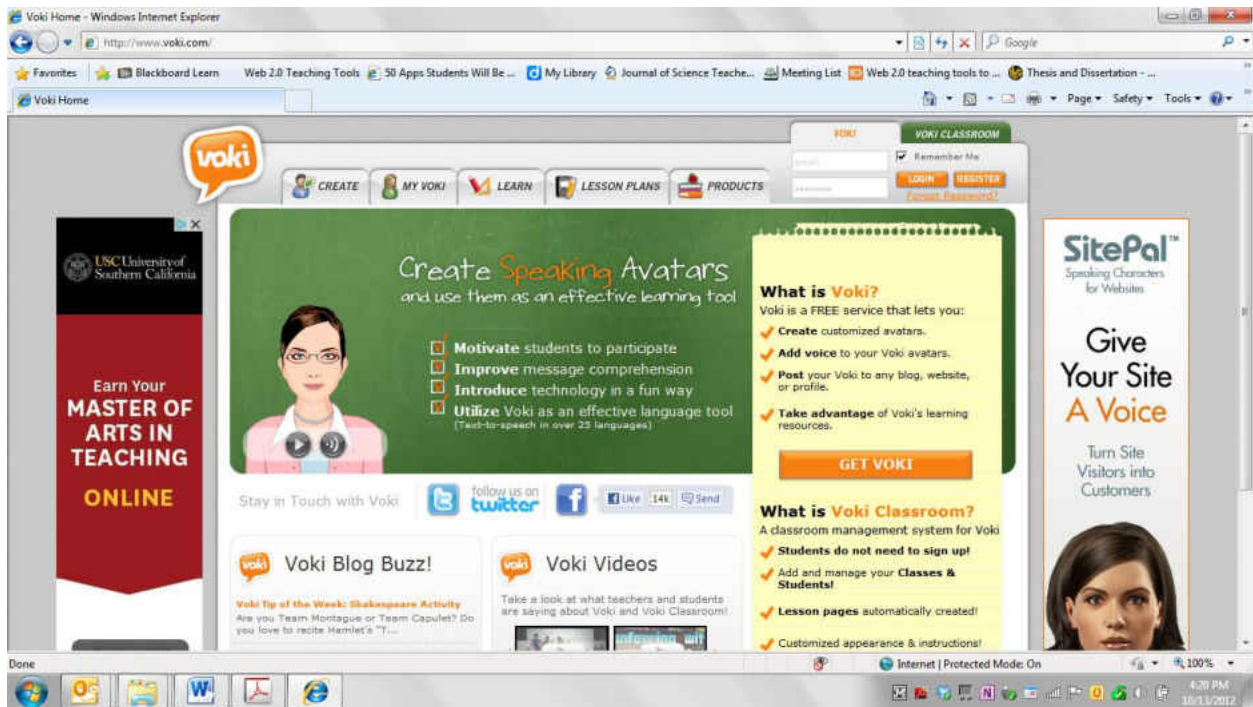
This study included four activities or lessons of science as outlined in the Research Procedure Timeline (see Appendix G) that involved all students participating in the implementation of UDL-E. The students in this study took a curriculum-based (CBA) pretest for each lesson activity of study prior to instruction beginning for each lesson followed by a CBA posttest. During Lesson 1, no intervention occurred and both Groups A and B were given a pre and post CBA. All students completed the Motivated Strategies Learner Questionnaire after the Lesson 1 Posttest. During Lessons 2 and 3, interventions occurred using UDL-E principles. The intervention phase consisted of students choosing a UDL-E tool to express their science vocabulary and concept understanding before administering the final CBA posttest. During Lesson 2, Group A received the intervention and Group B acted as a control. During Lesson 3,

Group B received the intervention and Group A acted as a control. The product created using the UDL-E tool was known as a UDL-E Performance-based assessment (UDL-E PBA) product and was evaluated for the correct use of the science vocabulary.

Prior to Lesson 2 and Lesson 3 occurring, students were given a list of three tools that they could use for UDL-E. To assist students in their selection of an approach to express their knowledge students were asked to watch the published tutorials of the UDL-E web-based tools offered. The paper and pencil option did not have a tutorial. The UDL-E tools were introduced in the following order for both units and across both groups during the group's intervention phase: Voki, then VoiceThread and finally explaining the paper and pencil option. Students had a minimum of one block schedule class period to explore and practice with both UDL-E web-based tools. Students completed a UDL-E Tool Evaluation Form (see Appendix K) indicating their comfort level with the UDL-E tools and then the method in which they chose for the UDL-E intervention. Students in the intervention phase were given a form with the UDL-E procedures (see Appendix M) and with their UDL-E tool chosen listed. Students who chose Voki and VoiceThread were also given their passwords to complete their assignment. UDL-E product directions were read aloud and questions answered by the researcher prior to releasing students to complete the UDL-E PBA product to express their science content knowledge using the method of choice for UDL-E. Students received the CBA posttest during the next class period. Students in the control group received an assignment from the teacher to be completed with tablemates during the class period. All UDL-E activities were evaluated utilizing the Science Vocabulary Checklist (see Appendix I).

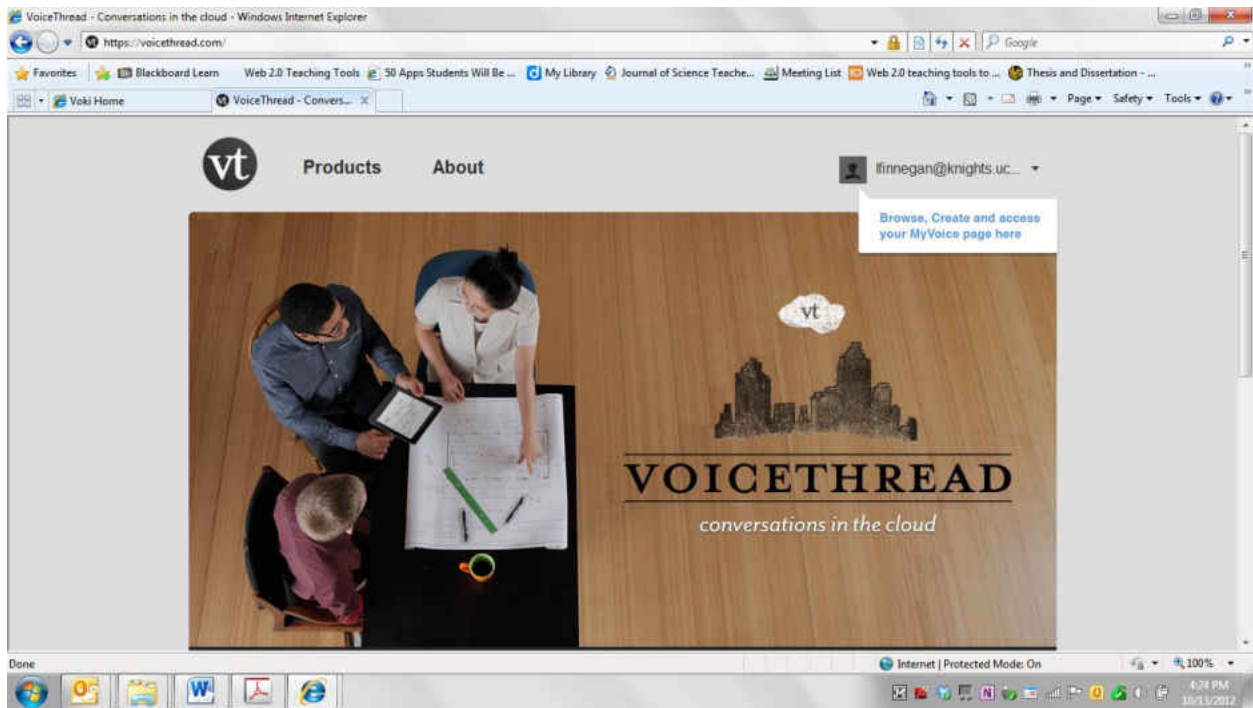
During Lesson 4, no intervention occurred and both Groups A and B were given a pre and post CBA. The researcher interviewed the case study participant and three randomly chosen students from each class to share their thoughts and perceptions about the UDL-E tools and their perceived personal learner behaviors.

One UDL-E tool that students could choose was Voki. Voki's are created by *Oddcast*, a New York based company that has been creating speaking characters on the web. Voki allows students to express themselves on the web in their own voice using a talking character. Voki characters can be designed to look like the creator or to take on the identity of other types of characters including animals, monsters, anime, or others. Each individual can make their Voki speak with their own voice which is added via microphone, can be uploaded, or added by phone. Each Voki can live on a blog, social network profile and will soon be integrated in various instant messaging platforms.



**Figure 1 Voki Technology Tool Webpage**

The second UDL-E web-based tool that students could choose to use was VoiceThread. A VoiceThread is a collaborative, multimedia slide show that holds images, documents, and videos and allows people to navigate slides and comment using voice (with a microphone or telephone), text, audio file, or video (via a webcam). VoiceThread can be shared and allows others to record comments also. The creator can doodle while commenting. VoiceThreads can be embedded to show and receive comments on other websites and exported to MP3 players or DVDs to play as archival movies.



**Figure 2: Voicethread Technology Tool Webpage**

A third and final UDL-E tool option that students could choose to express their science content knowledge was through using paper and pencils. The paper and pencil option was to provide students the opportunity to express their knowledge using a no-tech tool whereby they could either write an explanation or illustrate a diagram and label and explain the content.

Both Groups A and B took a student engagement survey after the Lesson 1 posttest and prior to the UDL-E intervention being initiated. During Lesson 4, Group A and Group B took a curriculum-based pretest before the lesson of study and a CBA posttest at the end of the lesson of study. No intervention was provided during Lesson 4. Pretest scores were analyzed against posttest scores (differentials) for all four lessons for each group independent of each other due to differences in curriculum content. Case study students along with three randomly selected



classmates participated in small focus group interviews regarding their perceptions of the tools used during the intervention phases, their perceptions about technology and personal learning behaviors.

### Instrumentation

Four different types of instruments were used in this study: (1) the Pearson Publishers CBA pretest and posttest (Appendix H); (2) the Science Vocabulary Checklist (see Appendix I); (3) the Time-on-Task Observation Form (see Appendix L) and (4) a student engagement survey, Motivated Strategies for Learning Questionnaire (MSLQ) (see Appendix J). In addition, at the conclusion of the study focus group questions were asked of students to better understand their thoughts about using UDL-E to understand science concepts.

Students completed the MSLQ a self-reporting survey (see Appendix J) on student engagement used to measure motivational beliefs and self-regulated learning strategies. The researcher read each statement and frequently reminded students to think of themselves only in science. Group A and Group B completed the MSLQ survey after Lesson 1 posttest and prior to Lesson 2 instruction. “The MSLQ was developed by a team of researchers from the National Center for Research to Improve Postsecondary Teaching and Learning (NCRIPTAL) and the School of Education at the University of Michigan” (Pintrich, Smith, Garcia & McKeachie, 1993, p. 802). Although originally developed for use with college students in mind, the MSLQ was adapted for middle school by the developers (Pintrich & DeGroot, 1990).

## Data Collection Procedures

Data collection of the research occurred in the spring semester over a 10 week period within the school districts' pacing guide. The researcher prepared materials for the study prior to requesting participant permission. Material preparation included locating the tutorials created by each web-based tool developer for each of the UDL-E tools selected for this study. The researcher developed a science vocabulary record form (Appendix I), and a time-on-task record (Appendix L) form that was used to collect data. The researcher also established a variety of TOT sub-behavior codes (Appendix L) to further identify specific on-task and off-task behavior. The researcher used the teacher-created curriculum publishers' test resources for the pretest and posttest (Appendix H) for each lesson of study.

All students were identified by a numerical identifier. The numerical identifier was used to label pretests, posttests, UDL-E PBA products, recording forms, and reflections from students in the focus groups. The researcher replaced student name identifiers for the case studies with Student 1A, 2B, 3A and 4B.

There are four dependent variables that were used in the data collection of this research study. The first was student pretest-posttest scores on curriculum-based assessments (see Appendix H). The lesson tests were teacher created from a databank of lesson questions created by Pearson Curriculum Publishers. The second dependent variable was the number of correct vocabulary words expressed in the Science Vocabulary Checklist (Appendix I). Additionally student engagement perceptions were evaluated through the MSLQ (Appendix J). Finally, time-on-task (TOT) observations were measured using a 1 minute time sampling procedure for students with LD during science lessons and activities as well as during the UDL-E intervention.

Prior to data collection beginning, the researcher sat in the classroom to allow students to adjust to the researcher's presence. The researcher gathered preliminary data on all students. These data comprised students' grades, teacher grading system, students' assignments, curriculum and status of curriculum within the district pacing guidelines. The researcher also reviewed the projected schedule which included district Spring Break (minus six days), FCAT review (minus 10 days), and FCAT testing (minus 7 days) that were yet to occur before the end of the academic year. After analyzing the classroom data the researcher determined the four classes that would participate in the study based on the information the teacher provided regarding the absences for the students with LD in the fourth period class. One student was chosen from each of the four participating classes to be a participant in the case study Time-on-task (TOT) observations. Along with being a student with LD, the students chosen had the lowest FCAT Reading score and Lexile Reading score of all students with LD in each class.

Throughout the research timeline the researcher observed the four case study students. The researcher observed students on academic days which consisted of a traditional period schedule on Mondays, Thursdays and Fridays and a block schedule on Tuesdays and Wednesdays. Observations included instructional time as well as lab activities; however transition times were not recorded. Observations were not conducted on the days that student's had chapter tests due to their accommodation of testing in the testing center. The TOT observations were completed using a 1 minute random scan. Field notes regarding student TOT behaviors were recorded and further analyzed using the on-task and off-task sub-behavior codes (Appendix L).

### Treatment of Fidelity

The researcher used several measures to ensure fidelity. Students took the same version of the curriculum-based assessment created by the classroom teacher. Students viewed the technology software company's tutorials on how to use each of the UDL-E tools offered as options and were provided in the same order to both groups. Students were provided classroom time to practice with all UDL-E tools prior to making a selection for the intervention phase. Directions for the UDL-E PBA products were typed and read to all students prior to students creating their UDL-E PBA product. The teacher provided classroom management and instruction for the all content during case study observations. The teacher was also present and provided student support with the researcher as students both explored the tech tools prior to and during UDL-E product creation.

### Reliability

One additional inter-observer assisted the researcher by observing 30% of the observations for TOT during instructional or lab activity time as well as during the UDL-E intervention. The inter-rater observer was trained to follow an interval scan procedure and used the Time-On-Task form. The inter-rater was trained to score the UDL-E PBA products for number of science words used correctly and to document words (Appendix I). The inter-rater also evaluated coded interview themes. The inter-rater and the researcher attained 83% or greater agreement at a minimum of 30% of recorded sessions for all inter-rater required activities, thereby attaining high inter-rater reliability (Kazdin,1982).

## Validity

The researcher in this study analyzed content validity, construct validity, internal validity and external validity. The pacing guide of the school district within this study took place required students to respond to key concept questions and understand science vocabulary terms. The CBA used in this study and the UDL-E product required students to answer key concepts and know and use the science vocabulary providing content validity. To look at engagement, the MSLQ student engagement survey was used. The MSLQ was validated using a sample of 173 seventh grade students across 15 classrooms (Pintrich & DeGroot, 1990). The Middle School MSLQ contains five subscales, two of which are relevant for engagement. Research by Pintrich and DeGroot (1990) reported Cronbach's alphas of .83-.88 for cognitive strategy use scale and .63-.73 for self-regulation scale. Additionally, construct validity is reported from correlational studies and criterion-related validity was also demonstrated through correlations of strategy use and self-regulation with indicators of academic performance (Pintrich & DeGroot, 1990). Focus group interviews were coded for themes and correlated with scores on the MSLQ survey demonstrating construct validity or "the degree to which scores on a scale have a pattern of correlation with other scores or attributes that would predicted by a sound, well-established theory", (Slavin, 2007, p. 182), that is, the theory of engagement for the purposes of this study.

To ensure internal validity, Campbell and Stanley (1963) suggest the researcher ask "Did in fact the experimental treatments make a difference in this specific instance (p. 5)? Efforts were made to reduce threats to internal validity through the research method of a quasi-experimental replicated nonequivalent control group design to control for the lack of

randomization. This research design is one of the most widely used experimental designs in educational research (Campbell & Stanley, 1963).

External validity can be answered through asking, “to what populations, settings, treatment variables, and measurement variables can this effect be generalized?” (p. 5). This study evaluated students with LD and students without LD and support the ideal of generalization through a non-replicated control group design.

The researcher for this study utilized previously validated instruments. To determine the validity in the number of correct science words used, a word checklist was used to compare the number of science vocabulary words used in the UDL-E PBA product and the number of science vocabulary words identified in the textbook per lesson thereby demonstrating face validity or the “degree to which the measure appears to assess what it supposed to measure” (Slavin, 2007, p. 179) that is, the correct science lesson vocabulary word.

### Data Analysis

In this study, the researcher utilized the MSLQ student engagement survey to measure cognitive and emotional student engagement, Pearson Interactive curriculum materials to evaluate student understanding, a science vocabulary checklist created using the curriculum materials to determine the number of correct vocabulary words expressed from each lesson, coding was used to analyze time-on-task observations and interviews were themed to evaluate learner perceptions and reflections during UDL-E activity and during general science activities. Once the data collection was completed, both quantitative and qualitative analyses were conducted. Mean differences were calculated from the pretest/posttest data and TOT data to

evaluate the effects of UDL-E versus traditional curriculum-based assignments for each group and for the groups compared to the case study students.

To answer the first research question, the researcher completed observations for time-on-task (TOT) of four students throughout the duration of the research timeline. Students exhibiting TOT was defined as the time that a student was fully engaged in an activity whereby they were writing, talking, looking, and participating in the designated activity being observed for on-task behavior and not an unrelated activity. The TOT behaviors were further analyzed through the evaluation of looking at the mean differences of specific on-task and off-task behaviors.

The second question was analyzed through the identification of themes from the interviews. Student reflections additionally supported data findings of student comfort level with web-based tools, TOT, and learner engagement.

For the third question, the researcher analyzed the mean differences on the Science Vocabulary Checklist for the case study students compared with their peers.

Finally, the fourth question was evaluated using Repeated-measures Analysis of Variance (ANOVA). Repeated-measures ANOVA's are used when a researcher is interested in observing a group repeatedly as in the case of the four pretests and posttests students encountered in this study (Stevens, 2007).

## CHAPTER FOUR: RESULTS

In this chapter, the researcher provides outcomes from a quasi-experimental study using a multiple case and a non-replicated control group design of students in four eighth grade science classrooms. This study was a validation of current practice in science and use of technology tools along with a glimpse of Universal Design for Learning Expression (UDL-E) principle's impact on students with LD and their classmates in inclusive science environments. The results of the research are presented in two phases. First, multiple case studies are presented followed by an analysis of quantitative data on curriculum-based assessment outcomes, survey data, and interviews to determine the impact of using Universal Design for Learning through Expression in science. Following a summary of the findings, the researcher provides a discussion of the data from a learner survey, curriculum-based assessments, and interviews. A discussion of how the data were analyzed and triangulated, are also provided. Finally, a description of the overarching themes that emerged from the data analysis and triangulation of multiple sources are presented from sources of: (a) records review, (b) curriculum-based assessment, (c) field notes, (d) teacher and student surveys, and (e) student interviews. The chapter concludes with a summary of the findings of the use of UDL-E.

### Research Questions

The following research questions were used to guide the data analysis across the four case study students and the quantitative data collected across the four classes of eighth grade science:



1. How do students with SLD demonstrate learner attention or engagement during instruction in inclusive science classes?
2. How do students with SLD demonstrate their understanding and recognize their understanding of the material learned in inclusive science classes?
3. Does the implementation of UDL- E principle impact student understanding of science content as measured by the number of correct vocabulary words used from the lesson?
4. Does the use of UDL-E principle impact the curriculum based assessment outcomes for students with LD in science?

A total of four students with LD, one student from each participating class, were selected for the case study analysis. Case study students were chosen based on being a student with LD in an inclusive science classroom and having the lowest score on the state test in reading and the lowest reading Lexile score for that class. The students in all four of the teacher's classes were observed and data were coded for the quantitative analyses. The case study and selected students within each class were observed using the TOT Observation Form found in Appendix L. The researcher also collected field notes from observations during each student's science class and for all students data were collected on classwork, homework, tests scores, engagement survey, and UDL-E products (Appendix M), including the number of science vocabulary words using the UDL-E activity. Group A students received the UDL-E intervention during Lesson 2, while Group B students served as a control. Group B students received the UDL-E intervention during Lesson 3, while Group B students served as a control. The case study students are identified with an A or B to show which control group they were in during the study. The researcher also

interviewed the case study students and 15 other students at the conclusion of the study. The researchers' observations occurred over 10 weeks within an inclusive science classroom making it bound by time and place.

## Data Analysis

### Time-On Task

To answer the first research question, the researcher completed observations for time-on-task (TOT) of four students throughout the duration of the research timeline. Students were observed in the classroom setting during instruction and lab activities but not during chapter tests as all students were removed per their Individual Education Program (IEP) that required accommodations to occur outside of the general education setting. In addition, some disruptions in observations occurred due to district Spring Break, State testing, and teacher training.

On-task and off-task behaviors were coded using the list of identifying sub-behaviors in Appendix L. Table 5 provides a listing of the on-task and off-task sub-behaviors and identifying characteristics used to code these behaviors observed during the case study observations. Each student was observed at one-minute time intervals and all behaviors were coded in only one category at each interval. Student 1A was observed during eight class periods, Student 3A was observed during 10 class periods, and Student 2B and 4B were both observed during 11 class periods. Any behaviors displayed by students were coded under the categories described in Table 5. For example, Student 2B would occasionally play with the strings of his hooded sweatshirt. This behavior was coded as SI for Student Inattentive and validated using Inter-rater Agreement as were 25% of all observations.

**Table 5: TOT Sub-behavior Codes**

Sub-behavior	Student behavior or characteristics
LRT	Looking or Reading Text. The student is looking at or reading their text pages or handout distributed in class.
ETS	Eyes on Teacher or Student. The student is looking at the teacher during instruction or student responding to a teacher directed question.
SW	Student Writing. The student is writing on their text pages, notepaper, quiz, etc.
SR	Student Response. The student is responding to a question posed by the teacher or participating in class discussion related to the lesson.
SGA	Student or Group Activity. The student is participating in a student activity or group activity such as a lab, web-quest activity, UDL-E activity. Writing during SGA activities will be included under the SGA activity.
EBS	Eyes on the Board or Screen. The student is looking at the whiteboard or screen where lessons are presented.
PI	Peer Interaction. The student may be talking with peers or peers talking to student.
SI	Student is Inattentive. Student may be looking down at floor, desk, or across room.
SDE	Student is Disengaged. Student may have their head down on the desk or working on another assignment.

The percentage of each behavior observed for the case study students are provided in Table 6. The four case study students collectively averaged 75% for being on-task and hence 25% of the time they were off-task. On-task behavior ranged from 66% to 90 % of all observation occurrences, while off-task behavior ranged from 10% to 34%. Student 1A had the highest rate of time on-task (90%).

**Table 6: Percentage of TOT Sub-behaviors**

Student	LRT	ETS	SW	SR	SGA	EBS	PI	SI	SDE	On Task	Off Task
Student 1A	14	11	27	0	17	21	6	4	0	90	10
Student 2B	19	2	21	0	16	12	4	15	15	66	34
Student 3A	16	6	14	1	19	16	15	10	2	73	27
Student 4B	10	7	15	0	18	22	9	18	1	72	28
Average	14.75	6.5	19.25	0.25	17.5	17	8.5	11.75	4.5	75	25
Stan. Dev.	3.77	3.7	6.02	0.50	1.29	5.94	4.80	6.13	7.05		

The percentage for SR was the lowest of all on-task sub-behaviors during observations. Case study students collectively spent the greatest percentage of their time-on-task in writing (SW) (19.25%), followed by actively participating in group activity or independent activity (SGA) at 17.5%, and when looking at the board or screen where lessons were displayed (EBS) (11.75%) respectively. Case study students jointly displayed greater off-task sub-behaviors in areas not surprising of inattentive tasks (SI) (11.75%) followed by peer interactions (PI) (8.5%).

On-task and off-task sub-behavior averages for the case study students collectively for pre-UDL-E and during UDL-E are provided in Table 7. The pre-UDL-E values are based on the averages of four observations that occurred for all students for the same four lessons prior to the UDL-E intervention. The UDL-E score consists of only one observation that occurred during the UDL-E intervention.

Student 1A's pre-UDL TOT ranged from 94% to 100% with an average of 96%. Her TOT during the UDL-E intervention was at 93%. Time on-task for writing (SW) ranged from 23% to 56% with an average of 36%. Student 1A's SW was 9% during the UDL-E intervention while her time spent looking at or reading the text pages (LRT) ranged between 10% to 33%. During the UDL-E intervention her LRT decreased 0%. Prior to the UDL-E intervention, Student 1A's active participation in a group or other activity (SGA) ranged from 0% to 7% with an average of 3%. During the UDL-E intervention Student 1A's SGA was 85% while her off-task SI ranged from 0% to 3% with an average of 2% and this behavior was also 2% during UDL-E. Student 1A's peer interaction (PI) pre-UDL-E ranged from 0% to 3% with an average of 1% and PI was 4% during the UDL-E intervention.

Student 2B's pre-UDL TOT ranged from 32% to 85% with an average of 64%. His TOT during the UDL-E intervention increased to 71%. Time on-task for writing (SW) ranged from 10 to 32% of observation occurrences with an average of 22%. During UDL-E, Student 2B's SW decreased to 9%. Student 2B's time spent looking at or reading the text pages (LRT) ranged between 4 to 40% and averaged 9% pre-UDL-E and remained at 9% post UDL-E. During the UDL-E Student 2B's active participation in a group or other activity (SGA) was 49% while his SI increased to 20% and his PI decreased from 5% pre-UDL-E to 4%

Student 3A's pre-UDL TOT ranged from 61% to 86% of observation occurrences with an average of 72%. His TOT during the UDL-E intervention decreased to 61%. The time spent writing (SW) for Student 3A ranged from 15 to 26% with an average of 21% and decreased to 13% during the UDL-E intervention. Student 3A's time spent looking at or reading text pages (LRT) ranged between 13 to 34% and averaged 21%. During the UDL-E intervention LRT decreased to 0%. Prior to the UDL-E intervention, Student's 3A's active participation in a group or other activity (SGA) ranged from 0% to 9% with an average of 4% however during the UDL-E intervention SGA sub- behavior increased 37%. Student 3A's inattentive behaviors (SI) ranged averaged 7% both pre and during UDL-E but his peer interaction (PI) which ranged from 9% to 23% increased from 16% pre-UDL-E to 33% during the UDL-E intervention.

Student 4B's pre-UDL TOT ranged from 67% to 84% of observation occurrences with an average of 75%. His TOT during the UDL-E intervention was slightly greater at 78%. Pre-UDL-E, writing (SW) ranged from 6% to 50% with an average of 29%. His SW decreased to 9% during the UDL-E intervention. Student 4B's time spent looking at or reading test pages (LRT) ranged between 0% to 14% and averaged 5% pre-UDL-E and decreased to 0% during UDL-E

while his active participation in a group or other activity (SGA) ranged from 0% to 12% with an average of 4% pre UDL-E and increased to 70% during UDL-E. The inattentive behavior (SI), for Student 4B ranged from 4% to 33% and averaged 15%, it decreased to 9% during UDL-E while his increased slightly from 11% to 13% during UDL-E.

The nature of peer interactions of the case study students, pre-UDL-E and during UDL-E varied in the types of interactions and incidences of what was considered “off task” behavior. Pre-UDL-E peer interactions were considered more disruptive to the case study students learning. Pre-UDL-E, case study students were either drawn into conversations that were unrelated to the learning that was occurring in the classroom by their tablemates or by classmates at another table. These types of peer interactions had a negative lens according to the researcher due to their disruptive nature to learning and working. During UDL-E the peer interactions among the case study students and their classmates focused on student directed questions to peers for support on how to create features on an avatar or how students answered the lesson question as well as excitedly sharing their avatar creations. These types of peer interactions had a positive lens according to the researcher as students worked together or in support of each other to solve a problem and lent to student engagement. Codes for positive peer interactions were not developed prior to the study and therefore were perceived as negative when in actuality the peer interactions during the UDL-E intervention were positive in nature.



**Table 7: Case Study Students Pre-UDL-E and UDL-E TOT-Task Sub-behaviors**

	Time On-task		SW		LRT		SGA		SI		PI	
	PreUDL-E/Range	UDL-E	PreUDL-E/Range	UDL-E	PreUDL-E/Range	UDL-E	PreUDL-E/Range	UDL-E	PreUDL-E/Range	UDL-E	PreUDL-E/Range	UDL-E
Student 1A	96% 94-100	93%	36% 23-56	9%	17% 10-33	0%	3% 0-7	85%	2% 0-3	2%	1% 0-3	4%
Student 2B	64% 32-85	71%	22% 10-32	9%	22% 4-40	9%	5% 0-17	49%	13% 4-25	20%	5% 0-21	4%
Student 3A	72% 61-86	61%	21% 15-26	13%	21% 13-34	0%	4% 0-9	37%	7% 0-13	7%	16% 9-23	33%
Student 4B	75% 67-84	78%	29% 6-50	9%	5% 0-14	0%	4% 0-12	70%	15% 4-33	9%	11% 0-25	13%

## Student Comfort with Technology

All Students in all classrooms evaluated the UDL-E technology tools that were used in the study. Students rated the tools according to their comfort level after they explored the tool websites. The scale ranged from 0 to 5 with 0 being not comfortable at all to a 5 being very comfortable. Table 8 shows the mean comfort levels for the types of web-based UDL-E tools chosen by the four case study students collectively and for their classmates. The average rating for the case study students as a group on their comfort level for Voki was a 3.75, while VoiceThread was a 3.25, and Paper & Pencil was a 2.25. The classmates average comfort level rating for Voki was 3.78, VoiceThread was 2.6, and Paper & Pencil was 2.8. Voki had the highest comfort level rating for the case study students and for their classmate students. Individual groups and individual case study students' scores are provided in Tables 7 and 8.

**Table 8: Comfort Level Ratings of Technology Tools and Paper & Pencil Approach for UDL-E**

	Voki	VoiceThread	Paper & Pencil
Case Study Students	3.75	3.25	2.25
Classmate Students	3.78	2.6	2.8

UDL-E Tool comfort rating levels were also analyzed for the Groups. The average scores by Groups A and B and are provided in Table 9. Group A had an average comfort 3.9 rating for Voki ( $n=39$ ), a 2.67 comfort rating for VoiceThread ( $n=39$ ) and a 2.58 comfort rating for Paper and Pencil ( $n=36$ ). Differences in the number of responses were due to students not

completing a rating for the paper and pencil option. The researcher attempted to correct this missing data but was only successful with the students that were in attendance on that day. Group B indicated an average comfort rating of 3.58 for Voki ( $n=38$ ), 2.63 for VoiceThread ( $n=38$ ) and 2.79 for Paper & Pencil ( $n=34$ ).

**Table 9: Group A and Group B UDL-E Tool Comfort Rating**

Group		Voki Comfort	VoiceThread Comfort	P & P Comfort
A	Mean	3.97	2.67	2.58
	N	39	39	36
	Std. Deviation	.903	1.325	1.645
	% of Total	53.3%	51.0%	47.7%
	Sum			
B	Mean	3.58	2.63	3.00
	N	38	38	34
	Std. Deviation	1.081	1.303	1.651
	% of Total	46.7%	49.0%	52.3%
	Sum			
Total	Mean	3.78	2.65	2.79
	N	77	77	70
	Std. Deviation	1.008	1.306	1.650
	% of Total	100.0%	100.0%	100.0%
	Sum			

Once students evaluated the UDL-E tools and determined their comfort rating, the researcher requested that all students make a determination on the tool that they would chose for the UDL-E intervention. Table 10 provides the frequencies with which students chose each tool. Voki (Tool 1) was chosen by for 68.4% ( $n=52$ ), VoiceThread (Tool 2) by 18.4% ( $n=14$ ) and Paper & Pencil (Tool 3) by 11.6% ( $n=10$ ) of the students in the study.

**Table 10: Frequencies for each UDL-E Tool**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	52	60.5	68.4	68.4
	2	14	16.3	18.4	86.8
	3	10	11.6	13.2	100.0
	Total	76	88.4	100.0	
Missing	System	10	11.6		
Total		86	100.0		

Individual case study students' comfort level ratings are provided in Table 11. Student 1A indicated the most comfort with Voki, but chose VoiceThread as her tool for UDL-E. Student 2B had the most comfort with Paper and Pencil yet chose to use Voki as did Student 3A who rated his highest comfort level with VoiceThread. Student 4B rated Voki at 4 as his greatest level of comfort and chose to use Voki during the UDL-E intervention.

**Table 11: Individual Case Study UDL-E Tool Comfort Rating and UDL-E Tool Choice**

	Voki	VoiceThread	Paper & Pencil	UDL-E Tool
Student 1A	4	5	3	VoiceThread
Student 2B	3	3	4	Voki
Student 3A	4	5	2	Voki
Student 4B	4	0	0	Voki

Two of the case study students who used Voki were available for interviews. Student 3A reflected that that "Voki was simple because everything was flat out in front of and available to

use.” He also indicated that password log-in system was not helpful and that he did have “trouble with that.” The researcher observed several students having difficulty with the password system for using Voki. Students initially went to the Voki site and did not click on the Classroom tab to enter their password and connect to the classroom section. Case study student 4B shared that he felt using the Voki was “easy and a fun thing to do.” He also indicated that he felt that when “It told you what you typed” it was helpful. Classmates comments also supported the thoughts shared by the case study students that chose to use Voki for their UDL-E activity.

The case study student that used VoiceThread for the UDL-E activity was absent for the interviews, however, another classmate that used VoiceThread was asked for his feedback. He stated, “It was easy to use because everything was precise. I didn’t like how it didn’t show a slide show as a practice so you know what our slides look like before you save it though.” Another VoiceThread user stated, “The buttons were simple and the directions were good” but also stated that the videos (tutorials) were not that helpful” for him. None of the case study students chose the option of using paper and pencil for UDL-E. A student from Group A who chose paper and pencil stated that he felt that using paper and pencil was easy because “it was simply writing without technology” but also acknowledged that his choice was because he considers himself “lazy.” Another classmate explained that she chose paper and pencil because it “was very easy for me because I love to write essays and stories. Writing is my favorite. All my thoughts come to me when I’m writing. That’s when I’m most comfortable and creative. I like to grip a pencil and reading a book.”

The curriculum utilized in this classroom was designed to integrate technology. The classroom had five laptops available at all times as well as access to a media lab across the hall

and mobile laptop lab carts. Students had limited opportunities to utilize the computers within the science classroom. The researcher observed students viewing BrainPop (FWD Media, Inc., 2013) videos as part of instruction, once the students used cell phones for a survey ( $N=1$ ) and participated in a webquest activity on balancing equations. Observations were further supported by the case study students and their classmates. Case study student 3A shared comments such as, “We use them (computers) in science. We use BrainPop (FWD Media, Inc., 2013).” Case study student 4B shared, “I use Google cuz I can look up answers.” Students from Groups A and B shared the following comments: “There really isn’t technology in our classes except for computers for tests and science tools for labs.”; “I don’t use any in any classes. I hate the computer for school. Hate it!”; “Honestly I don’t use technology when learning.”; “I am not using any in any of my classes.”; “We use BrainPop (FWD Media Inc., 2013) in science. It shows videos and asks questions.”; “Using our cell phones. We have done surveys with them.”; and “I usually use Microsoft Word for typed projects. I also use the internet for information about a subject.” The use of technology across all curriculum content appears to be minimal to non-existent however students do use it for projects and gaining information. Two students shared that they “enjoy using technology” and that not only is it “more in with our generation” and “makes things easier with written work and projects”, but that it can also have “a big impact in class.”

#### Vocabulary use and UDL-E

To determine if the implementation of UDL- E principle impacted student understanding of science content the number of correct vocabulary words used in the UDL-E lesson were counted. The researcher evaluated the case study students’ and their classmates’ UDL-E products

for the correct use of the science vocabulary words. Descriptive statistics were used to evaluate Group A's and Group B's UDL-E products for the use of the correct science vocabulary.

\ Table 12 provides the Science Vocabulary Form score frequency. A total of 68 students completed the UDL-E product scoring between a 0 and 6 points. The scores with the greatest frequency were four and six.

**Table 12: Frequency of UDL-E Product Scores**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	5	5.8	7.4	7.4
	1	7	8.1	10.3	17.6
	2	13	15.1	19.1	36.8
	3	4	4.7	5.9	42.6
	4	17	19.8	25.0	67.6
	5	5	5.8	7.4	75.0
	6	17	19.8	25.0	100.0
	Total	68	79.1	100.0	
Missing	System	18	20.9		
Total		86	100.0		

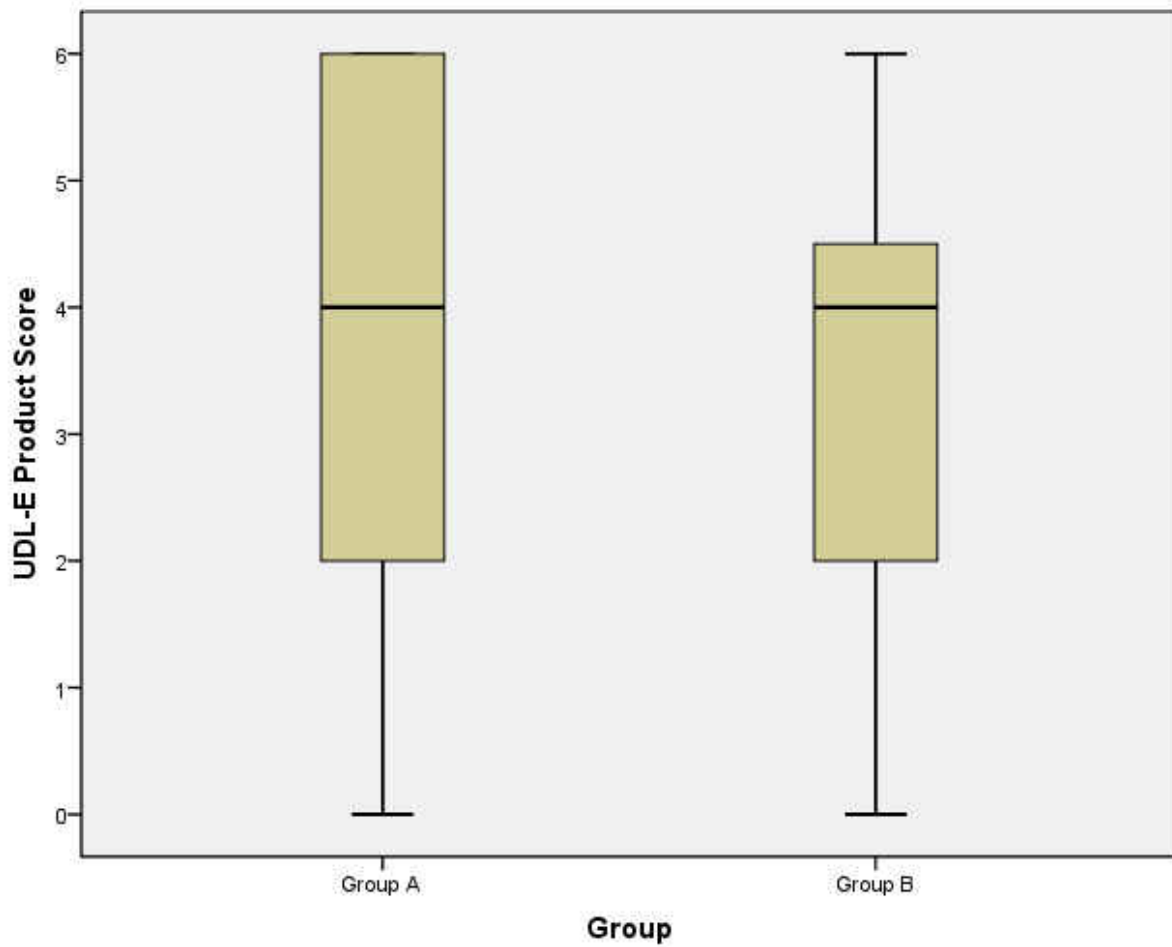
Table 13 shows the mean for Group A (3.51) with a *S.D.* 2.103 and Group B has a *M*= 3.55 with a *S.D.* = 1.804. Both Group A and B indicate a negative skewness and negative kurtosis. Group A and Group B have a Median of 4. Interquartile range for Group A equals 4 and the interquartile range for Group B equals 3. Although Group A and B had the same Median score of 4, Group A had a greater distribution in the range of scores than Group B.

**Table 13: Descriptive Statistics for Group A's and Group B's UDL-E Product Scores**

		Group		Statistic	Std. Error	
UDL-E Product Score	Group A	Mean		3.51	.346	
		95% Confidence	Lower Bound	2.81		
		Interval for Mean	Upper Bound	4.21		
		5% Trimmed Mean		3.57		
		Median		4.00		
		Variance		4.423		
		Std. Deviation		2.103		
		Minimum		0		
		Maximum		6		
				Interquartile Range	4	
			Skewness	-.181	.388	
			Kurtosis	-1.301	.759	
	Group B	Mean		3.55	.324	
		95% Confidence	Lower Bound	2.89		
		Interval for Mean	Upper Bound	4.21		
		5% Trimmed Mean		3.59		
		Median		4.00		
		Variance		3.256		
		Std. Deviation		1.804		
		Minimum		0		
		Maximum		6		
				Range	6	
				Interquartile Range	3	
				Skewness	-.284	.421
				Kurtosis	-.949	.821



The box plot below (Figure 3) does not display any outliers, the diagram shows that both Group A and Group B have the same mean  $M=4$ . Scores ranged for both Group A and B from 0 to 6 points total however Group A's scores indicate a greater amount of scores above the mean.



**Figure 3: Boxplot of Group UDL-E Product Scores**

Individual Case Study Students UDL-E Products scores are presented in Table 14. The average score of all Case Study Students was 3.25 out of a six point scale. Case Study Student 1A and Case Study Student 4B scored 6 points out of a possible six points. Student 1A used

VoiceThread and Student 4B used Voki. Case Study Student 2B scored 1 point and Case Study Student 3A scored 0 points and both students used Voki. Student 1 A and Student 4B both scored above the median, both scoring six points for the UDL-E product. Student 1A used VoiceThread and opted to create her own VoiceThread rather than respond only to the VoiceThread created by the researcher. She spent time searching for images that would support her explanation. Student 1A was the only case study student that chose VoiceThread as a tool and was a student who was an outlier in her average time-on-task behaviors at 90%. She was observed to have completed her classwork consistently. Student 4B chose Voki as the tool to express his science knowledge. Although he missed the directions to sign in on the Classroom table of the Voki website, he did create a Voki avatar and responded to the question stated on directions. Both Students 1A and 4B utilized their text pages and notes to assist them with their explanation. Case study Student 2B and Student 3A not only scored below the group Mean but also scored below case study students 1A and 4B. Student 2B scored a 1 because he only used 2 vocabulary words whereas Student 3A scored a 0 because he spent his entire period working on the Voki avatar creation and did not move ahead to creating a response to the question. Student 2B used his text pages to identify the vocabulary words used but he did not explain what the words meant. When asked he if needed any assistance, he indicated that he did not and both the researcher and the classroom teacher checked with him to confirm that he had answered the question on the directions page after the student had put his laptop in the cart. Student 2B indicated he had but upon checking by the researcher discovered that he had not. It is possible that Student 2B did not want to draw attention to himself from his classmates by receiving assistance or could have chosen to move on to the homework assignment in class so that he did

not have to complete the assignment at home. Student 3A received reminders from both the classroom teacher and the researcher to move on from creating the Voki avatar to completing the assignment by answering the question. He was reminded that he could use his text pages to help guide him in developing his response. Student 3A continued to disregard the reminders and at the class indicated that he was not finished. The researcher asked if Student 3A had access to a computer at home and could complete the assignment at home. Student 3A indicated that he did have a computer at home and he would complete the assignment but he did not. When asked the next day he replied that he had forgot and had homework in other classes that he had to do. It is possible that Student 3A did not understand the assignment or how to complete it even with the support of his text pages and notes and may have needed Student 1 A and Student 4B both scored above the median, both scoring six points for the UDL-E product. Student 1A used VoiceThread and opted to create her own VoiceThread rather than respond only to the VoiceThread created by the researcher. She spent time searching for images that would support her explanation. Student 1A was the only case study student that chose VoiceThread as a tool and was a student who was an outlier in her average time-on-task behaviors at 90%. She was observed to have completed her classwork consistently. Student 4B chose Voki as the tool to express his science knowledge. Although he missed the directions to sign in on the Classroom table of the Voki website, he did create a Voki avatar and responded to the question stated on directions. Both Students 1A and 4B utilized their text pages and notes to assist them with their explanation. Case study Student 2B and Student 3A not only scored below the group Mean but also scored below case study students 1A and 4B. Student 2B scored a 1 because he only used 2 vocabulary words whereas Student 3A scored a 0 because he spent his entire period working on

the Voki avatar creation and did not move ahead to creating a response to the question. Student 2B used his text pages to identify the vocabulary words used but he did not explain what the words meant. When asked he if needed any assistance, he indicated that he did not and both the researcher and the classroom teacher checked with him to confirm that he had answered the question on the directions page after the student had put his laptop in the cart. Student 2B indicated he had but upon checking by the researcher discovered that he had not. It is possible that Student 2B did not want to draw attention to himself from his classmates by receiving assistance or could have chosen to move on to the homework assignment in class so that he did not have to complete the assignment at home. Student 3A received reminders from both the classroom teacher and the researcher to move on from creating the Voki avatar to completing the assignment by answering the question. He was reminded that he could use his text pages to help guide him in developing his response. Student 3A continued to disregard the reminders and at the class indicated that he was not finished. The researcher asked if he had access to a computer at home and would he try to complete the assignment. Student 3A indicated that he did have a computer at home and he would complete the assignment but he did not. When asked the next day he replied that he had forgot and had homework in other classes that he had to do. It is possible that Student 3A did not understand the assignment or have the requisite skills needed for completing independent activities.

**Table 14: Case Study Students UDL-E Product Scores**

Students	UDL-E Product Score
1A	6
2B	1
3A	0
4B	6
Average	3.25

To evaluate the use of the UDL-E principle's impact on curriculum based assessment outcomes for students with LD in science, the researcher used a Repeated-Measure Analysis of variance (ANOVA). A repeated- measures ANOVA was conducted to assess the impact of UDL\_E intervention on four curriculum-based (CBA) assessments (PrePost Test 1, PrePost Test 2, PrePost Test 3, and PrePost Test 4) for two groups (Group A and Group B) in a replicated control group design. The means and standard deviations for Group A and B and the four case study participants are presented in Table 15. There was no significant interaction between the implementation of the Groups and the outcome on the CBA pre and post, Wilks' Lambda = .1988,  $F(3, 75) = 2.417$ ,  $p = .123$ , partial eta squared = .074.

**Table 15: Multivariate Test Results for Group A and Group B and PrePost Tests**

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Tests	Pillai's Trace	.074	1.988 <sup>a</sup>	3.000	75.000	.123	.074
	Wilks' Lambda	.926	1.988 <sup>a</sup>	3.000	75.000	.123	.074
	Hotelling's Trace	.080	1.988 <sup>a</sup>	3.000	75.000	.123	.074
	Roy's Largest	.080	1.988 <sup>a</sup>	3.000	75.000	.123	.074
	Root						
Tests *	Pillai's Trace	.049	1.288 <sup>a</sup>	3.000	75.000	.285	.049
	Wilks' Lambda	.951	1.288 <sup>a</sup>	3.000	75.000	.285	.049
	Hotelling's Trace	.052	1.288 <sup>a</sup>	3.000	75.000	.285	.049
	Roy's Largest	.052	1.288 <sup>a</sup>	3.000	75.000	.285	.049
	Root						

A comparison of case study students' PrePost Test differentials and Group A and Group B's average differentials can be found in Table 16. All students collectively had a differential of 12.81 points on PrePost Test 1. Group A PrePost Test differential points was greater than the whole class and Group B's differential on PrePost Test 1 was less than the whole class. Whole class average point differential on PrePost Test 2 was 8.35. Group B performed better (12.12) than Group A (5.12) during the UDL-E intervention. The whole class average point differential on PrePost Test 3 was 8.61. Group A performed below the whole average and Group B performed above. Group A (2.53) collectively performed below the whole class average (2.78) while Group B performed better (3.33) on PrePost Test 4. All case study students performed better than their group average except for Student 2B (-20) on PrePost Test 4 which was during a whole class no intervention stage. The test scores for the whole class ranged from as low as -80 to as high as 100.

**Table 16: PrePost Test Differentials**

Participant	Mean PrePost 1 Test Differences,	Mean PrePost 2 Test Differences	Mean PrePost 3 Test Difference	Mean PrePost 4 Test Difference
Group A	15.47 S.D. 20.73	5.12 S.D.24.34	4.65 S.D. 29.87	2.53 S.D. 32.72
Group B	9.64 S.D. 18.892	12.22 S.D.38.63	13.33 S.D.37.95	3.33 S.D.39.28
Total Average	12.81	8.35	8.61	2.78
Range of Score	-34 - 67	-60 - 80	-80 - 100	-80 - 100
1A	Absent	20	40	20
2B	Absent	0	20	-20
3A	33	20	40	60
4B	Absent	20	40	40

### Students' Perceptions and Voices as Learners

#### Student Perceptions

Students also took the Motivational Learning Strategies Questionnaire (MSLQ) prior to the UDL-E intervention. The MSLQ is based on a 7 point Likert scale. The MSLQ for middle school students is divided into five component areas. The component areas are classified as Intrinsic Value (IV), Self -Efficacy (SE), Test Anxiety (TA), Cognitive Strategy (CS), and Self-Regulation (SR). Table 17 provides the averages for both groups. Group A's and Group B's

averages for all components are .1% greater or less than the mean MSLQ score. The CS and SR components are identified by Pintrich as learner engagement components. On a scale from 0 to 7 both Group A and B scored on or near neutral.

**Table 17: MSLQ Component Ratings for Group A and Group B**

Group	MSLQ_IV	MSLQ_SE	MSLQ_TA	MSLQ_CS	MSLQ_SR
A	3.7	4.0	3.5	3.7	3.7
B	3.5	4.0	3.3	3.8	4.0
Total	3.6	4.0	3.4	3.8	3.9

IV=Intrinsic Value SE= Self Efficacy TA=Test Anxiety CS= Cognitive Strategy  
SR=Self –Regulation

Table 18 provides the MSLQ components categories for the four case study students. The groups’ case study students’ collective ratings on all components average between the ranges of 3.5-3.9. Collectively the case study students rated their Intrinsic Value at 3.5 as well as their Test Anxiety. Case study students’ self-regulation was collectively rated at 3.6 while their Self-efficacy was rated at 3.9. Case study students’ Cognitive Strategy value was 3.8. The case study students’ collective rating for Test Anxiety (3.5) was greater than the Group A and B collective rating for Test Anxiety (3.4). Case study students’ Cognitive Strategy (3.8) rating was equal to the collective rating of Group A and B. Intrinsic Value, Self-efficacy, and Self-regulation were all less for the case study students than Group A’s and Group B’s joint rating.

Student 1A had a high Test Anxiety rating of 6.8. Her Intrinsic Value rating was 4.9 and her Cognitive Strategy score was rated at 4.7. Student 1A’s Self-efficacy was 4.1 and her Self-



regulation rating was 4.2. Student 1A's ratings were all above the case study students' collective average ratings. Student 2 B has a low test anxiety rating at 1.5. His Intrinsic Value was rated at 2.3. Student 2B's Self-efficacy was rated at 3.2 while his Cognitive Strategy rating and Self-regulation were both rated at 4.5. Student 3A had an Intrinsic Value rating of 5. His Self-efficacy rating was 4.6. Student 3A's Test Anxiety was rated at 3.3 while his Cognitive Strategy rating was 3.1. Self-regulation rating for Student 3A was 2.9. Student 4B had a high Self-efficacy rating at 6. His Cognitive Strategy rating was a 3.2. Intrinsic Value for Student 4B was 2.0. Self-regulation was rated 2.7 and Test Anxiety was 2.5. Student 1A's Test Anxiety (6.8) and Student 3B's Test Anxiety (1.5) were outliers within the Test Anxiety rating.

**Table 18: Case Study Students MSLQ Components**

Participant	IV	SE	TA	CS	SR
Student 1A	4.9	4.1	6.8	4.7	4.2
Student 2B	2.3	3.2	1.5	4.5	4.5
Student 3A	5.0	4.6	3.3	3.1	2.9
Student 4B	2.0	6	2.5	3.2	2.7
Total	3.5	3.9	3.5	3.8	3.6

IV= Intrinsic Value SE= Self-Efficacy TA=Test Anxiety CS= Cognitive Strategy  
SR=Self-Regulation

### Students' Voices

Interviews were conducted with two of the four (1 student was absent due to illness and 1 student was absent due to a family vacation) case study students as well as several of their classmates (n=25). The researcher identified four themes after analyzing the interviews.

Theme One centers on student interest in learning science. Science can be an interesting and engaging class especially when labs and inquiry activities are involved but often the depth of the text can defuse student interest. The students in this study shared that science is one of their favorite classes and is a class that they enjoy. Students reflected that having a fun and interesting learning environment was motivating. The researcher observed this when students were eager for the researcher to see a demonstration lab that the teacher had previously conducted. This demonstration entailed a dollar being emerged in various mixtures of isopropyl alcohol and water and then lit on fire. This eagerness to learn science was further supported by one student sharing that “things that are fun and picking up my grades. And labs.” are what motivates them in Science.

Theme Two centered on students’ knowledge fluidity, recall, and expression in science. Direct instruction was the primary mode of instruction in the classroom. However, students did have opportunities to respond to questions posed by the teacher throughout instruction. Tests were recognized as a typical method of measurement however students also identified their classwork, quizzes, labs, and the questions posed by the teacher as ways that they know they understand the material or the way they believe their teacher knows they understand the material. This theme was supported by student statements such as, “if I can re-explain it thoroughly”, or answer the teacher’s question” they felt they knew the material and the teacher did as well.

A third theme that emerged from the interviews was the need for technology fluency. The researcher observed that the classroom had five laptops however across the hall from the classroom was one media lab that the teacher could access. The teacher also had access to two other media centers in other buildings and two mobile lab carts. The researcher and the teacher

attempted several times to book the media centers or mobile labs for the UDL-E intervention. The researcher observed the difficulty that the teacher experienced to incorporate technology into instruction. The teacher did have access to BrainPop (FWD media, Inc., 2013) that she could present during instruction on the screen as a class and she included a web-based poll activity during one lesson allowing students to use their cell phones. Students were excited about the activity and only one student shared that they had done something like this before. Students used the mobile laptops for a balancing equations webquest. During the webquest activity both the teacher and the researcher assisted students that struggled with the activity. One student shared, “I enjoy using technology. It is more in with our generation and better than doing written assignments or projects. I’ve used VoiceThread in science before this year and computers in classes to do some projects.” but the majority students indicated that, “There really isn’t technology in our classes except for computers for tests and science tools for labs”. Student fluency with technology would benefit from additional computers in the classroom and possibly could have impacted the student during the UDL-E intervention with increased comfort levels using new technology tools.

A fourth theme identified was peer influence on the learning environment. The researcher observed students talking with each other during instruction. In fact, the researcher thought that peer interaction (PI) was going to be greater than times when the student was inattentive (SI). Students shared three lines of thought related to their peers. One line was that is peers are distracting similar the researchers line of thinking. One student shared “Sometimes I feel my peers affect my learning because of distractions.” and another confirmed by sharing “Too much talking and I can’t hear what the teacher is saying”. A second line of thought is

neutral. One student share “They don’t.” when asked his thoughts on how his peers impact his learning. A third thought is one of assistance and supports the instructional strategies of peer tutoring and peer learning groups. Students felt that although their peers could be distracting sometimes they are also important to their learning. This was demonstrated from one student that said “sometimes they distract me but not to the point of failing. Other than that, they’re a big help” and another student who felt that her peers “are calm and can help when people need it and ask many questions”.

Student interest in learning science, their technology fluency, and the peer influence on the learning environment can impact the student fluency and recall of material especially as they try to express their understanding to the teacher. The implementation of UDL-E supports students in improving technology fluency and providing options for students to demonstrate the fluidity and recall of what they know.

#### Validity of Data

Triangulation of data through observations, interviews, and the evaluation of pretests and posttests support the internal validity of the data (Brantlinger et al., 2005; Gast, 2010). Pretests and posttests were created using questions from the curriculum materials required by the district. Construct validity was strengthened through member checking (Brantlinger et al., 2005; Gast, 2010). The researcher discussed the results of observations, interviews, pretests and posttests data with the teacher who confirmed and clarified questions about the data. Multiple case study Students were chosen enabling a stronger effect and minimizing the criticisms and skepticism

that single-case studies have to avert (Yin, 2009). Throughout the research study only previously validated instruments were used in this study.

### Reliability

To reduce researcher bias inter-observer/inter-rater reliability (IOA) was used for completing and coding observations, evaluating and scoring UDL-E products, and interview transcription verification (Kazdin, 1982; Gast, 2010). Point by point method of IOA was used on 25% of observation occurrences for TOT. IOA agreement for the observation was 83%. Observations were then coded for on-task and off-task sub-behaviors. IOA agreement for 25% of coded sub-behavior records was 97% agreement. Thirty percent of the UDL-E products were evaluated for correct use of science vocabulary with 95% agreement. The UDL-E products were scored and then evaluated for IOA with 100% agreement. The interobserver analysis was reviewed multiple times with consistent results indicating over 83% agreement or greater on over a minimum of 25% of all recorded observations or products indicating interobserver/interrater reliability (Fraenkel & Wallen, 2000; Slavin, 2007).

### Summary of Data Analysis

In this chapter, the researcher provided a summary of the data that demonstrated that the UDL-E activities can be used to demonstrate science content knowledge. A repeated-measures ANOVA and descriptive statistics were used to reveal no statistical significant relationships or interactions between the UDL-E intervention and student outcomes on pretest-posttests. Qualitative analysis revealed that Students did perceive that the UDL-E intervention was helpful

to their learning and would be an approach to learning that they would use. Time-on-task was analyzed using descriptive statistics and comparing the mean differences between pre-UDL-E and during UDL-E for case study students. The TOT was the same during UDL-E as pre-UDL-E however the off-task behavior of peer interactions (PI) increased during UDL-E.

The purpose of this study was to evaluate the impact on UDL-E on the CBM outcomes for students in inclusive science classroom. In addition this study evaluated how students demonstrate engagement in the science instructional environment. The data did not show statistical significance for using UDL-E however; students in this study received only one opportunity to explore the UDL-E interventions prior to using the UDL-E intervention perhaps without a feeling of efficiency.

## CHAPTER FIVE: DISCUSSION

The report *Rising above the Gathering Storm* (National Academy of Science, 2007) reported a national crisis for engineering, technology, and other science related jobs in the United States. The Next Generation Science Standards (Achieve, Inc., 2013) asserts that science is at the heart of the United States' ability to continue to innovate, lead, and create the jobs of the future, and regardless of what students become as future employees and citizens, they must have a solid K–12 science education. Science helps all citizens to have a basic understanding as to what is happening in the global environment, to create and improve technological and medical advances, and to evaluate and improve the health and wellness of every individual (Achieve, Inc., 2013). Students today, particularly students with disabilities, are in need of a revamping of how they think and approach science instruction to prevent a decline in participation in higher-level science courses or, even worse, potentially dropping out of high school due to not being able to pass new end-of-course exams required in many states in science (Achieve, Inc., 2013). Improving and supporting the development of stronger science instruction that impacts student understanding of content and students' ability to share their knowledge is the foundation for the implementation of Universal Design for Learning (UDL) Principles (Meyer & Rose, 2005; Rose & Meyer, 2006). Using UDL principles could be a solution to the rejuvenation of science content so that potentially every student would have the opportunity to learn and enjoy science and choose whether to pursue a science-related career.

The researcher in this study intended to demonstrate the impact of using Universal Design for Learning Expression (UDL-E) on science content; however, because of the realities of present-day schools, the outcomes actually resulted in an analysis of integrating technology

tools for students to express their understanding of science. What is more, based on the findings in Chapter Four, the researcher addresses in this chapter the current status of science teaching and the learning environment in many contemporary middle schools while providing an in-depth discussion of the need for critical changes in science education. The chapter concludes with recommendations for bringing science education, including the potential power of using UDL-E tools, into the 21<sup>st</sup> century and beyond.

### Summary of Findings

#### Technology Tools and Time-on-task

The four case study students, all students labeled as LD, were evaluated for time on task (TOT) and demonstrated greater on-task behavior than off-task behavior both prior to and during the technology tool integration. Greater TOT, however, did not equate to improved understanding of the lesson content for all students, as scores on the lesson posttest indicate.

When students used technology tools to demonstrate their understanding of science vocabulary in the study, scores ranged from a perfect score of a six to a score of zero. Two case study students, Student 1A and Student 4B, used the technology tools and their text pages to include and explain all science vocabulary words correctly from the assigned lesson. One case study student, Student 2B, listed two vocabulary words but did not include all of the words from the lesson or explain the vocabulary words listed correctly. Both the teacher and the researcher tried to prompt the correct response by asking the student if he completed the assignment by responding to the question written on the directions page. This student indicated that he had completed the assignment, but after checking the assignment, the researcher discovered that the



student only partially completed the required components. Another case study student, Student 3A, scored a zero on his UDL-E product because of not using or explaining any of the science vocabulary words from the lesson. Student 3A did not respond at all to the question written on the directions but rather spent his class time attempting to create an avatar, even after a reminder from his teacher and the researcher to move ahead to the task. The two case study students who did not complete the assignment, 1A and 2B, could have benefited from a checklist with estimated time limits to guide them toward completion and establish the final product outcome. This need for more structure was not something expected due to the clear directions and structure of the technology, yet tools and checklist may not be enough for students who struggle. Technology may provide benefits and create new barriers at the same time. These issues need further investigation as the ultimate outcome of science instruction and use of technological tools must be a stronger assessment and at the same time a direct impact on student learning.

#### Technology Tools and Curriculum-based Assessments (CBA)

In this study, the researcher initially attempted to assess the overall use of UDL-E on student learning but in the end was simply able to provide some technological tools to begin to think about the complexity of UDL-E in today's science classrooms. Students' use of technology tools to express science understanding in this study were examined using pretests and posttests that indicated no statistical significance between the two groups, Group A and Group B. Although Group B did have slightly higher mean scores than Group A on the test, the differences were not significant. However, what was significant were the observations made by the researcher related to the complexity of doing anything different or unique, including using technology, in a middle school science classroom.

Overall the utilization of technology by the students in this study was minimal in general, both inside the science classroom and out. Students did not use technology tools in their other content classes nor even for their homework assignments, with the exception of looking up their homework assignments. As states move away from their current assessment methods used to measure science learning to new tools that are to align with Common Core State Standards and the Next Generation Science Standards, students will need access to the same technology that they will be using in these assessments. They also will need to acquire the skills required to use these assessments through classroom practice prior to taking tests that are technology driven. In other words, “if the student does not know how or when to use the tool, it will not make a difference” (Marino, 2009, p. 3) and may in fact be detrimental to the students’ test outcomes. As new standards and new technological tools are combined, unless students learn at a deeper level and are more proficient in using technology, some students with LD, like Students 1A and 2B, may fail because of not being able to navigate this way of learning and assessment, as observed in this study. As the use of these structures and assessment tools evolve in science, all student, including those with LD, need to be involved with technological tools that embrace both assessment and rich peer dialogue that is expected in both the CCSS and NGSS for learning science content (Achieve, Inc., 2013; Common Core Standards Initiative, 2012c; Mastropieri et al., 2006)).

#### Peer Learning and Technology Tool Integration

Peer interactions of the case study students during the pre-technology tool integration phase and during the technology tool integration phase varied in types of interaction behaviors from what the researcher initially considered as “off task” behavior. The peer interactions before technology tool integration was introduced were more disruptive to the case study students’

learning. Case study students were drawn into conversations that were unrelated to the learning that was occurring in the classroom either by their tablemates or by classmates at another table. These types of peer interactions were considered negative in nature on the observation tool, as the students were not involved in a learning task when they were talking with or listening to their peers.

During the technology tool integration, the peer interactions among the case study students and their classmates focused on student-directed questions to peers for support on how to create features on an avatar or how students answered the lesson questions. In addition, they were excitedly sharing their avatar creations or pictures downloaded for their VoiceThread. These types of peer interactions were positive in nature as students worked together or in support of each other to solve a problem, and this led to student engagement that was positive but not coded in that vein in this study, a limitation. The students in this study experienced opportunities to work together during labs and completing worksheets together, but these peer learning opportunities occurred on a less-than-weekly basis. This level of preparation for and participation in a range of conversations with diverse partners to build on ideas is required by the Speaking and Listening Common Core Standard in the NGSS (Achieve, Inc., 2013) and CCSS Common Core Standards Initiative, 2012c) and by NSTA related to effective science instruction (National Science Teachers Association, 2013a, 2013b). Although TOT did not appear to increase, the researcher observed an increase in student engagement on topic during the use of technological tools that was not observed during traditional paper-pencil science instruction.

## Limitations

This lack of flexibility in the TOT observation tool was just one of the limitations of this study. The limitations overall ranged from the definition of on-task, sample size, time constraints, and overall study procedures. The impact of these limitations is discussed in relation to the finding of this study.

Although the researcher found in this study that students with LD were equally on-task during the implementation of the intended UDL-E through technology tool integration as they were during direct instruction, students with LD scored better on CBA than the average of their class peers when using technology tool integration, and students enjoyed the flexibility in how they expressed their science knowledge; nonetheless the results were not without limitations. The researcher experienced the following limitations during this study: small sample size, time constraints, participant technology utilization concerns, participant attrition, and nature of self-reporting concerns.

Participants in this study came from a small sample and were not selected randomly but rather were already in groups that were pre-assembled (inclusive science classrooms) and therefore are considered a convenience sample. Convenience samples do have potential for bias and should typically be avoided because they are not representative of a population nor can they be generalized under this sampling method (Fraenkel & Wallen, 2000). To reduce this limitation the researcher used a replicated non-equivalent control group design. In this design, when Group A received the UDL-E intervention Group B acted as the control group and when Group B received the UDL-E intervention Group A acted as the control group. This design required a control group that was as closely matched to the experimental group in as many dimensions as

possible (Slavin, 2007). Under this design pretests and posttests are also used however they are prone to many errors and biases (Slavin, 2007) as students have a history of the test when taking the posttest. If students make gains it is difficult to decipher whether those gains would have occurred regardless of the intervention and what factors may have influenced those gains. Additionally, taking the pretest may affect taking the posttest, particularly when the tests are the same. Having a small sample created a number of issues for this study, but the replicated non-equivalent groups improved the ability to generalize findings.

The time constraint limitations in this study were multi-faceted. The researcher experienced a delay within the districts' approval process. Once the study had been approved, a request was made for the researcher to be fingerprinted. Results for fingerprinting went to a volunteer coordinator rather than the principal, which further reduced the research study timeline goal. Additional time constraints such as district spring break, state assessment required review, state assessment test days, researcher attendance at a national conference, and teacher training or other absences even further impacted the timeline. Upon receiving final clearance to begin the study the researcher revised the timeline and added multiple case study observations to ensure that adequate data could be collected. Observations of students were further reduced when students were tested on chapter materials. The researcher made every effort to observe case study students on every day allowable. If not for the end of the academic year, additional observations and data would have been collected.

The web-based technology tools used in this study presented an unplanned limitation for the researcher. The researcher had made the assumption that students at the eighth grade level would have had more experience using technology in their academic coursework than was

discovered during this study. Students shared that technology is rarely used in any of their coursework and in fact science was the one class in which they have used technology. Students received one block class period to explore the web-based tools before using them for the UDL-E intervention. Many students encountered difficulty with understanding how to access the classroom account rather than simply signing up to create a Voki or VoiceThread. To assist students during the UDL-E intervention activities the researcher checked in with students who were having urgent issues initially and then walked around the room to support students as needed. The researcher would have preferred to have students use the web-based tech tools throughout an entire chapter for each of the replication designs as originally planned, rather than only one lesson of a chapter, but due to time constraints experienced in this study this process was not possible.

Participant attrition, although not a complete loss of the participant, was experienced during this study. The researcher had planned to use the first five observations to analyze pre-UDL data and during UDL-E data, but due to one absence from one of the case study students, pre-UDL-E data was established at four observations. Additionally, one case study student was absent for ten days toward the end of the semester for a family vacation, including the day that the last chapter test was taken. In addition to participant attrition due to absences, there is a form of experimental attrition whereby the students, who are eighth graders, behave as though they are finished with middle school and have their minds set on summer vacation and their pending attendance in high school. Anyone who has been a classroom teacher knows that feeling of trying to continue to teach students who may be present physically but are certainly not there mentally. The researcher continued to thank students for their participation and asked them to

give her their best effort. Students were always courteous and polite throughout the interactions and appeared genuinely interested in exploring the web-based tools.

Finally, students in this study completed a Motivation Strategy Learning Questionnaire (MSLQ) independently. When research subjects self-report, they tend to report what they believe the researcher expects to see or report what reflects positively on their own abilities, knowledge, beliefs, or opinions (Cook & Campbell, 1979). This potential limitation is one that requires further research to compare the findings in this study to other studies for the use of technological tools and middle school students in science.

The presence of the researcher can also influence participant self-reporting through the Hawthorne Effect. The Hawthorne effect is the tendency for research subjects to exert outstanding results because they are participating in an experiment or research (Slavin, 2007). The researcher's presence in the classroom began prior to the beginning data collection. Additionally, the researcher reminded students throughout the MSLQ survey to think of themselves currently as students in science as she read the statements to them. The teacher was also present and actively involved in rotating around the classroom to support students and remind students that the activities completed during the research did not affect their grade negatively but needed to be taken seriously.

## Unexpected Findings

### Loss of Academic Learning Time

Of far greater impact and alarm than the results of this study are the unexpected findings discovered about the current science learning environment and the need for a dramatic shift with regard to both instruction and the use of technology. Time constraints were listed as a major limitation for the researcher, but of greater concern was the loss of 10 academic days due to the participating teacher's being *required* to spend time reviewing the earth, space, and life science concepts taught in the sixth and seventh grades before these students took the eighth grade state assessment. This particular state mandates that teachers test students in science only in fourth and eighth grades and requires end-of-course exam passage at the high school level. Therefore, the teachers at this school were expected to withhold new content and do more of a "drill and kill" type of review in preparation for the state assessment covering content learned prior to eighth grade. In addition, seven more academic days were spent on actual state testing. When the discussion arises that the U.S. is behind other countries in STEM and that there is a need for better teachers, improved curriculum, and higher standards, where does our drive for high-stakes-assessment outcomes lead us in understanding its negative impact on the learning environment? The problem appears to be fairly simple: if 17 days or approximately 10% of the year is not spent on learning science, but instead time is being spent on what some students during the interviews in this study called "boring reviews," what are the odds that the U.S. can catch up to other countries when time is against gaining greater momentum in learning science deeply? The new NGSS focuses on more in-depth science investigation, but yet deeper learning



does not mean a day of review but rather more discourse and more—not less—time engaged in science (Achieve, Inc., 2013).

Simply stated, these eighth grade students lost 17 days of learning time for a high stakes test that has remained stagnant since 2011 (FL DOE, 2012). Whether or not the days of review had any impact remains to be seen pending return of the test results; however, the researcher questions the use of intensive review practices that have not yielded positive results to date. Investing in a more in-depth, active approach may lead to deeper learning and better long term outcomes for science learners instead of spending 17 days without active learning. Learning science deeply is learning that is not textbook driven but hands-on (McFarland, 1997; Pearce, 1999; Shymansky et al., 1997; Mastropieri et al., 2006). From the researcher’s perspective nothing appeared to have occurred in those 17 days that took students to the highest level of learning—application and evaluation—but simply provided the lowest level of Bloom’s taxonomy (Bloom, 1956): knowledge and a hint at comprehension of science content. Changing this practice alone from both disrupting and denying 17 days of rich science instruction could change the outcome of our ranking nationally in science by providing additional days of rich science instruction.

#### Lack of Hands-on Learning

A second unanticipated finding was the textbook-driven approach to teaching and learning that the researcher did not expect to observe. The teacher in this study was highly qualified and had advanced training in mathematics and science instruction that reflected best practices. However, she was tied to the process, timelines, and structure that were demanded of her in order to be consistent with her team (and which were also part of the teacher-evaluation

process). The curriculum adopted by the district is an integrative curriculum and does have a strong technological component, although these tools were often not used due to “keeping up with the pacing guide.” Additionally, this school, located in one of central Florida’s more affluent counties (SDR, LLC, 2009), was a place where students did have access to technology beyond the classroom, and this interactive component of the science curriculum could have been applied even outside of the classroom for higher level learning. Despite the potential for higher-level thinking and application of tools that could have been used to increase students’ expression of their learning through use of technology, the investment in the technological component of the curriculum was simply not observed and was perceived to be too difficult to implement with the newly added teacher-evaluation pressures and constraints felt by the participating teacher. This teacher could easily employ other tools if given the freedom to move away from a daily pacing guide and given more support as she was the one teacher who was not instructing students who were “gifted.” This teacher had more students with a range of needs than suggested by the district guidelines and had no external support for the range of learners in the science classroom. Changes must be made to flip science classrooms (AAAS, 1989; Mastropieri et al., 2006; Scruggs, Brigham, Mastropieri, 2013; Scruggs et al., 1993) from a textbook-driven teaching style to one that is inquiry based, and learning is at the highest level of Bloom’s taxonomy (Bloom, 1956) so that students can be actively engaged in hands-on science during the day and able to access a range of tools available at home through interactive enrichment activities.

### Student Support

A third unforeseen finding in this study was the lack of support and collaboration for students with special needs in this inclusive learning environment. Far worse than the lack of

support and collaboration by a special education teacher was the lack of administrative support evidenced during a classroom observation of this teacher. The teacher requested assistance for one particular class near the beginning to the school year, and this request was turned into an area of concern by the administrator during the teacher's annual performance evaluation. As a dually certified special education and science teacher, the researcher clearly saw and noted early in the study that the number and the dynamics of the learners in this classroom should have entitled this teacher to some level of support beyond what was provided because of the academic and behavioral challenges present. This teacher was left with the student who did not qualify for the "gifted" track, leaving her with students she enjoyed working with but who carried with them a range of needs that were difficult to support on her own and at the pace "required" by the school leadership. This complexity of her students' needs along with a new evaluation system and lack of administrative support caused this teacher to share with the researcher that she felt like a victim. She struggled, knowing that her students and her job would be evaluated on student science performance in the eighth grade, with no clear evidence that their past learning in grades six and seven provided the level of understanding needed to be successful with science content. This issue combined with the dynamics of her students' needs and the reins put on her to keep up with the pacing guide created a situation wherein anything new or innovative was a struggle both related to addressing individual needs and keeping up with the other sections of gifted learners.

#### Use of Technology in the Classroom

A fourth unforeseen finding was the lack of tools that students were exposed to and used daily. This finding, also listed as a limitation, was far greater than the researcher had anticipated, particularly because the curriculum used in this district and by this school had a built-in

technological component. The only consistent use of technological tools that the researcher observed over the 15 weeks in the classroom was of the teacher's use of BrainPop videos, but even this use was not individualized but was rather a case of the entire class watching and responding to the questions. Students also were observed accessing one balancing-equations web-quest tool and were known to have accessed another web-quest tool when the researcher attended a conference. Other than the UDL-E activity, students had never accessed technological tools to present, express, or demonstrate their understanding of content (as noted during the interviews). The researcher thought she might observe minimal use of the tools, but basically tool utilization was non-existent in the teaching and learning environment.

This disheartening lack of acceptance and integration of technological tools along with the results from this study do not indicate that the integration of technology tools to express science knowledge were inappropriate and ineffective, but instead the true outcome of this study is that science instruction must change to impact the trajectory learning in the area of science. The researcher contends that these additional findings and the results from this study are perhaps a small window for other researchers to consider of potential student performance and outcome occurring nationwide and a true implication of how science is taught in middle schools today. The researcher understands that this observation occurred over an extended period of time in just one class, but this class was a microcosm of what was observed across the school (e.g., 17 days of missing instruction). The observations and findings were further confirmed by the researcher's dissertation committee members; national experts in co-teaching, collaboration, instruction, and middle school science, who affirmed that the same situation occurs in most classrooms. Therefore, the outcome from this study although just an in-depth view of one classroom, allows

for strong recommendations to the field that go beyond the findings of this study to science education in general, including use of UDL-E and integration of technological tools. These specific recommendations are grounded in the literature in the field of science education, observations from this study, and the lens and expertise of this researcher's extensive background in science, special education, and UDL-E.

### Recommendations

Text-driven science instruction must be replaced with hands-on activities. Hands-on science learning is a highly effective and engaging instructional approach to learning science in middle school (Wiggins, 2006). Additionally, technology tools can advance the lines of scientific research (AAAS, 1989) and promote the scientific investigation practices required in both the NGSS and CCSS.

The following recommendations are established to create the flexible learning environment needed for students in middle school classrooms today and in the future. These recommendations outline what school districts, administrators, teachers, and students should do to impact science education in this nation and make the changes needed to improve global competitiveness through the implementation of technology tool use, the Universal Design for Learning Principles framework, and science instruction practices. These recommendations are provided as a bulleted list for the field to consider at the district, administrative, teacher, and student level in the area of science instruction and learning.

## School District Recommendations

New understandings about how students learn science influence choices that teachers make in their instruction (Bybee, 2002). Teachers must continuously assess students' abilities, evaluate students' misconceptions and understanding, while actively engaging students in science learning (Bybee, 2002). To support teachers in order to improve science outcomes of their students, the following technology tool integration, universal design for learning, and science instruction requirements must be implemented across school districts:

Technological tools and curriculum adopted by leaders throughout the district need to

- ensure all middle schools have and maintain adequate equipment, tools, and technological supports that are used and integrated daily within the curriculum
- be used by teachers who are prepared and receive ongoing direct support to use these emerging and alternative methods that show an impact on student learning outcomes
- recognize and reward creativity in teachers to both discover and embrace new tools and approaches that impact student learning
- support schools to enable educators to become globally connected to other educators, allowing a sharing of technology tools in the learning environment and expanding their professional learning community
- review the use of tools at the school and classroom level weekly through a report created to identify usage of tools and practices that are tied to

standards, while at the same time approaching student learning using proven and promising practices.

District leaders need to ensure Universal Designed for Learning principle guidelines are integrated into the learning environment from a top-down and bottom-up approach (Rose & Meyer, 2002) by

- incorporating UDL training district wide for all administrators to support and train their staff
- reviewing and evaluating the implementation of UDL at school levels
- hiring and promoting teachers based upon their knowledge, experience, and ability to demonstrate UDL principles
- reviewing administrator reports on teacher practices
- evaluating the impact on UDL principles for students with special needs particularly students with learning disabilities

Science instruction at the middle school level based upon the NGSS (Achieve, Inc., 2013; Bybee, 2002) needs to

- allow teachers to use resources and materials that promote hands-on science learning—including tools that relate to science and UDL
- provide teachers with supervisors who can evaluate teacher practice and student learning so that teachers are recipients of best and innovative practices related to science instruction by content specialists

- establish a network of science teachers who are continuously learning both science and emerging technological practices through global networking, collaboration, and mentorship of evidence-based and promising practices
- encourage and support co-teaching instructional opportunities for general education content teachers and special education teachers when requested by administrators

School districts must financially support the purchase of enough technology equipment and tools and the appropriate information technology infrastructure and high-speed wired and wireless capability; they must recruit and hire one highly effective educational technology support person for research and development for the middle school level, as well as two dedicated technology equipment field support personnel per middle school. School districts should be mandated to review monthly summary reports from school administrators to evaluate technology equipment and tool issues and establish procedures to proactively address persistent issues. School districts should also be mandated to evaluate individual school utilization reports for the tools and global networking efforts. It is vital that school districts establish a source of funding and awards to recognize individuals, including administrators, teachers, and students, who have discovered new tools or innovative approaches for using an existing tool within the district. It should be compulsory for school districts to evaluate the utilization of technology for each middle school in the way that teachers are using tools for instruction and assessment and provide assistance and support to administrators so that they can support teachers who are identified as non-users or fearful users of technology tools in the classroom, so that all students have the option to use tools of their choice. Providing technology tools only to the teachers is



not enough, since the students of teachers who do not use technology tools become victims of inequality. School districts must support administrators in exploring why teachers are not using technology tools in the learning environment and provide the mentorship and data reflecting the technology impact on learners in order to change resistant thinking. All professional developments offered to administrators and teachers need to be evaluated for their effectiveness and impact and improvements based on that information need to be implemented.

In addition to school districts requirement to establish a robust technological infrastructure, school districts should be mandated to implement and support the UDL framework district wide. The district could, for example, designate key personnel to attend the Center for Applied Special Technology's UDL training to support schools K-12 in training and supporting teachers in the implementation of UDL in the classroom environment. For example, a district leaders could randomly select lesson plans to evaluate the implementation of the UDL principles in instruction and assessment to review teacher reflections and student surveys indicating student engagement, as well as to initiate a research agenda on UDL's implementation. District leaders need to hire and promote teachers based on their knowledge and implementation of the UDL principles during instruction and assessment.

Finally, school districts must address the changes that need to be made district-wide in science education. School district leaders need to provide the resources and materials teachers require for hands-on science instruction. School districts need to hire and prepare highly effective science supervisors to evaluate science teachers and provide feedback to teachers and school administrators as well as collect data on teacher practices. Finally, district funds need to

be allocated to financially support science teachers in continuous learning through professional development and National Science Teacher Association conference attendance.

#### School Administrator Recommendations

In addition to the school districts' leaders being charged to improve science outcomes, school administrators need to be the next tier of support to change the learning environment through the integration of technological tools, UDL, and science instruction requirements so as

- to ensure that infrastructure is in place school wide for a variety of tools to be used, such as iPads, computers, cell phones
- to determine effective use in instruction and assessment from reviewing lesson plans and identify specific strategies implemented by teachers for students with special needs specifically students with learning disabilities
- to evaluate daily utilization in the classroom by students
- to support tool use and discovery through supporting teachers in professional learning communities
- to disseminate instructional and assessment practices used by teachers at educational conferences on school implementation of tools

School administrators are instrumental in the effort to incorporate UDL into the learning environment (Rose & Meyer, 2002) through their efforts of

- supporting training and implementation of a UDL framework

- providing feedback on how UDL can be incorporated into lesson plans specifically for students with special needs and to ensure that it is incorporated for instruction and assessment
- supporting collaborative meetings for UDL idea sharing
- presenting with teachers at educational conferences on school implementation of UDL
- creating a culture that embraces building walk-throughs to identify, capture and elevate examples of UDL principle guidelines

The implementation and adoption of new educational standards are changing how science must and will be taught (Scruggs, Brigham, & Mastropieri, 2013). Highly effective science instruction from teachers can be accomplished with school administrator support through their efforts to

- support hands-on science activities through training and curriculum resources
- observe hands-on science learning during classroom/teacher observations
- review lesson plans for hands-on science learning in lesson plans
- provide opportunities quarterly for teachers to collaborate
- present with teachers at educational conferences on science instruction using UDL framework and tech tools
- evaluate classroom demographics and dynamics to determine and address the need for general education teacher support through the provision of a special education co-teacher

School administrators are a critical connection between the school district and the teachers, who in turn have direct impact on students. Additionally, school administrators, either through their support and mentorship or non-constructive criticism, can directly impact teacher turnover. School administrators need to both lead and support changes in science education in inclusive classes for teachers to have the impact needed on students. School administrators should be required to ensure that the infrastructure is in place to support adequate technology equipment such that computers, laptops, cell phones, and iPads in every classroom for every student. School administrators need to mandate that tools be written into lesson plans and used during instruction and assessment. Additionally, school administrators should make it compulsory that tools be used in the classroom daily and verify utilization and practices through classroom walk-throughs, review of weekly teacher reflections on tool use, and random surveys of students on the use of tools. School administrators should be required to support tool use and discovery through training and professional development on a monthly basis. administrators also should establish a procedure to recognize innovative use of tools by teachers. Administrators must review technology equipment and tool issues that arise for proactive correction and address areas of need as indicated by teachers and students.

School administrators must also support the implementation of the UDL framework school wide through training of educational staff. Administrators need to provide feedback to the teachers on how UDL can be incorporated into lesson plans and then evaluate how the UDL framework is being used in instruction and assessment through walk-throughs and teacher evaluations. Administrators should be obligated to provide collaborative meetings among teaching teams to share ideas on implementing the UDL framework.

Technology tools and UDL should be incorporated into science instruction, and it is the school administrator's job to dictate that they be a part of the daily teaching and learning environment. Science instruction must be hands-on and no longer textbook driven. School administrators can ensure that this will happen by requesting resources, supplies, and materials needed for hands-on learning from the district. School administrators must provide science teachers with needed training and continuing professional development, including an option to participate virtually on a monthly basis and support funding for professional memberships of educational science organizations such as the National Science Teachers Association. It is necessary that administrators observe hands-on science learning during classroom/teacher observations and they should review lesson plans for hands-on learning activities and track student engagement through random observations and interviews. Administrators need to provide teachers with the opportunity to collaborate with district science teachers on a quarterly basis.

#### Teacher Recommendations

To improve science outcomes the following technology tools, universal design for learning framework, and science instruction requirements must be implemented by teachers. "Inclusive science instruction concerns the ability or willingness of general education teachers to implement specialized or differentiated instruction"(Scruggs, Brigham, & Mastropieri, 2013, p. 55) as well as other initiatives.

The teacher's job when partnering content with technological tools is to coach and guide students in the use of the tools for effective learning (Prensky, 2010). Teachers need to focus on,

and become experts at, good questioning, providing context, ensuring rigor, and evaluating students' work (Prensky, 2010), all of which can be done by using technology tools to

- integrate daily into instruction or assessment aligned with the learning objectives
- share with a professional learning community how a tool can be used during instruction or assessment each quarter
- attend training sessions and become familiar with supports by the district
- empower students to use a range of tools in their classroom daily, to “think outside of the box” to complete assignments, and to be innovative
- provide supportive structures such as checklists, graphic organizers, sample models, etc., for students with special needs particularly students with learning disabilities to ensure success in assignment completion with tools

“Part of the beauty of UDL, and the reason that teachers warm to it so quickly, is that it doesn't have to be a separate initiative” (Rose & Meyer, 2002, p. 164). Teachers are vital to improving the science outcome of students through the inclusion of UDL to

- instruct, assess, and reflect on student engagement
- incorporate innovative ways students will access curriculum and multiple ways students will be assessed—with students empowered with choice in the tools they will use
- survey students for their interest in content areas in an effort to increase their engagement as learners

- collaborate and share ways that UDL is being implemented in classrooms
- integrate tools across the curriculum and embed them in CCSS and NGSS.

Science instruction at its best is a complex process (Bybee, 2002). Bybee (2002) stated that science instruction combines an understanding of students' ability and interest, science, and the educational learning environment, including the use of best and promising practices (Bybee, 2002) so that

- students have the tools they need to learn science differently, including tools and UDL
- only hands-on science is used to teach science during all science learning
- student interests are supported for meeting learning objects
- student science knowledge can be evaluated in alternative ways
- teachers can connect globally to other science educators and develop a professional learning community
- teachers incorporate opportunities to co-teach content with special education teacher
- teachers can join a science organization such as NSTA and consider attending a national conference
- teachers can practice scholarly work by submitting a manuscript on the effectiveness of teaching hands-on science using UDL and tech tools.

Teachers have a direct connection to the students and therefore have the greatest impact if given the necessary tools to support their students' learning. Teachers should have students use a

variety of tools aligned with the learning objectives daily in instruction or assessment. Teachers need to be given support to attend training to become familiar with tools supported by the district, and to share new ways in which these have been used to impact learning in targeted content areas. In addition to training, teachers must identify tools they want the district to purchase and indicate its uses to impact student learning, engagement and assessment outcomes.

Teachers in all content areas need both support and to be empowered to use innovative and creative tools in their craft. Teachers need to evaluate how they could use a range of tools to incorporate the UDL framework within their instruction and assessment of students. Teachers also should be required to incorporate UDL in their instruction and their assessment and reflect on student engagement after discussing how the learning objective was met. It is essential to incorporate innovative ways students will access curriculum and multiple ways students will be assessed, with students empowered with choice in the tools they will use. At the beginning of each learning object, teachers should be required to survey students to identify their interests and learner engagement and interest. Teachers must collaborate and share ways that UDL is integrated in their learning environment along with the tools students use to demonstrate learning.

Teachers should be mandated to integrate technology tools and the UDL framework in hands-on science instruction daily. Hands-on science learning should be compulsory. Teachers should be obligated to become globally connected to other science teachers to share information and support student connection to other global learners. Globally connected teachers are important in developing a professional learning community that extends beyond the school walls and further supports teachers in learning how other schools are using technology tools to



improve the learning environment. Teachers are vital in addressing the need to join in a national or international science teacher association and present at a conference or submit a manuscript on teaching practices in inclusive science environments that include tools and the UDL framework. Teachers need to advocate for all students' needs by requesting resources for hands-on science activities from school administrators. Teachers should also be required to collect data on students' meeting the learning objective and provide additional review and support when the objective has not been met.

#### Student Recommendations

Finally, to improve science outcomes the following technology tools, universal design for learning, and science instruction requirements need to be embraced by students. Students need to take an active role in their learning environment to connect the real world to the content that they are learning (Scruggs, Brigham & Mastropieri. 2013). Students can learn differently by

- becoming familiar with tools prior to using them in class
- registering for the tool with parent acknowledgment signed
- demonstrating a level of originality and creativity in tool use
- advocating for alternative and new tools as they are developed
- respecting equipment and treating it with care
- using tools daily with integrity and high academic standards

Identifying the barriers of curriculum opens the door to UDL so that all students have their academic needs met (Rose & Meyer, 2002). Integrating UDL allows students to

- advocate for themselves in receiving the resources for their academic needs or interests especially when identified as a student with learning disabilities or other special needs
- promote peer learning by contributing positively
- create innovative and original approaches to demonstrate mastery in content through three areas of UDL
- choose tools that best fit their learning needs and ability to demonstrate their knowledge acquisition

Students must be taught to take control of their learning (Bybee, 2002) in order to change their future outcomes in science related fields. In order for this shift to occur, students need to

- meet the learning objectives and actively and appropriately demonstrate learner behaviors for hands-on engaged science instruction
- advocate for making science personally meaningful
- advocate for support by special education teacher and services as needed to promote success in science
- connect science to future career interests
- embrace a range of tools, including technology, to support their learning particularly those students with learning disabilities
- learn by defining goals and self-monitoring their own progress towards goals in science.

As accountability is being addressed from the top down, students are the next element of the learning environment who must change their attitude and make the determination that they are an integral part of teaching and learning. As teachers determine which tools they prefer for instruction and assessment of learning objects, students are to become registered and familiar with the tools as well as advocate for alternative ways to learn that may better suit their attainment of the learning object. Students must demonstrate a level of originality and creativity in tool use. Respect of the equipment and treating the equipment with care as well as integrity needs to be a student expectation in every classroom. Students must also use tools daily to meet learning objectives with high academic integrity. Students need to advocate for themselves to address their individual learning needs or interests and embrace peer learning by positively contributing to learning rather than detracting through personal comments and off-task discussions. Students should be required to meet the learning objectives and actively and appropriately demonstrate learner behavior. Students need to advocate to make science personally meaningful and to connect science to their possible future career interests. This future can only be realized through embracing a range of 21<sup>st</sup> century tools to support learning.

### Closing

These recommendations may seem ambitious, but science education today is in need of a major overhaul to begin to make a difference in students' national and state scores. These recommendations need to be implemented into a pilot study to collect and evaluate data from the impact of the implementation of the recommendations.

Technology needs to be a critical component of the learning environment in science. Teachers and educational leaders cannot prepare students as though they live in silos when in

fact they live in a global learning system that requires the use of technology. Educators need to connect students with classrooms around the world, and the way students are taught needs to incorporate this sense of learning using any means available. Students coming into the classroom in three to five years will want to swipe dry erase boards and move on to more interesting material; just as they do their parents' smartphones or tablets as they wait in doctor offices, at restaurants tables, or while being transported to their destination in the family vehicle.

Teacher preparation programs also need to be more comprehensive where teachers have the preparation in academic content, evidence-based instructional strategies, and promising practices including UDL and technology (Darling-Hammond, 2006; Kennedy & Deshler, 2010; Meyer & Rose, 2005). Programs should incorporate the UDL principle framework within all the courses and required skills. In addition to preparing highly effective instructors, teacher preparation programs need to include the fundamentals of policy making and the need to advocate for all the learners in their future classrooms (Smith et al., 2010). Finally teacher preparation programs need to include research analysis practices so that teachers can analyze and evaluate their students' data and implement instructional practices for the success of their students. Once teachers are in the field, mentorship, continuing education, and support must be a requirement of every district.

For students with LD, science in general needs to be taught from Pre-Kindergarten through Grade 12. Students need to be actively engaged in hands-on learning opportunities with support to guide connections and assist in scaffolding the information learned from Pre-K to where students are today. General science teachers need preparation in the evidence-based practices that work for students with LD and that will work for all students (Mastropieri &

Scruggs, 1992). Behavioral techniques need to be in place that support a focused learning environment but yet also include peer and group learning opportunities (Mastropieri et al., 2008). UDL principles should be infused within instruction and assessment. Students with LD—and all learners—can be successful in science, when science changes from a textbook-driven instructional model to one that incorporates evidence-based instructional strategies.

Currently, UDL is being mandated from the top of education through the Higher Educational Opportunity Act and potentially will reach down toward the reauthorization of the Elementary and Secondary Education Act (ESEA) as seen in drafts of this revised legislation. If UDL is incorporated into ESEA, it truly will have a top-down, bottom-up presence in teaching and learning, providing potentially an effective framework foundation in all content areas. Since the UDL principles are supported by evidence-based practices, students with LD can be successful in science when science curriculum and instruction are infused with UDL principles. Success in science can mean success in Science, Technology, Engineering, and Mathematics careers for students with LD as well. The indications from this study supports student interest in having options in this, at times challenging, but potentially engaging science content utilizing technology and other methods to express their knowledge. The true outcome of engaging all students, and especially students with LD, is that when students they are engaged they have the potential to demonstrate all that they know. The true outcome needed for both learning and assessing science instruction.

The time to make changes in science education is now as the Common Core State Standards and Next Generation Science Standards are being implemented and are intended to support deeper learning of students. These innovative recommendations are intended to move

students toward a deeper understanding of science content while encouraging student engagement during instruction and assessment. Continuous evaluation of these recommendations must be made to determine their effectiveness.

## APPENDIX A: IRB APPROVAL



**Approval of Human Research**

From: [Redacted]  
FWA00000351, IRB00001138

To: [Redacted]

Date: **January 17, 2013**

Dear Researcher:

On 1/17/2013, the IRB approved the following human participant research until 1/16/2014 inclusive:

- Type of Review: [Redacted] Initial Review Submission Form
- Project Title: The Impact of the Implementation of Universal Design for Learning-Expression Principle on Student Outcomes in Middle School Science
- Investigator: [Redacted]
- IRB Number: SBE-12-09028
- Funding Agency:
- Grant Title:
- Research ID: N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at <https://iris.research.ucf.edu> .

If continuing review approval is not granted before the expiration date of 1/16/2014, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of [Redacted] IRB Chair, this letter is signed by:

[Redacted Signature Line]

IRB Coordinator



## APPENDIX B: DISTRICT PERMISSION

February 12, 2013

[REDACTED]

Dear [REDACTED],

I am in receipt of the proposal and supplemental information that you submitted for permission to conduct research in the [REDACTED] County Public Schools. After review of these documents, it has been determined that you are granted permission to conduct the study described in these documents under the conditions described herein.

If possible, please remove the second attached form that requests parents indicate permission for their child to take part in the research **and** "*to the use and disclosure of this child's protected health information*". If this form is removed, then your research project is approved as submitted. If this form is not removed, I respectfully request an opportunity to have legal services review your request prior to giving approval.

The principal has the authority to decide if she wishes to participate in your study. Therefore, your first order of business is to contact the principal and explain your project and seek permission to conduct the research. You are expected to make appointments in advance to accommodate the administration and/or staff for research time. Your research should not interfere with staff duties or instructional time of students. Please do not use SCPS email or courier mail to disseminate your research information.

Please forward a summary of your project to my office upon completion. Good Luck!

Sincerely,

[REDACTED]

[REDACTED] Deputy  
Superintendent  
Instructional Excellence and Equity

Cc: [REDACTED]

## APPENDIX C: SCHOOL PRINCIPAL PERMISSION

# The Impact of the Implementation of Universal Design for Learning-Expression Principle on Student Outcomes in Middle School Science

## *School Principal Consent Form*

I give consent for [REDACTED] to approach learners in Grade 8 to participate in The Impact of the Implementation of Universal Design for Learning-Expression Principle on Student Outcomes in Middle School Science. I have read the Project Information Statement explaining the purpose of the research project and understand that:

- The role of the school is voluntary
- I may decide to withdraw the school's participation at any time without penalty
- Students in Grade 8 will be invited to participate and that permission will be sought from them and also from their parents.
- All students will participate however data will be collected only on students who consent and whose parents consent will participate in the project
- All information obtained will be treated in strictest confidence.
- The learners' names will not be used and individual learners will not be identifiable in any written reports about the study.
- The school will not be identifiable in any written reports about the study.
- A report of the findings will be made available to the school.
- I may seek further inf [REDACTED]  
[REDACTED] or [REDACTED] or [REDACTED] at [REDACTED] [u](#) or [REDACTED].

[REDACTED]

Principal

[REDACTED]

Signature

\_\_\_\_\_

Date

Please return to:

[REDACTED]

## APPENDIX D: TEACHER PERMISSION

# The Impact of the Implementation of Universal Design for Learning-Expression Principle on Student Outcomes in Middle School Science

## *Teacher Consent Form*

I give consent for [REDACTED] to approach learners in my science classrooms to participate in The Impact of the Implementation of Universal Design for Learning-Expression Principle on Student Outcomes in Middle School Science. I have read the Project Information Statement explaining the purpose of the research project and understand that:

- All information obtained will be treated in strictest confidence.
- The learners' names will not be used and individual learners will not be identifiable in any written reports about the study.
- The school will not be identifiable in any written reports about the study.
- A report of the findings will be made available to the school and myself
- I may seek further information on the project from [REDACTED] at [REDACTED] or [REDACTED] or [REDACTED] at [REDACTED] or [REDACTED].

[REDACTED]

Teacher Name

[REDACTED]

Signature

\_\_\_\_\_

Date

Please return to:

[REDACTED]

## APPENDIX E: STUDENT PERMISSION



Assent:

My name is [REDACTED], and I am trying to learn more about student expression of their understanding of science concepts. I would like you to choose a non-tech or tech tool; include video/audio taping if appropriate.

I understand what the research project is about and I agree to participate in the study that will take place in my science class. Please sign below indicating your permission to allow researcher collect data.

---

Student Name (Print)

---

Student Name (Signature)

---

Date



## APPENDIX F: RESEARCH PROCEDURE CHECKLIST

### Research Procedure Checklist

<b>Group</b>	<b>Task/Activity</b>	<b>Status (Circle one)</b>	<b>Notes</b>
Group A	Lesson 1 CBA Pretest	Complete	
Group B	Lesson 1 CBA Posttest MSLQ Survey	In Process	
Group A	Lesson 1 CBA Pretest	Complete	
Group B	Lesson 1 CBA Posttest MSLQ Survey	In Process	
Group A	Lesson 2 Pretest	Complete	
Group B	UDL-E Tool Evaluation UDL-E Intervention Lesson 2 Posttest	In Process	
Group A	Lesson 2 Pretest	Complete	
Group B	Lesson 2 Control Lesson 2 Posttest	In Process	
Group A	Lesson 3 Pretest	Complete	
Group B	Control Lesson 3 Posttest	In Process	
Group A	Lesson 3 Pretest	Complete	
Group B	UDL-E Tool Evaluation UDL-E Intervention Lesson 2 Posttest	In Process	
Group A	Lesson 4 CBA Pretest	Complete	
Group B	Lesson 4 CBA Posttest Interviews	In Process	
Group A	Lesson 4 CBA Pretest	Complete	
Group B	Lesson 4 CBA Posttest Interviews	In Process	

## APPENDIX G: RESEARCH PROCEDURE TIMELINE

### Research Timeline

The activities listed below are procedures that will occur prior to the beginning research in the classroom. These procedures must be in place in order for intervention and data collection to occur.

<b>Date</b>	<b>Activity</b>
Week 1 IRB	<p>Researcher will submit IRB to the University of Central Florida the day of Dissertation proposal defense.</p> <p>A formal request will be filed with school district the same day as well as a request to the principal of the school of the participating teacher.</p>
Week 2 Permissions	<p>Permissions will be requested from the parents and students as directed by the school district's IRB approval.</p>
Week 3 Permissions	<p>A reminder email will be sent home as needed from the participating teacher to all parents of students for the return of the permission requests after one week of -receipt of permission requests and again right before the winter break should parents or students require an additional copy of the permission request or require an additional reminder.</p> <p>All students will participate in the UDL-E activities however data will be collected only on the students agreeing to participate. Students will be assigned a random number for data collection purposes.</p>

The instructional unit schedules are based on guidelines set by the school district pacing guide and may vary due to the instructional needs of the students. Instruction of students will be done by the classroom teacher not the researcher. The curriculum-based assessment (CBA) pretest and posttest for each unit will be the same test. The CBA will be created by the teacher using the Pearson Success curriculum before instruction begins. The pretest design will be similar in layout and question design to tests given through the year as well as to the posttest that will be used for this study. The tests will contain multiple choice questions including application-type questions, true/false, and one short answer bonus question totaling 50 test questions plus one bonus question. All student data will be collected and participating students' scores will be recorded.

DATE & UNIT OF STUDY	ACTIVITY	
	Group A	Group B
Chapter Review & Preparation for Chapter  1 weeks	Researcher gathered data on all students and students with LD in all classes to determine case study students. One student was selected from Period 2 & Period 5 for case studies	Researcher gathered data on all students and students with LD in all classes to determine case study students. One student was selected from Period 2 & Period 5 for case studies
Students returned from Spring Break and had FCAT review for curriculum taught in sixth and seventh grade, then FCAT review.  4 weeks	<p>Researcher will continue to make observations of four case study students prior to FCAT testing and post FCAT testing.</p> <p>Researcher was not able to observe students during FCAT testing days. (FCAT testing occurred for 6 days) and an additional four days due to attendance at a national conference</p>	<p>Researcher will continue to make observations of four case study students prior to FCAT testing and post FCAT testing.</p> <p>Researcher was not able to observe students during FCAT testing days. (FCAT testing occurred for 6 days) and an additional four days due to attendance at a national conference</p>
Students will work on Chapter lessons and UDL-E activity	<p>Group A will take pretest &amp; posttest for Lesson 1 Group A will take the MSLQ survey Group A will take the pretest for Lesson 2 Group A will explore UDL-E web-based tools. Group A will complete UDL-E activity Group A will take Lesson 2 posttest</p> <p>Group A will take the pretest for Lesson 3 Group A will act as control Group A will take Lesson 3 posttest</p> <p>Group A will take pretest &amp; posttest for Lesson 4</p>	<p>Group B will take pretest &amp; posttest for Lesson 1 Group A will take the MSLQ survey Group B will take the pretest for Lesson 2 Group B will act as control Group b will take Lesson 2 posttest</p> <p>Group B will take the pretest for Lesson 3 Group B will explore UDL-E web-based tools. Group B will complete UDL-E activity Group B will take Lesson 3 posttest</p> <p>Group B will take pretest &amp; posttest for Lesson 4</p>
Students will work on parts of chapter that will be on semester exam	Group A will take the CBA pretest & posttest for Lesson 4	Group B will take the CBA pretest & posttest for Lesson 4.  Group B will take the CBA posttest.

## APPENDIX H: CBA PRETEST & POSTTEST

Name \_\_\_\_\_ Class Period \_\_\_\_\_ Date \_\_\_\_\_

1. All of the following statements are true about a pure substance, **except**
  - a. It is a single kind of matter.
  - b. It can be easily separated physically.
  - c. It has a specific makeup, or composition.
  - d. It can be an element or a compound.
  
2. Which of the following is an example of a heterogeneous mixture?
  - a. Soy sauce
  - b. Lemonade
  - c. Honey
  - d. Trail mix
  
3. Which of the following mixtures can be separated using filtration?
  - a. Sulfur and water
  - b. Salt and water
  - c. Alcohol, food coloring, and water
  - d. Iron filings and sand
  
4. What are the ways that heterogeneous mixtures can be separated depending on the substance they are made of?
  - a. Magnetic attraction and evaporation only
  - b. Magnetic attraction, filtration, distillation, or evaporation
  - c. Boiling, freezing, and filtration
  - d. Boiling only
  
5. Which of the following is an example of a homogeneous mixture?
  - a. Chicken noodle soup
  - b. Carbon dioxide
  - c. Trail mix
  - d. Ketchup

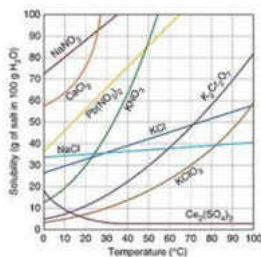
Name \_\_\_\_\_ Class Period \_\_\_\_\_ Date \_\_\_\_\_

1. A mixture containing particles that are too small to be seen easily but are large enough to scatter a light beam is called a(n) \_\_\_\_\_.
  - a. solution
  - b. colloid
  - c. suspension
  - d. alloy
  
2. When a few spoonfuls of sugar are mixed into a cup of water, sugar is the \_\_\_\_\_.
  - a. acid
  - b. base
  - c. solvent
  - d. solute
  
3. Which of the following statements about solutions is **NOT** true?
  - a. Solutions are mixtures
  - b. Solutions contain a solvent dissolved in a solute.
  - c. A solution has the same properties throughout
  - d. The solute in a solution can be a solid, liquid, or gas.
  
4. Adding more solvent to a solution makes the solution more \_\_\_\_\_.
  - a. Concentrated
  - b. Saturated
  - c. Diluted
  - d. Suspended
  
5. \_\_\_\_\_ is considered a universal solvent.
  - a. Rubbing alcohol
  - b. Hydrogen peroxide
  - c. Water
  - d. Oil



Name \_\_\_\_\_ Class Period \_\_\_\_\_ Date \_\_\_\_\_

- How would a solute affect the boiling point of water?
  - The water will boil at a lower temperature.
  - The water will boil at a higher temperature.
  - The will not boil.
  - The boiling point will be the same as the freezing point.
- A solution that has so much solute in it so that no more can dissolve in it is a(n) \_\_\_\_\_.
  - Dilute solution
  - Concentrated solution
  - Heterogeneous solution
  - Saturated solution
- The factors that affect the solubility of a substance are \_\_\_\_\_.
  - Time and temperature
  - The type of solvent, pressure and temperature
  - The type of solvent, pressure and time.
  - Pressure and time
- Solubility is \_\_\_\_\_.
  - A measure of how much solute can dissolve in a solvent at a given temperature
  - A concentrated solution that will be saturated at any moment
  - A measure of how much solvent can dissolve at a given temperature.
  - A measure of how many more spoonfuls of solute can be added to a diluted solution.
- Using the graph on the next page, which compounds are most soluble at  $0^{\circ}\text{C}$  \_\_\_\_\_ and least soluble at  $100^{\circ}\text{C}$  \_\_\_\_\_?
  - $\text{CaCl}_2$  and  $\text{NaCl}$
  - $\text{NaNO}_3$  and  $\text{NaCl}$
  - $\text{KNO}_3$  and  $\text{SO}_2$
  - $\text{NaNO}_3$  and  $\text{Ce}_2(\text{SO}_4)_3$



## APPENDIX I: SCIENCE VOCABULARY CHECKLIST

## UDL-E PBA Product Form

**Student Number** \_\_\_\_\_

**UDL-E Tool** \_\_\_\_\_

**Directions:** For each vocabulary word listed in this chapter please indicate if the student used the vocabulary word in the UDL-E product and also indicate if the vocabulary was used correctly based on the definition for student resources.

### Chapter 7 Vocabulary

Vocabulary Word	Yes	No	Vocabulary Definition	Yes	No
Pure substance			A single kind of matter that has a specific makeup or composition. Pure substances cannot be separated easily or sometimes at all.		
Mixture			Two or more substances that are together in the same place.		
Heterogeneous mixture			A mixture in which you can see the different parts and easily separate them out.		
Homogeneous mixture			A mixture so evenly mixed that you can't differentiate the parts simply by looking at the mixture.		
Solution			A mixture containing a solvent and at least one solute and has the same properties throughout.		
Solvent			Dissolves other substances.		
Solute			The substance that is dissolved by the solvent		
Colloid			A mixture containing small, undissolved particles that do not settle out. Particles are too small to be seen without a microscope yet large enough to scatter a beam a light		
Suspension			A mixture in which particles can be seen and easily separated by settling or filtration. Does not have the same properties throughout. Contains visible particles that are larger than the particles in solutions or colloids.		
Dilute solution			A mixture that has only a little solute dissolved in a certain amount of solvent.		
Concentrated solution			A mixture that has a lot of solute dissolved in the solvent.		
Solubility			The measure of how much solute can dissolve in a solvent at a given temperature. Factors that can affect the solubility of a substance include pressure, the type of solvent, and temperature.		
Saturated solution			The point at which no more solute will dissolve in a solution.		

## APPENDIX J: STUDENT ENGAGEMENT SURVEY (MSLQ SURVEY)

## Motivated Strategies for Learning Questionnaire\*

Please rate the following items based on your behavior in this class. Your rating should be on a 7-point scale where **1= not at all true of me** to **7=very true of me** .

1. I prefer class work that is challenging so I can learn new things.
2. Compared with other students in this class I expect to do well
3. I am so nervous during a test that I cannot remember facts I have learned
4. It is important for me to learn what is being taught in this class
5. I like what I am learning in this class
6. I'm certain I can understand the ideas taught in this course
7. I think I will be able to use what I learn in this class in other classes
8. I expect to do very well in this class
9. Compared with others in this class, I think I'm a good student
10. I often choose paper topics I will learn something from even if they require more work
11. I am sure I can do an excellent job on the problems and tasks assigned for this class
12. I have an uneasy, upset feeling when I take a test
13. I think I will receive a good grade in this class
14. Even when I do poorly on a test I try to learn from my mistakes
15. I think that what I am learning in this class is useful for me to know
16. My study skills are excellent compared with others in this class
17. I think that what we are learning in this class is interesting
18. Compared with other students in this class I think I know a great deal about the subject
19. I know that I will be able to learn the material for this class
20. I worry a great deal about tests
21. Understanding this subject is important to me
22. When I take a test I think about how poorly I am doing
23. When I study for a test, I try to put together the information from class and from the book
24. When I do homework, I try to remember what the teacher said in class so I can answer the questions correctly
25. I ask myself questions to make sure I know the material I have been studying
26. It is hard for me to decide what the main ideas are in what I read
27. When work is hard I either give up or study only the easy parts
28. When I study I put important ideas into my own words
29. I always try to understand what the teacher is saying even if it doesn't make sense.
30. When I study for a test I try to remember as many facts as I can
31. When studying, I copy my notes over to help me remember material
32. I work on practice exercises and answer end of chapter questions even when I don't have to

33. Even when study materials are dull and uninteresting, I keep working until I finish
34. When I study for a test I practice saying the important facts over and over to myself
35. Before I begin studying I think about the things I will need to do to learn
36. I use what I have learned from old homework assignments and the textbook to do new assignments
37. I often find that I have been reading for class but don't know what it is all about.
38. I find that when the teacher is talking I think of other things and don't really listen to what is being said
39. When I am studying a topic, I try to make everything fit together
40. When I'm reading I stop once in a while and go over what I have read
41. When I read materials for this class, I say the words over and over to myself to help me remember
42. I outline the chapters in my book to help me study
43. I work hard to get a good grade even when I don't like a class
44. When reading I try to connect the things I am reading about with what I already know.

\*Pintrich, R. R., & DeGroot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance, *Journal of Educational Psychology*, 82, 33-40.

APPENDIX K: UDL-E TOOL EVALUATION & SELECTION FORM

### UDL-E Tool Evaluation & Selection Form

UDL-E TOOL	PROS/LIKE	CONS/DISLIKE	<b>RATING</b> On a scale from 0 to 5 rate your comfort level in each tool where <b>0 = Not Comfortable At All</b> and <b>5 = Very Comfortable</b>
Voki			0   1   2   3   4   5
Voicethread			0   1   2   3   4   5
Paper and Pencil			0   1   2   3   4   5

Based on the UDL-E tool choices and my evaluation of what I like and dislike about each tool I have decided that I would like to use

\_\_\_\_\_.



APPENDIX L: TIME-ON-TASK (TOT) OBSERVATION FORM & SUB-BEHAVIOR CODES

**Date:**

**Period:**

**Student:**

**Observer:**

<b>Minute</b>	<b>TOT Evaluation</b>	<b>Comments/Notes:</b>
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

### On-task and Off-task Sub-behavior Codes

Sub-behavior	Student behavior or characteristics
LRT	Looking or Reading Text. The student is looking at or reading their text pages or handout distributed in class.
ETS	Eyes on Teacher or Student. The student is looking at the teacher during instruction or student responding to a teacher directed question.
SW	Student Writing. The student is writing on their text pages, notepaper, quiz, etc.
SR	Student Response. The student is responding to a question posed by the teacher or participating in class discussion related to the lesson.
SGA	Student or Group Activity. The student is participating in a student activity or group activity such as a lab, web-quest activity, UDL-E activity. Writing during SGA activities will be included under the SGA activity.
EBS	Eyes on the Board or Screen. The student is looking at the whiteboard or screen where lessons are presented.
PI	Peer Interaction. The student may be talking with peers or peers talking to student.
SI	Student is Inattentive. Student may be looking down at floor, desk, or across room.
SDE	Student is Disengaged. Student may have their head down on the desk or working on another assignment.

## APPENDIX M: UDL-E PROCEDURE DIRECTIONS

## UDL-E Intervention Directions

Group A (Period 2 and Period 5)

7.1

Using the tech tool (Voki or Voicethread) or alternative method (Paper & Pencil) you have chosen explain pure substances and mixtures. Explain how mixtures are different from pure substances. Identify two types of mixtures. Include all or as many vocabulary words from lesson 7.1 as you can to support your explanation.

Group B (Period 2 and Period 7)

7.2

Using the tech tool (Voki or Voicethread) or alternative method (Paper & Pencil) you have chosen explain solutions. Explain how mixtures are classified and how a solution forms. Include all or as many vocabulary words from lesson 7.2 as you can to support your explanation.

APPENDIX N: INTERVIEW QUESTIONS AND TRANSCRIPTIONS

## UDL-E Intervention Focus Group Interview Questions

My name is Lisa Finnegan. Would you mind if I audio record this interview so that I can make sure my notes are accurate. No personal information about you will be shared in this recording. Do I have your permission to record this interview?

Today is \_\_\_\_ (State date). My name is Lisa Finnegan. I have just turned on the digital recorder and I am speaking with a group of students in Grade 8 Science. I would like for you to verify that I have your permission to record our conversation now that the recorder is running. As I mentioned, I am tape recording the discussion so that I don't miss anything you have to say. Do you have any questions before I begin asking questions?  
(Wait for students to respond if needed)

**This part of the interview will focus on your perceptions or thoughts and use of the technology tools to express your science understanding.**

Researcher: "Thank for the opportunity to ask you some questions regarding the tools that you used in class to express your science knowledge.

Please tell me which method you used to express your science knowledge."

Researcher: Can you please explain why you feel the method you chose was easy for you to use.

If it wasn't easy, tell me why it wasn't."

Researcher: If student choose paper and pencil over web-based tools ask : "Why did you choose paper and pencil over the technology?"

Researcher: "What parts of the tools or method you used were most helpful?"

Researcher: "Is there anything of the approach you chose that you would say was not helpful?"

Researcher: "In the future, would you use the approach you used on your own to help you learn and understand the science content like you did in this activity?"

Researcher: Would you describe your homework habits or behaviors for science class.

Researcher: "What about tests? How and when do you typically study for tests in science?"

Please share with me your thoughts about technology within your educational studies. Can you name any specific technology that is of value to you within your current science class or other classes? What Web 2.0 tools are you using in any classes?

Researcher: “What motivates you as a learner or student to do well in science?”

Researcher: How do you know that you typically understand a science concept?

Researcher: “When do you feel that that your teacher knows what you know?”

Researcher: “Speaking of your classmates, how do you feel your peers or classmates influence or affect your learning or academic performance?”

Thank you for taking the time to answer my questions. I really appreciate the information you shared. The last question that I have is if you would personally share with me if you have any identified disability or personal concern that you have as a learner?

Here is a copy of the contact information for you and it is also on your copy of the consent form.

Thank you for letting me speak with you today. Your time, which I know is valuable, is very much appreciated and your comments have been very helpful.

*Turn off tape recorder. Thank them again, and say goodbye.*



## Period 2 Interview Notes

This interview comprised Students 0201, 0206, 0212, and 0216. Student 0217, case study, was absent on the day of the interview. These students were randomly chosen.

Researcher: “Thank for the opportunity to ask you some questions regarding the tools that you used in class to express your science knowledge.

Please tell me which method you used to express your science knowledge.”

Student 0206: “Voicethread”

Student 0212: “I used Voicethread too.”

Student 0201: “Voki.”

Student 0216: “Paper and pencil.”

Researcher: Okay, can you please explain why you feel the method you chose was easy for you to use. If it wasn't easy, tell me why it wasn't.”

Student 0212: “It was easy to use because everything was precise. I didn't like how it didn't show a slide show as practice so you know what our slides look like before you save it though.”

Student 0206: I think it was easy because all you have to do is input a picture or video and either talk or put captions to explain what's going on.”

Student 0216: “With paper and pencil it was simply just writing without technology. “

Researcher: “Why did you choose paper and pencil over the technology?”

Student 0216: “To be honest, I'm lazy.”

Student 0201: “I used Voki. It was easy because everything had instructions with it.”

Researcher: “What parts of the tools or method you used were most helpful?”

Student 0206: “The way the website is set up made it easy to do the assignment I think.”

Student 0212: “The most helpful thing for me was making comments because it helps you explain and the way you can add pictures is also helpful.”

Student 0216: “Putting it in my own words instead of multiple choice questions.”

Student 0201: “The avatar telling the information back to me.”

Researcher: “Is there anything of the approach you chose that you would say was not helpful?”

Student 0216: “With paper & pencil there isn’t much input from others the way it was done.”

Student 0201: “I don’t know.”

Student 0206: “I don’t think it (Voicethread) gives you a lot of things to use.

Student 0212: Most was good to use besides color changing and Voicethread needs something so you can make a title.”

Researcher: “In the future, would you use the approach you used on your own to help you learn and understand the science content like you did in this activity?”

Student 0206: “Probably because if it worked so good this time, it would be good later on.”

(Student used Voicethread)

Student 0212: “I would stick to notes because writing with my hands helps more than typing on a keyboard.” (Student used Voicethread and did not audio record)

Student 0201: “Probably not because I’m a really lazy person.” (Voki used)

Student 0216: Yes, because I can put all my thoughts down and go over them, and because I know what I mean, whereas someone could get confused trying to speak your answer.”

Researcher: Would you describe your homework habits or behaviors for science class.

Student 0216: “I don’t do homework. I get my assignments done in class and typically homework is classwork we don’t finish.”

Student 0212: “That’s the same for me. We don’t have many homework assignments because I finish much of it in class but if needed I do all the homework required.”

Student 0201: I always do my homework for science because we don’t get much and it’s usually easy.”

Student 0206: “I do most of my homework. Sometimes I don’t get to do all of it but when I’m on the ball I do it.”

Researcher: “What about tests? How and when do you typically study for tests in science?”

Student 0212: “Before test.”

Student 0216: “Rarely ever”

Student 0201: “I usually go over my text pages.”

Student 0206: “I usually study using the classwork we did and study that instead of the textbook.”

Please share with me your thoughts about technology within your educational studies. Can you name any specific technology that is of value to you within your current science class or other classes? What Web 2.0 tools are you using in any classes?

Student 0216: “I am not using any in any of my classes.”

Student 0212: “We use BrainPop (FWD Media, Inc., 2013) in science. It shows videos and asks questions.”

Student 0201: “Using our cell phones. We have done surveys with them.”

Student 0206: “I usually use Microsoft Word for typed projects. I also use the internet for information about a subject.”

Researcher: “What motivates you as a learner or student to do well in science?”

Student 0201: “Candy” (Student laughs)

Student 0212: “A treat or knowing I won’t have homework if I finish.”

Student 0216: “Something interesting”

Student 0206: “Trying to get an A or B motivates me to do good.”

Researcher: How do you know that you typically understand a science concept?

Student 0216: “Passing the test.”

Student 0201: “When I can answer a question about it easily.”

Student 0206: “When I know the term and automatically know what she is talking about.”

Student 0212: “I study the main parts and mainly vocabulary words.”

Researcher to Student 0212: “So by studying the main parts and the vocabulary words how does that let you know you understand what you learned?”

Student 0212: “I know the words and what they mean.”

Researcher: “So besides tests how do you know when your teacher knows what you know?”

Student 0201: “By answering questions she asks in class. And sometimes by the worksheets we do.”

Student 0206: “By answering questions and participating in RT activities. Then we can see that we are really understanding what we read.”

Student 0216: Answering questions in class. I think that explaining it to classmates also lets me know I know it.”

Researcher: “Speaking of your classmates, how do you feel your peers or classmates influence or affect your learning or academic performance?”

Student 0206: “Sometimes they distract me but not to the point of failing. Other than that, they’re a big help.”

Student 0212: “They are calm and can help when people need it and ask many questions.”

Student 0201: “Sometimes they distract me.”

Student 0216: “At times distracting, but other times helpful by giving their input.”

Thank you for taking the time to answer my questions. I really appreciate the information you shared. The last question that I have is if you would personally share with me if you have any identified disability or personal concern that you have as a learner?

One student disclosed that they had ADD and OCD.

### Period 3 Interview Notes

This interview comprised Students 0303, 0305, 0312, and 0315. Student 0320, case study student, was absent on the day of the interview. These students were randomly chosen.

Researcher: “Thank for the opportunity to ask you some questions regarding the tools that you used in class to express your science knowledge.

Please tell me which method you used to express your science knowledge.”

Student 0315: “Voki”

Student 0303: “Voki.”

Student 0305: “Paper & pencil”

Student 0312: “Paper and pencil.”

Researcher: Thanks, can you please explain why you feel the method you chose was easy for you to use. If it wasn't easy, tell me why it wasn't.”

Student 0315: “Typing on a computer is much easier than writing on paper. Also the question was more straight forward.”

Student 0303: “Yes, because it was easy to understand. It clearly stated where everything was and told you what to do.”

Student 0312: “The method I used was very easy for me because I love to write essays and stories. Writing is my favorite. All my thoughts come to me when I'm writing. That's when I'm most comfortable and creative. I like to grip a pencil and reading a book.”

Student 0305: I could look for the research myself without any trouble. And I could create my own chart for my research using paper and pencil.”

Researcher: “What parts of the tools or method you used were most helpful?”

Student 0305: “Making a poster with definitions and summaries.”

Researcher: You used paper & pencil –what was helpful with that method?

Student 0312: Being organized in what I wrote so like when I was creating my paper & pencil poster, I was organized. I had a set way of doing things my way.”

Researcher : “And for Voki?

Student 0315: “Probably the multiple options of answering.”

Researcher: “Is there anything of the approach you chose that you would say was not helpful?”

Student 0315: “The option to create a character was fun but mostly useless.”

Student 0303: “Trying to use it at first was difficult not knowing what to do.”

Student 0312: “For me it was more of other people. When other people were talking to me nothing I did was helpful. I kept getting distracted.”

Researcher: “In the future, would you use the approach you used on your own to help you learn and understand the science content like you did in this activity?”

Student 0303: “Yes, it makes it easier to understand what to do.” (Voki used)

Student 0305: Yes, this way of learning helped me the most.” (Paper & pencil)

Student 0315: “If there was an option to I would use the Voki due to it being easy to answer and it being a much faster process.”

Student 0312: “Yes, paper & pencil will always come with me. I will always use paper and pencil and I like it cause I can express myself better than talking.”

Researcher: Would you describe your homework habits or behaviors for science class.

Student 0305: “I usually go home and do my homework with my music. It helps me think.”

Student 0312: “I do homework when I have it and study when I really have to.”

Student 0315: "I usually just get my assignments then do them with paper and pencil."

Student 0303: "I try to finish my text pages and try to study more often for tests. I also finish assignments that I didn't in class."

Researcher: "What about tests? How and when do you typically study for tests in science?"

Student 0305: "Almost never."

Student 0312: "When I really need to. Not every night but when I need to."

Student 0303: "I go over it with my friends or look it over. Sometimes I do it at school but mostly at home."

Student 0315: "I study for tests when I am at home and use the study guide and book."

Please share with me your thoughts about technology within your educational studies. Can you name any specific technology that is of value to you within your current science class or other classes? What Web 2.0 tools are you using in any classes?

Student 0315: "There really isn't technology in our classes except for computers for tests and science tools for labs."

Student 0303: "I could use my laptop or phone to look up information I don't get in class."

Student 0312: "I don't use any in any classes. I hate the computer for school. Hate it!"

Student 0305: "Honestly I don't use technology when learning."

Researcher: "What motivates you as a learner or student to do well in science?"

Student 0315: "A better career."

Student 0312: "I learn and memorize things better when they're more fun. Like projects, group projects, presentations, acting things out, making up songs and slogans to memorize things, stuff like that."



Student 0305: "Getting good grades and fun class labs."

Researcher: How do you know that you typically understand a science concept?

Student 0305: "When I do good on papers and tests that have to do with the subject."

Student 0315: "When I can fully explain it."

Student 0303: "When I know the definition and when someone asks me and I can answer it without looking."

Student 0312: I don't really know but I get a feeling that tells me, "Wow" "You actually understand this!" Then I get scared when the test comes and I forget everything and I fail or get a D. I feel like it is never really plastered into my brain."

Researcher: "So besides tests how do you know when your teacher knows what you know?"

Student 0305: "Probably answer questions in class."

Student 0315: " Answer questions in class and how you write your response on the worksheets shows that you understand what your writing about."

Student 0305: "You just start to feel confident about the subject."

Researcher: "How do you feel your peers or classmates influence or affect your learning or academic performance?"

Student 0305: "I feel that they really don't affect my learning."

Student 0315: "They can either speed it up or slow it down."

Student 0312: "They affect it negatively cause they're **always** (emphasis) distracting the learning process and I get distracted and laugh and goof off and forget what's going on. "

Student 0303: "I think both because sometimes they help me and other times they distract."

Thank you for taking the time to answer my questions. I really appreciate the information you shared. The last question that I have is if you would personally share with me if you have any identified disability or personal concern that you have as a learner?

One student disclosed that he/she has ADHD and another student disclosed that he/she gets distracted if not engaged and zones out. Student also disclosed that he/she has had a seizure when little and again recently.

## Period 5 Interview Notes

This interview comprised Students 0509, 0518, and 0521, as well as, Case Study Student 0507.

All but the case study student were randomly selected.

Researcher: “Thank for the opportunity to ask you some questions regarding the tools that you used in class to express your science knowledge.

Please tell me which method you used to express your science knowledge.”

Student 0507: “Voki”

Student 0521: “Voki.”

Student 0509: “Voki.”

Student 0518: “Paper and Pencil.”

Researcher: Thank you. Can you please explain why you feel the method you chose was easy for you to use. If it wasn't easy, tell me why it wasn't.”

Student 0507: “Voki was simple because everything was flat out in front of you and available to use.”

Student 0521: “It was fun and easy to use plus it was fun to create.”

Student 0518: “I felt personally that Voki and Voicethread were hard for me to use.”

Student 0509: “I felt it was easy because nothing was complicated and it was fun to work on.”

Researcher: “What parts of the tools or method you used were most helpful?”

Student 0507: “Everything.”

Student 0518: “The questions were in the textbook. It came from our work.”

Student 0521: “The response to the question on Voki.”

Student 0509: “Yeah, the box where you could type what you wanted to say. It was easy.”

Researcher: “Is there anything of the approach you chose that you would say was not helpful?”

Student 0521: “I would think that if you were trying to use it with research.”

Student 0518: “If you had question that involve a lot of math it would be hard.”

Student 0507: “The password log-in system. I had trouble with that.”

Student 0509: “The designing part of the avatar. Too many choices.”

Researcher: “In the future, would you use the approach you used on your own to help you learn and understand the science content like you did in this activity?”

Student 0518: Yes, because it could help me a lot especially with tests I think.”

Student 0521: “Yes, it would help me learn easier.”

Student 0507: Researcher looks at student and student shrugs shoulders.

Student 0509: “Yes and no. Yes because it’s a fun way of learning but no because I need more than that to study for things.”

Researcher: Would you describe your homework habits or behaviors for science class.

Student 0507: “I try to get things done in class.”

Student 0521: “I do it sometimes unless I need the grade.”

Student 0509: “I sit down at my desk and make notecards.”

Student 0518: “I usually do my homework but forget to turn it in.”

Researcher: “What about tests? How and when do you typically study for tests in science?”

Student 0509: “usually a couple days before the test so I will remember the info.”

Student 0518: “I read out loud and I answer the questions but only once before the test.”

Student 0521: “Rarely.”

Student 0507: “I hardly ever study at all. It must be from a concussion I got.”

Please share with me your thoughts about technology within your educational studies. Can you name any specific technology that is of value to you within your current science class or other classes? What Web 2.0 tools are you using in any classes?

Student 0507: “Science and FCAT explorer. We use BrainPop (FWD Media, Inc., 2013) in Science”

Student 0521: “I think technology has a big impact in class. The better the technology the easier it is.”

Student 0518: “We use a little bit of BrainPop (FWD Media, Inc., 2013) in my classes.”

Student 0509: “I enjoy using technology. I only use Microsoft and Excel.”

Researcher: “What motivates you as a learner or student to do well in science?”

Student 0507: “Science is my favorite subject.”

Student 0509: “My parents and wanting to get good grades.”

Student 0521: “All of science interests me.”

Student 0518: “I love science—it’s my favorite subject.”

Researcher: How do you know that you typically understand a science concept?

Student 0518: “Getting the answers right.”

Student 0521: “I just question myself.”

Student 0507: “If I can re-explain it thoroughly.”

Student 0509: “I know when I can read the subject and completely understand what’s going on.”

Researcher: “Not including test scores and grades, how do you know when your teacher knows what you know?”

Student 0518: The teacher uses questions, so when you answer the questions right.”

Student 0521: “She asks questions and we raise our hand and we get it right.

Student 0509: “good grades on classwork, quizzes and homework.”

Student 0507: Student would not look up or make eye contact.

Researcher: “Can you tell me how you feel your peers or classmates influence or affect your learning or academic performance?”

Student 0509: “Sometimes I feel my peers affect my learning because of distractions.”

Student 0507: “My peers don’t impact my learning. They interfere sometimes.”

Student 0518: “Too much talking and I can’t hear what the teacher is saying.”

Student 0521: “Sometimes they slow me down but other times it helps.”

Thank you for taking the time to answer my questions. I really appreciate the information you shared. The last question that I have is if you would personally share with me if you have any identified disability or personal concern that you have as a learner?

One student disclosed that he/she has ADHD and another student disclosed that he/she has an IEP in Math. Case study student did not disclose that he/she was a student with a learning disability.

## Period 7 Interview Notes

This interview comprised Students 0708, 0714, and 0715, as well as, Case Study Student 0511.

All but the case study student were randomly selected.

Researcher: “Thank for the opportunity to ask you some questions regarding the tools that you used in class to express your science knowledge.

Please tell me which method you used to express your science knowledge.”

Student 0714: “Voicethread”

Student 0711: “Voki.”

Student 0708: “Voki.”

Student 0715: “Voki, too.”

Researcher: Thank you. Can you please explain why you feel the method you chose was easy for you to use. If it wasn't easy, tell me why it wasn't.”

Student 0711: Yes, it was easy and it was a fun thing to do.

Student 0708: You could easily type your answer and pick the voice that you wanted.”

Student 0714: “The buttons were simple and the directions were good. (Voicethread user)

Student 0715: It was easy because you got to type your answer and go over it by listening to what you typed.

Researcher: “What parts of the tools or method you used were most helpful?”

Student 0714: “I used the Powerpoint presentation for my assignment and uploaded it to create my own.”

Student 0715: “To listen to what you wrote.”

Student 0708: “You could easily type out your answer and pick the voice that you wanted.”

Student 0711: "It told you what you typed."

Researcher: "Is there anything of the approach you chose that you would say was not helpful?"

Student 0714: "I would say that the video was the least helpful for me."

Student 0711: "Nothing, it was pretty easy to understand."

Student 0715: "Making the Voki person."

Student 0708: "I agree, making the Voki person. It didn't really add to what you knew."

Researcher: "In the future, would you use the approach you used on your own to help you learn and understand the science content like you did in this activity?"

Student 0715: "Yes, now I have a better understanding of it."

Student 0714: "Yes, the program helped me make clearer conclusions about the section. I would definitely love to use it more."

Student 0711: "Yes, it was fun and educational."

Student 0708: "Yes, because it was simple and I think it actually did help me remember the science material more quickly and a lot easier also."

Researcher: "Would you describe your homework habits or behaviors for science class."

Student 0711: "I don't do homework."

Student 0708: "I turn in homework on time most of the time but sometimes late and not at all."

Student 0714: "I turn my homework in on time. I've only had one late assignment for science."

Student 0715: "I sometimes turn mine in on time."

Researcher: "How and when do you typically study for tests in science?"

Student 0711: "Never."

Student 0714: "I study by going through the book chapters and usually the night before."



Student 0715: "Usually whenever there is a test or quiz."

Student 0708: "Occasionally I study and usually by looking over the textbook."

Please share with me your thoughts about technology within your educational studies. Can you name any specific technology that is of value to you within your current science class or other classes? What Web 2.0 tools are you using in any classes?

Student 0715: I use Blackboard to find a study guide or an answer in Blackboard but no other technology."

Student 0708: "I don't use any websites to help me with science or other classes."

Student 0711: "Google cuz I can look up answers."

Student 0714: "I enjoy using technology. It is more in with our generation and better than doing written assignments or projects. I've used Voicethread in science before this year and computers in classes to do some projects."

Researcher: "What motivates you as a learner or student to do well in science?"

Student 0711: "Things that are fun and picking up my grades. Also labs."

Student 0714: "I'm motivated by my parents and also I hold myself accountable for the success of my future."

Student 0715: "My mom and dad motivate me to do well in science and other subjects."

Student 0708: "Going to high school and passing."

Researcher: How do you know that you typically understand a science concept?

Student 0714: "When I can do activities without the textbook."

Student 0711: "When I pass the test."

Student 0708: "When I can repeat it in my head without looking in the book."

Researcher: “So besides tests how do you know when your teacher knows what you know?”

Student 0711: “Answering questions in class. Filling out the worksheets”

Student 0714: “With other assignments than tests and the feedback we get and seeing what we write gets more developed. When we do the |RT”

Student 0715: Answering questions in class.”

Researcher: “How do you feel your peers or classmates influence or affect your learning or academic performance?”

Student 0711: “They motivate to keep learning things and get good grades.”

Student 0714: “I feel sometimes that when they talk too much I don’t learn as well, but usually they are encouraging.”

Student 0708: “They don’t.”

Thank you for taking the time to answer my questions. I really appreciate the information you shared. The last question that I have is if you would personally share with me if you have any identified disability or personal concern that you have as a learner?

One student disclosed that they had had a concern that they will fail. The case study student with a learning disability chose not to disclose anything.

## REFERENCES

- Achieve, Inc. (2013). *Next generation science standards*. Washington, DC: Author.
- Acrey, C., Johnstone, C., & Milligan, C. (2005). Using universal design to unlock the potential for academic achievement of at-risk learners. *Teaching Exceptional Children, 41*(2), 22-31.
- American Association for the Advancement of Science (AAAS). (1989). *Project 2061: Science for all Americans*. New York, NY: Oxford University Press.
- American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for science literacy*. New York, NY: Oxford University Press.
- Assistive Technology Act of 1998, 29 U. S. C. § 3001 *et seq.* (1998).
- Bakken, J. P., Mastropieri, M. A., & Scruggs, T. E. (1997). Reading comprehension of expository science material and students with learning disabilities: A comparison of strategies. *Journal of Special Education, 31*(3), 300-324.
- Baxter, G. P., Glaser, R., & Raghavan, K. (1993). *Analysis of cognitive demand in selected alternative science assessments* (Vol. ED 368 776). Pittsburgh, PA: CRESST/Learning Research and Development Center.
- Bergerud, D., Lovitt, T. C., & Horton, S. (1988). The effectiveness of textbook adaptations in life science for high school students with learning disabilities. *Journal of Learning Disabilities, 21*(2), 70-76.
- Bloom B. S. (1956). *Taxonomy of educational objectives, handbook I: The cognitive domain*. New York, NY: David McKay.

- Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. S. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3-4), 369-398.
- Borsuk, E. R. (2010). Examination of an administrator-read vocabulary-matching measure as an indicator of science achievement. *Assessment for Effective Intervention, 35*(3), 168-177.
- Bowen, S. K., & Rude, H. A. (2006). Assessment and students with disabilities: Issues and challenges with educational reform. *Rural Special Education Quarterly, 25*(3), 24-30.
- Bower, M., Hedberg, J. G., & Kuswara, A. (2010). A framework for web 2.0 learning design. *Educational Media International, 47*(3), 177-198.
- Brantlinger, E., Jimenez, R., Klinger, J., Pugach, M., & Richardson, V. (2005). Qualitative studies in special education. *Exceptional Children, 71*(2), 195-207.
- Brockett, L. P. (1855). Idiots and institutions for their training. *American Journal of Education*, Retrieved from <http://www.disabilitymuseum.org/dhm/lib/catcard.html?id=1438>
- Burgstahler, S. E. (2008). Universal design in higher education. In S. E. Burgstahler & R. C. Cory (Eds.), *Universal design in higher education: From principles to practice* (pp. 3-22). Cambridge, MA: Harvard Education Press.
- Bybee, R. W. (2002). *Learning science and the science of learning*. Arlington, VA: National Science Teachers Association Press.
- Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental design for research*. Boston, MA: Houghton Mifflin.
- Carey, S., & Smith, C. (1993). On understanding the nature of scientific knowledge. *Educational Psychologist, 28*(3), 235-251.

- CAST, Inc. (2012a). *About UDL: What is universal design for learning?* Retrieved from <http://www.cast.org/udl/index.html>
- CAST, Inc. (2012b). *CAST Timeline: One mission, many innovations, 1984-2010*. Retrieved from <http://www.cast.org/about/timeline/index.html>
- CAST, Inc. (2012c). *National center on universal design for learning: About UDL:UDL guidelines-version 2*. Retrieved from <http://www.udlcenter.org/aboutudl/udlguidelines>
- CAST, Inc. (2012d). *Transforming education through universal design for learning*. Retrieved from <http://www.cast.org/>
- Center for Universal Design (2008). *About the center: Ronald L. Mace: Last speech*. Retrieved from [http://www.ncsu.edu/www/ncsu/design/sod5/cud/about\\_us/usronmacespeech.htm](http://www.ncsu.edu/www/ncsu/design/sod5/cud/about_us/usronmacespeech.htm)
- Cole, C. (2006). Education policy brief: Closing the achievement gap series: Part III What is the impact of NCLB on the inclusion of students with disabilities? *Center for Evaluation & Education Policy*, 4(11), 1-12.
- Common Core Standards Initiative. (2012a). *Application to students with disabilities*. Retrieved from <http://www.corestandards.org/assets/application-to-students-with-disabilities.pdf>
- Common Core Standards Initiative. (2012b). *English language arts standards: Science & technical subjects: Grade 6-8*. Retrieved from <http://www.corestandards.org/ELA-Literacy/RST/6-8>
- Common Core Standards Initiative. (2012c). *English language arts standards: Speaking & listening: Grade 8*. Retrieved from <http://www.corestandards.org/ELA-Literacy/SL/8>
- Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings*. Chicago, IL: Rand McNally.

- Council of Exception Children. (2012). *CEC Milestones*. Retrieved from <http://www.cec.sped.org/Content/NavigationMenu/AboutCEC/CECsMissionandVision/CECMilestones/default.htm>
- Coyne, P., Pisha, B., Dalton, B., Zeph, L. A., & Cook- Smith, N. (2012). Literacy by design: A universal design for learning approach for students with significant intellectual disabilities. *Remedial and Special Education, 33*(3), 162-172.
- Crawford, B. A., Krajcik, J. S., & Marx, R. (1999). Elements of a community of learners in a middle school science classroom. *Science Education, 83*, 701-723.
- Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches* (3<sup>rd</sup> ed). Thousand Oaks, CA: Sage.
- Cutting, L. E., & Denckla, M. B. (2003). Attention: Relationships between attention-deficit hyperactivity disorder and learning disability. In H. L. Swanson, K. R. Harris, & S. Graham (Eds.), *Handbook of learning disabilities* (pp. 125-139). New York, NY: Guilford Press.
- Darling-Hammond, L. (2006). Constructing 21<sup>st</sup> century teacher education. *Journal of Teacher Education, 57*(3), 300-314.
- Darling-Hammond, L. (2011). Restoring our schools: The quest for equity in the United States. *Education Canada, 51*(5), 14-18.
- DeMers, K. D. (2010). The brain within its groove: Language and struggling students. *English Journal, 100*(2), 31-35.

- Diana vs. California Board of Education. (1973). Retrieved from [http://education.vermont.gov/new/pdfdoc/pgm\\_esl/guide\\_94/guide\\_94\\_01.pdf](http://education.vermont.gov/new/pdfdoc/pgm_esl/guide_94/guide_94_01.pdf)
- Dix, D. L. (1843). *The history of mental retardation*. Collected papers. University Park Press.  
Retrieved from <http://www.disabilitymuseum.org/dhm/lib/detail.html?id=737&page=11>
- Dunn, R. S. (1929). *Old Deluder Satan Law of 1647: The laws and liberties of Massachusetts*. (Reprinted from 1648 edition). Boston, MA: Harvard University Press.
- Duschl, R. A. (1990). *Restructuring science education: The importance of theories and their development*. New York, NY: Teachers College Press.
- Duschl, R. A. (2003). Assessment of scientific inquiry. In J. M. Atkin & J. Coffey (Eds.), *Everyday assessment in the science classroom* (pp. 41-59). Arlington, VA: National Science Teachers Association.
- Duschl, R. A., & Gitomer, D. H. (1997). Strategies and challenges to changing the focus of assessment and instruction in science classrooms. *Educational Assessment*, 4(1), 37-73.
- Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education*, 38, 39-72.
- Duschl, R. A., Schweingruber, H. A., & Shouse, A.W. (2007). *Taking science to school: Learning and teaching science in grades K-8*. Washington, DC: The National Academies Press. Retrieved from <http://www.nap.edu/catalog/11625.html>
- Edelson, D. C. (2001). Learning-for-use: A framework for integrating content and process learning in the design of inquiry activities. *Journal of Research in Science Teaching*, 38(3), 355-385.

- Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences*, 8(3-4), 391-450.
- Edelson, D. C., & Reiser, B. J. (2006). Making authentic practices accessible to learners: Design challenges and strategies. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 335-354). New York, NY: Cambridge University Press.
- Education for All Handicapped Children Act of 1975, Public. L. No. 94-142 (1975).
- Elbaum, B., & Vaughn, S. (2003). Self-concept and students with learning disabilities. In H. L. Swanson, K. R. Harris, & S. Graham (Eds.), *Handbook of learning disabilities* (pp. 229-241). New York, NY: Guilford Press.
- Elementary and Secondary Education Act, Pub L No. 89-10, 20 U.S.C. § 2701 *et seq.* (1965).
- Farrell, E. E. (1908–1909). Special classes in the New York City schools. *Journal of Psychopathology*, 13, 91-96.
- Farrell, E. E. (1921). The unclassified child. *Ungraded*, 3(5), 97- 104.
- FDW Media, Inc. (2013). *BrainPop*. Retrieved from <http://www.brainpop.com/>
- Fiestier, L. (2012). *Don't "DYS" our kids: Dyslexia and the quest for grade-level reading proficiency*. Commissioned by the Emily Hall Tremain Foundation on behalf of The Campaign for Grade-Level Reading. Retrieved from [http://www.tremainefoundation.org/News/customer-files/LD\\_AND\\_READING\\_PAPER.pdf](http://www.tremainefoundation.org/News/customer-files/LD_AND_READING_PAPER.pdf)
- Finson, K. D., Ormsbee, C. K., & Jensen, M. M. (2011). *Differentiating science instruction and assessment for learners with special needs, K-8*. Thousand Oaks, CA: Corwin Press.



- Fleischman, H. L., Hopstock, P. J., Pelczar, M. P., & Shelley, B. E. (2010). *Highlights from PISA 2009: Performance of U.S. 15-year-old students in reading, mathematics, and science literacy in an international context* (NCES 2011-004). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.
- Florida Department of Education. (2008). *FCAT achievement levels*. Retrieved from <http://fcat.fldoe.org/pdf/fcAchievementLevels.pdf>
- Florida Department of Education. (2012). *FCAT 2.0 statewide comparison of science score for grade 8*. Retrieved from <http://fcat.fldoe.org/mediapacket/2012/default.asp>
- Fraenkel, J. R., & Wallen, N. E. (Eds.) (2000). *How to design & evaluate research in education*. Boston, MA: McGraw Hill.
- Galton, F. (1909). *Essays in eugenics*. London, UK: The Eugenics Education Society.
- Gast, D. L. (2010). *Single subject research methodology in behavioral sciences*. New York, NY: Routledge.
- Geier, R., Blumenfeld, P. C., Marx, R. W., Krajcik, J., Fishman, B., & Soloway, E. (2008). Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform. *Journal of Research in Science Teaching*, 45(8), 922-939.
- Glesne, C. (2011). *Becoming qualitative researchers: An introduction* (4<sup>th</sup> ed). Boston, MA: Pearson.
- Goddard, H. H. (1912). *The Kallikak family: A study in the heredity of feeble mindedness*. New York, NY: Macmillan.

- Harris, M. L., Schumaker, J. E., & Deshler, D. D. (2011). The effects of strategic morphological analysis instruction of the vocabulary performance of secondary students with and without disabilities. *Learning Disability Quarterly*, 34(1), 17-33.
- Higher Education Opportunity Act of 2008, 20 U.S.C. § 1001 *et seq.* (2008).
- Howe, S. G. (1833, July). Education of the blind. *The North American Review*. Retrieved from <http://www.disabilitymuseum.org/dhm/lib/detail.html?id=1350>
- Individuals with Disabilities Education Act Amendments of 1997, Pub. L. No. 105-17, 1400-1406, 117 Stat. 37 (1997).
- Individuals with Disabilities Education Act (IDEA) of 2004, Pub. L. No. 108-446, 1400-1487, 118 Stat. 2647 (2004).
- Kauffman, J. M., Nelson, C. M., Simpson, R. L., & Mock, D. R. (2011). Contemporary issues. In J. M. Kauffman & D. P. Hallahan (Eds.), *Handbook of Special Education* (pp. 15-26). New York, NY: Routledge Taylor & Francis.
- Kazdin, A. E. (1982). *Single-case research designs: Methods for clinical and applied settings*. New York, NY: Oxford University Press.
- Kellogg, J. H. (1897). *Are we a dying race?* [Pamphlet] Read at the Civic, Philanthropic, Hygienic Conference, Battle Creek, Michigan, October 12-17, 1897 (Reprinted from Good Health, Wellesley College Archives (Control Number P613 K29)). Retrieved from <http://www.disabilitymuseum.org/dhm/lib/catcard.html?id=797>
- Kennedy, M., & Deshler, D. D. (2010). Literacy instruction, technology, and students with learning disabilities: Research we have, research we need, 33(4), 289-298.

- Kesidou, S., & Roseman, J. E. (2002). How well do middle school science programs measure up? Findings from Project 2061's curriculum review. *Journal of Research in Science Teaching, 39*(6), 522-549.
- King-Sears, M. E., & Mooney, J. F. (2004). Teaching content in an academically diverse class. In B. K. Lenz & D. D. Deshler (Eds.), *Teaching content to all evidence-based inclusive practices in middle and secondary schools* (pp. 221-257). Boston, MA: Pearson.
- Kirk, S. A. (1953). What is special about special education? The child who is mentally handicapped. *Exceptional Children, 19*(4), 138-139.
- Kirk, S. A. (1962). Diagnosis and remediation of learning disabilities. *Exceptional Children, 29*(2), 73-78
- Kirk, S. A. (1968). *Special education for handicapped children: First annual report of the national advisory committee on handicapped children*. Retrieved from <http://www.eric.ed.gov/PDFS/ED018058.pdf>
- Kirk, S. A. (1977). Specific learning disabilities. *Journal of Clinical Psychology, Winter*, pp. 23-26.
- Kirk, S. A., & Bateman, B. (1962). Diagnosis and remediation of learning disabilities. *Exceptional Children, 29*(2), 73-78.
- Kolodner, J. L., Camp, P. J., Crismond, D., Fasse, B., Gray, J., & Holbrook, J. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting learning by design into practice. *Journal of the Learning Sciences, 12*(4), 495-547.

- Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *Journal of the Learning Sciences*, 7(3-4), 313-350.
- Krajcik, J., McNeil, K. L., & Resier, B. J. (2007). Learning-goals-driven model: Developing curricula, materials that align with national standards and incorporate project-based pedagogy. *Wiley Interscience*, November, 1-32. doi:10.1002/sce.20240
- Kuhlmann, F. (1913). The results of grading thirteen hundred feeble-minded children with the Binet-Simon tests. *Journal of Educational Psychiatry*, 4(5), 261-268.
- Lehrer, R., & Schauble, L. (Eds.). (2002). *Investigating real data in the classroom: Expanding children's understanding of math and science*. New York, NY: Teachers College Press.
- Lenz, B. K., Bulgren, J. A., Kissam, B. R., & Taymens, J. (2004). SMARTER Planning for academic diversity: Teaching content in an academically diverse class. In B. K. Lenz & D. D. Deshler (Eds.), *Teaching content to all evidence-based inclusive practices in middle and secondary schools* (pp. 47-77). Boston, MA: Pearson.
- Lenz, B. K., & Deshler, D. D. (Eds.). (2004). *Teaching content to all evidence-based inclusive practices in middle and secondary schools*. Boston, MA: Pearson.
- Lopes-Murphy, S. (2012). Universal design for learning: Preparing secondary education teachers in training to increase academic accessibility of high school English learners. *The Clearing House: A Journal of Educational Strategies, Issues, and Ideas*, 85(6), 226-230.
- Lovitt, T., Rudsit, J., Jenkins, J., Pious, C., & Benedetti, D. (1986). Adapting science materials for regular and learning disabled seventh graders. *Remedial and Special Education*, 7(1), 31-39.

- Lynch, S., & Taymans, J. (2004). The challenges of diversity and reform teaching content in an academically diverse class. In B. K. Lenz & D. D. Deshler (Eds.), *Teaching content to all evidence-based inclusive practices in middle and secondary schools* (pp. 19-46). Boston, MA: Pearson.
- Mace, R. A. (1998). Universal design in housing. *Assistive Technology: The Official Journal of RESNA*, 10(1), 21-28.
- Marino, M. T. (2009). Understanding how adolescents with reading difficulties utilize technology-based tools. *Exceptionality*, 17(2), 88-102.
- Marino, M. T., Black, A. C., Hayes, M. T., & Beecher, C. C. (2010). An analysis of factors that affect struggling readers' achievement during a technology-enhanced STEM astronomy. *Journal of Special Education Technology*, 25(3), 35-48.
- Marzano, R. J. (2007). *The art and science of teaching: A comprehensive framework for effective instruction*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Mastropieri, M. A., & Scruggs, T. E. (1992). Science for students with disabilities. *Review of Educational Research*, 6(4), 377-411.
- Mastropieri, M. A., & Scruggs, T. E. (1995). Teaching science to students with disabilities in general education settings. *Teaching Exceptional Children*, 27(4), 10-13.
- Mastropieri, M. A., Scruggs, T. E., Berkeley, S., McDuffie, K., Tornquist, E. H., & Connors, N. (2006). Differentiated curriculum enhancement in inclusive middle school science: Effects in classrooms and high-stakes tests. *The Journal of Special Education*, 40(3), 130-137.

- Mastropieri, M. A., Scruggs, T. E., & Butcher, K. (1997). How effective is inquiry learning for students with mild disabilities? *The Journal of Special Education, 31*(2), 199-211.
- Mastropieri, M. A., Scruggs, T. E., & Fulk, B. (1990). Teaching abstract vocabulary with the keyword method: Effects on recall and comprehension. *Journal of Learning Disabilities, 23*(2), 92-107.
- Mastropieri, M. A., Scruggs, T. E., & Graetz, J. (2005). Cognition and learning in inclusive high school chemistry classes. In T. E. Scruggs & M. A. Mastropieri (Eds.), *Advances in learning and behavioral disabilities: Cognition and learning in diverse settings* (pp 107-118). Oxford, UK: Elsevier.
- Mastropieri, M. A., Scruggs, T. E., & Levin, J. R. (1985). Mnemonic strategy instruction with learning disabled adolescents. *Journal of Learning Disabilities, 18*(2), 94-100.
- Mastropieri, M.A., Scruggs, T. E., & Levin, J. R. (1986). Direct vs. mnemonic instruction: Relative benefits for exceptional learners. *Journal of Special Education, 20*(3), 299-308.
- Mastropieri, M. A., Scruggs, T. E., Levin, J. R., Gaffney, J., & McLoone, B. (1985). Mnemonic vocabulary instruction for learning disabled students. *Learning Disability Quarterly, 8*(1), 57-63.
- Mastropieri, M. A., Scruggs, T. E., & Marshak, L. (2008). Training teachers, parents, and peers to implement effective strategies for content area learning. In T. E. Scruggs & M. A. Mastropieri (Eds.), *Personnel preparation: Advances in leaning and behavioral disabilities* (pp. 311-329). Bingley, UK: Emerald.

- Mastropieri, M. A., Scruggs, T. E., Norland, J. J., Berkley, S., McDuffie, K., Tornquist, E. H., & Connors, N. (2006). Differentiated curriculum enhancement in inclusive middle school science: Effects on classroom and high-stakes tests. *The Journal of Special Education, 40*(3), 130-137.
- Matthews, M. R. (1994). *Science teaching: The role of history and philosophy of science*. New York, NY: Routledge Taylor & Francis.
- McDuffie, K. A., Mastropieri, M. A., & Scruggs, T. E. (2009). Differential effects of co-teaching and peer-mediated instruction: Results for content learning and student-teacher interactions. *Exceptional Children, 75*(4), 493-510.
- McFarland, J. L. (1997). A comparison of regular education students and students with learning disabilities on performance-based assessment in the area of science. *Learning Disabilities, 8*(2), 109-115.
- McGinnis, J. R., & Stefanich, G. P. (2007). Special needs and talents in science learning. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 287–317). Mahwah, NJ: Erlbaum.
- McMurthie, D. C. (1918). Returning the disabled soldier to economic independence. *Annals of The American Academy of Political and Social Science*. Retrieved from <http://www.disabilitymuseum.org/dhm/lib/detail.html?id=2873>
- McNeill, K. L., Lizotte, D. J., Krajcik, J., & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *Journal of the Learning Sciences, 15*(2), 153-191.

- Metrametrics. (2013). *The lexile framework for reading: Lexile-to-grade correspondence*. Retrieved from <http://www.lexile.com/about-lexile/grade-equivalent/grade-equivalent-chart/>
- Meyer, A., & Rose, D. H. (2005). The future is in the margins: The role of technology and disability in educational reform. In D. H. Rose, A. Meyer, & C. Hitchcock (Eds.), *The universally designed classroom: Accessible curriculum and digital technologies* (pp 13-35), Cambridge, MA: Harvard Education Press.
- Mills vs. Board of Education of the District of Columbia, Lexsee 348 F. Supp 866. Retrieved from <http://www.maine.gov/education/speced/cds/training/miscellaneous/mills.pdf>
- Monroe, M. (1932). *Children who cannot read: The analysis of reading disabilities and the use of diagnostic tests in the instruction of retarded readers*. Chicago, IL: The University of Chicago Press. Retrieved from <https://babel.hathitrust.org/cgi/pt?id=mdp.39076005323402#page/5/mode/1up>
- Morgan, L. (2012). Generation Y, learner autonomy and the potential of Web 2.0 tools for language learning and teaching. *Campus Wide Information Systems*, 29(3), 166-176.
- National Academy of Science. (2007) *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academy Press.
- National Assessment Governing Board. (2010). NAEP testing and reporting on students with disabilities and English language learners: Policy statement. Retrieved from [http://www.nagb.org/content/nagb/assets/documents/policies/naep\\_testandreport\\_studentswithdisabilities.pdf](http://www.nagb.org/content/nagb/assets/documents/policies/naep_testandreport_studentswithdisabilities.pdf)



National Defense Act of 1916, 39 Stat 166 *et seq.* (1916).

National Defense Education Act of 1958 (P.L. 85-864; 72 Stat. 1580). Retrieved from

<http://federaleducationpolicy.wordpress.com/2011/06/03/national-defense-education-act-of-1958-2/>

National Federation of the Blind. (2012). *What is the National Federation of the Blind?*

Retrieved from <http://nfb.org/who-we-are>

National Governors Association (NGA) & Council of Chief State School Officers (CCSSO).

(2012). *Common core standards application to students with disabilities: Common Core State Standards Initiative*. Retrieved from

<http://www.corestandards.org/assets/application-to-students-with-disabilities.pdf>

National Science Research Council. (1996). *National science educational standards*.

Washington, DC: National Academy Press.

National Science Teachers Association (2013a). *Next generation science standards*. Retrieved

from <http://www.nsta.org/about/standardsupdate/default.aspx>

National Science Teachers Association. (2013b). *NSTA position statement: Scientific inquiry*.

Retrieved from <http://www.nsta.org/about/positions/inquiry.aspx>

Nelson, J. R., Smith, D. J., & Dodd, J. M. (1992). The effects of teaching a summary skills

strategy to students identified as learning disabled on their comprehension of science text.

*Education & Treatment of Children*, 15(3), 271-279.

No Child Left Behind Act of 2001 (Reauthorization of the Elementary and Secondary Education

Act). Pub. L. No. 107-110, 115 U.S.C. § 1425 (2002).

- O'Connor, R. E., & Sanchez, V. (2011). Responsiveness to intervention models for reducing reading difficulties and identifying learning disability. In B. K. Lenz & D. D. Deshler (Eds.), *Teaching content to all evidence-based inclusive practices in middle and secondary schools* (pp. 123-133). Boston, MA: Pearson.
- Old Deluder Satan Law of 1647*. (1929). Retrieved from <http://www.lawlib.state.ma.us/docs/DeluderSatan.pdf>
- Olsen, J. K., & Slater, T. F. (2009). Impact on modifying activity-based instructional materials for special needs students in middle school astronomy. *Astronomy Education Review*, 7(2), 40-56.
- The Organisation of Economic Cooperation and Development (OECD). (2013). *Online education database*. Retrieved from <http://www.oecd.org/education/database.htm>
- Orton, S. T. (1929). The "sight reading" method of teaching reading, as a source of reading disability. *The Journal of Educational Psychology*, 20(2), 135-143.
- Orton, S. T. (1989). *Reading, writing, and speech problems in children and selected papers*. Austin, TX: PRO-ED, Inc (Original work published in 1937).
- O'Sullivan, C. Y., & Weiss, A. R. (1999). Student work and teacher practices in science: A report on what students know and can do. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.
- Pearce, C. R. (1999). *Nurturing inquiry: Real science for the elementary classroom*. Portsmouth, NH; Heinemann.

- Pellegrino, J. W., Chudowsky, N., & Glaser, R. (2001). *Knowing what students know: The science and design of educational assessment*. Washington, DC: National Academy Press.
- Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning component of classroom academic performance. *Journal of Educational Psychology*, 82(1), 33-40.
- Pintrich, P. R., Smith, D., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). *Educational and Psychological Measures, Inc.*, 53(3), 801-813.
- Pisha, B., & Coyne, P. (2001). Smart from the start: The promise of universal design for learning. *Remedial and Special Education*, 22(4), 197-203.
- Prensky, M. R. (2010). *Teaching digital natives: Partnering for real learning*. Thousand Oaks, CA: Sage.
- Quellmalz, E. S., Timms, M. J., Silberglitt, M. D., & Buckley, B. C. (2012). Science assessment for all: Integrating science simulation into balanced state science assessment systems. *Journal of Research in Science Teaching*, 49(3), 363-393.
- Randolph-Shephard Act, 20 U.S.C. § 107 *et seq.* (1936).
- Rose, D. H., & Gravel, J. A. (2009). Getting from here to there: UDL, global positioning, and lessons for improving education. In D. Gordon, J. J. Gravel, & L. Schifter (Eds.), *A policy reader in universal design for learning* (pp. 5-18). Cambridge, MA: Harvard Education Press.

- Rose, D. H., Hall, T. E., & Murray, E. (2008). Accurate for all: Universal design for learning and the assessment of students with learning disabilities. *Perspectives on Language and Literacy*, 34(4), 23-28.
- Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).
- Rose, D. H., & Meyer, A. (2006). *A practical reader in universal design for learning*. Cambridge, MA: Harvard University Press.
- Rose, D. H., Meyer, A., Strangman, N., & Rappolt, G. (2002). *Teaching every student in the digital age: Universal design for learning*, Alexandria, VA: ASCD.
- Samuels, A. H. (1918, June). Reconstructing the public. *Carry On: Magazine on the Reconstruction of Disabled Soldiers and Sailors*. Retrieved from <http://www.disabilitymuseum.org/dhm/lib/detail.html?id=2701>
- Samuels, C. A. (2007). Universal design concept pushed for education. *Education Week*, 27(10), 1-12.
- Sandoval, W. A. (2003). Conceptual and epistemic aspects of students' scientific explanations. *Journal of the Learning Sciences*, 12(1), 5-51.
- Sandoval, W. A., & Reiser, B. J. (2004). Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education*, 88(3), 345-372.
- Schmidt, W. H., Houang, R., & Cogan, L. (2004). A coherent curriculum: The case of mathematics. *American Educator*, 26(2), 10-26, 47-48.

- Schneider, R. M., Krajcik, J., Marx, R. W., & Soloway, E. (2002). Performance of students in project-based science classrooms on a national measure of science achievement. *Journal of Research in Science Teaching*, 39(5), 410-422.
- Schumaker, J. E., Deshler, D. D., Bulgren, J. A., Davis, B., Lenz, K., & Grossen, B. (2002). Access of adolescents with disabilities to general education curriculum: Myth or reality?. *Focus on Exceptional Children*, 35(3), 1-16.
- Scruggs, T. E., Brigham, F. J., & Mastropieri, M. A. (2013). Common core science standards: Implications for students with learning disabilities. *Learning Disabilities Research & Practice*, 28(1), 49-57.
- Scruggs, T. E., & Mastropieri, M. A. (1993). Current approaches to science education: Implications for mainstream instruction of students with disabilities. *Remedial and Special Education*, 14(1), 15-24.
- Scruggs, T. E., & Mastropieri, M. A. (1994a). The construction of scientific knowledge by students with mild disabilities. *Journal of Special Education*, 28, 307-321.
- Scruggs, T. E., & Mastropieri, M. A. (1994b). Successful mainstreaming in elementary science classes: A qualitative investigation of three reputational cases. *American Educational Research Journal*, 31(4), 785-811.
- Scruggs, T. E., & Mastropieri, M. A. (1995). Science education for students with behavioral disorders. *Education and Treatment of Children*, 18(3), 322-34.
- Scruggs, T. E., & Mastropieri, M. A. (2000). The effectiveness of mnemonic instruction for students with learning and behavior problems: An update and research synthesis. *Journal of Behavioral Education*, 10(2-3), 163-173.

- Scruggs, T. E., & Mastropieri, M. A. (2007). Science learning in special education: The case for constructed versus instructed learning. *Exceptionality, 15*(2), 57-74.
- Scruggs, T. E., Mastropieri, M. A., Bakken, F. J., & Brigham, F. J. (1993). Reading versus doing: The relative effects of textbook-based and inquiry-oriented approaches to science learning in special education classrooms. *The Journal of Special Education, 27*(1), 1-15.
- Scruggs, T., Mastropieri, M., Berkely, S., & Graetz, J. (2010). Do special education interventions improve learning of secondary content? A meta-analysis. *Remedial and Special Education, 3*(6), 437-449.
- Scruggs, T. E., Mastropieri, M. A., & Bohs, K. (1994). Mainstreaming an emotionally handicapped student in science: A qualitative investigation. In T. E. Scruggs & M. A. Mastropieri (Eds.), *Advances in learning and behavioral disorders* (pp. 131-146). Greenwich, CT: JAI Press.
- Scruggs, T. E., Mastropieri, M. A., Levin, J. R., & Gaffney, J. S. (1985). Facilitating the acquisition of science facts in students with learning disabilities. *American Educational Research Journal, 22*(4), 575-586.
- Scruggs, T. E., Mastropieri, M. A., McLoone, B., Levin, J., & Morrison, C. (1987). Mnemonic facilitation of learning disabled students' memory for expository prose. *Journal of Educational Psychology, 79*(1), 27-34.
- Scruggs, T. E., Mastropieri, M. A., & Okolo, C. M. (2008). Science and social studies for students with disabilities. *Focus on Exceptional Children, 41*(2), 1-24.

- Scruggs, T. E., Mastropieri, M. A., & Wolfe, S. (1995). Scientific reasoning of students with mental retardation: Investigating preconceptions and conceptual change. *Exceptionality*, 5(4), 223–244.
- SDR, LLC. (2009). *Seminole County: Income rank report*. Retrieved from [http://www.seminolecountyfl.gov/gm/ecodev/pdf/Metro\\_Orlando\\_MSA\\_Income\\_Report.pdf](http://www.seminolecountyfl.gov/gm/ecodev/pdf/Metro_Orlando_MSA_Income_Report.pdf)
- Seguin, E. (1856). Origin of the treatment and training of idiots. *American Journal of Education*. Retrieved from <http://www.disabilitymuseum.org/dhm/lib/detail.html?id=1437>
- Seguin, E. (1907). *Idiocy and its treatment by the physiological method*. New York, NY: Teachers College. Retrieved from <http://www.disabilitymuseum.org/dhm/lib/detail.html?id=1531>
- Shymansky, J. A., Chidsey, J. L., Henriques, L., Enger, S., Yore, L. D., Wolfe, E. W., & Jorgensen, M. (1997). Performance assessment in science as a tool to enhance the picture in student learning. *School Science and Mathematics*, 97(4), 172-183.
- Singer, J., Marx, R. W., Krajcik, J., & Chambers, J. C. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, 35, 165-178.
- Slavin, R. E. (2007). *Educational research in an age of accountability*. Boston, MA: Pearson.
- Smith, C. L., Maclin, D., Houghton, C., & Hennessey, M. G. (2000). Sixth-grade students' epistemologies of science: The impact of school science experiences on epistemological development. *Cognition and Instruction*, 18(3), 349-422.

- Smith, D.D., Robb, S. M., West, J., & Tyler, N.C. (2010). The changing educational landscape: How special education leadership preparation can make a difference for teachers and their students with disabilities. *Teacher Education and Special Education, 33*(1), 25-43.
- Smith-Hughes Vocational Act, 20 U.S.C. § 11 *et seq.* (1917).
- Smith-Sears Veterans Rehabilitation Act, 40 U.S.C. § 617 *et seq.* (1918).
- Social Security Act, 42 U.S.C. § 42 *et seq.* (1935).
- Sparks, S.D. (2012, May). 8<sup>th</sup> grade scores inch upward on national science test. *Education Week, 31*(31), 6.
- Spencer, V. G., Scruggs, T. E., & Mastropieri, M. A. (2003). Content area learning in middle school social studies classrooms and students with emotional or behavioral disorders: A comparison of strategies. *Behavioral Disorders, 28*(2), 77-93.
- Staskowski, M., Hardin, S., Klein, M., & Wozniak, C. (2012). Universal design for learning: Speech-language pathologists and their teams making common core curriculum accessible. *Seminars in Speech and Language, 33*(2), 111-129.
- Stevens, J. P. (2007). *Intermediate statistics: A modern approach*. New York, NY: Routledge Taylor & Francis.
- Swanson, H. L., & Sáez, L. (2003). Memory difficulties in children and adults with learning disabilities. In H. L. Swanson, K. R. Harris, & S. Graham (Eds.), *Handbook of learning disabilities*. New York, NY: Guilford Press.
- Taymans, J., & Lynch, S. (2004). Developing a unit planning routine. In B. K. Lenz & D. D. Deshler (Eds.), *Teaching content to all evidence-based inclusive practices in middle and secondary schools* (pp. 162-194). Boston, MA: Pearson.



- Thompson, S. J., Morse, A. B., Sharpe, M., & Hall, S. (2005). Accommodations manual: How to select, administer, and evaluate use of accommodations for instruction and assessment of students with disabilities. Retrieved from [http://www.ccsso.org/Documents/2005/Accommodations\\_Manual\\_How\\_2005.pdf](http://www.ccsso.org/Documents/2005/Accommodations_Manual_How_2005.pdf)
- U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP). (2011). *Science 2011: About the assessment: Exclusion rates*. Retrieved from: [http://nationsreportcard.gov/science\\_2011/exclusion.asp?tab\\_id=tab2&subtab\\_id=Tab\\_1#chart](http://nationsreportcard.gov/science_2011/exclusion.asp?tab_id=tab2&subtab_id=Tab_1#chart)
- U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. (2012a). *Digest of education statistics, 2011* (NCES 2012-001). Retrieved from <http://nces.ed.gov/fastfacts/display.asp?id=64>
- U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. (2012b). *The nation's report card: Science 2011*. Washington, DC: Institute of Education Services. Retrieved from <http://nces.ed.gov/nationsreportcard/pubs/main2011/2012465.asp>
- U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Education Progress (NAEP). (2012c). *NAEP: Measuring Student Progress Since 1964*. Retrieved from <http://nces.ed.gov/nationsreportcard/about/naephistory.asp>
- U.S. Department of Education, National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform*. Retrieved from [http://datacenter.spps.org/uploads/SOTW\\_A\\_Nation\\_at\\_Risk\\_1983.pdf](http://datacenter.spps.org/uploads/SOTW_A_Nation_at_Risk_1983.pdf)

- U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics. (1999). *Student work and teacher practices in science*, (NCES 1999-455). Retrieved from <http://nces.ed.gov/nationsreportcard/pubs/main1996/1999455.asp>
- U.S. Department of Education, Office of Elementary and Secondary Education. (2002). *No child left behind: A desktop reference*. Washington, DC: Education Publications Center, U.S. Department of Education.
- U.S. Department of Education, Office of Planning, Evaluation and Policy Development. (2010). *A blueprint for reform: The reauthorization of the elementary and secondary education act*. Retrieved from <http://www2.ed.gov/policy/elsec/leg/blueprint/blueprint.pdf>
- U.S. Department of Education, Office of Special Education and Rehabilitation Services. (2011). *30th annual report to Congress on the implementation of the Individuals with Disabilities Education Act, 2008* (U.S. DOE Contract No. ED06CO0062). Retrieved from <http://www2.ed.gov/about/reports/annual/osep/index.html>
- U. S. Senate Committee on Health, Education, Labor, & Pensions. (2013). *Harkin, HELP committee democrats introduce bill to prepare all children for success and fix “No Child Left Behind”* [Press release]. Retrieved from <http://www.help.senate.gov/newsroom/press/release/?id=e561493c-1cc4-46ba-8e8d-b427b82891be&groups=Chair>
- Wehmeyer, M. L., Palmer, S. B., Davies, D., & Stock, S. (2005). The role of technology use by a person with intellectual or development disabilities as a family support. § *Rivista di studi Familiari: FIR Famiglia Intedisciplinarita Ricerca*, 16(2), 90-99.

- Weiss, I. R., & Pasley, J. D. (2004). What is high-quality instruction? *Educational Leadership*, 61(5), 24- 28.
- Weiss, I. R., Pasley, J. D., Smith, P. S., Banilower, E. R., & Heck, D. J. (2003). *Looking inside the classroom: A study of K-12 mathematics and science education in the United States*. Chapel Hill, NC: Horizon Research.
- Wiggins, F. (2006). *The effects of hands-on science instruction on the science achievement of middle school students*. (Doctoral dissertation). Retrieved from Proquest Dissertation and Theses database. (UMI Number: 3317522).
- Wilbur, H. B. (1877). The classifications of idiocy. *Proceedings of the Association of Medical Officers of American Institutions for Idiotic and Feeble-minded Persons*, Philadelphia, PA: Lippincott.
- Wissick, C. A., & Gardner, J. E. (2011). Technology and academic instruction: Considerations with high incidence cognitive disabilities. In J. M. Kauffman & D. P. Hallahan (Eds.), *Handbook of special education* (pp. 484-500). New York, NY: Routledge Taylor & Francis.
- Yell, M. L., Katsiyannis, A., & Bradley, M. R. (2011). The individuals with disabilities education act: The evolution of special education law. In J. M. Kauffman & D. P. Hallahan (Eds.), *Handbook of special education* (pp. 61-76). New York, NY: Routledge Taylor & Francis.
- Yell, M. L., Rogers, D., & Rogers, E. L. (1998). The legal history of special education: What a long strange trip it's been. *Remedial and Special Education*, 19(4), 219-228.
- Yin, R. K. (2009). *Case study research: Design and method* (4<sup>th</sup> ed). Thousand Oaks, CA: Sage.