Comparing Multimedia-Based Approaches to Academic Vocabulary Instruction for Middle Schoolers with Learning Disabilities

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A Dissertation

Presented to

The Faculty of the School of Education and Human Development

University of Virginia

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

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May 2024

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Date of Defense: 3/27/2024

This doctoral dissertation has been approved by the Graduate Faculty of the School of Education and Human Development in partial fulfillment for the degree of Doctor of Philosophy.

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Comparing Multimedia-Based Approaches to Academic Vocabulary Instruction for Middle Schoolers with LD

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APPROVAL OF THE DISSERTATION

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ABSTRACT

With complex forms of written and oral discourse in secondary classrooms, middle schoolers with learning disabilities (LD) must be able to acquire deep understanding of academic words with multiple senses of meaning (e.g., foundation of a house compared to foundation of a scientific theory). Although multimedia instructional approaches are emerging as promising options for improving word-learning for students with LD, there is a dearth of empirical guidance for supporting their deep knowledge of these types of words. This pilot study examines the initial efficacy of a multimedia-based vocabulary intervention called MultiVision (MV) designed to foster deep understandings of academic vocabulary with multiple senses for adolescent students with LD. This adapted alternating-treatments design study evaluates the effects of MV on custom measures of word knowledge depth for three middle schoolers with LD, relative to an established multimedia instructional approach (i.e., CAP-S) and to a baseline condition with no instruction. Results showed that both MV and CAP-S supported word-learning gains across participants relative to the baseline condition. Further, MV demonstrated a relative advantage in word-learning performance over CAP-S for one out of three students. However, for the other two students, MV demonstrated varied effects. Additionally, two out of three students maintained word-learning gains from both treatments, but degrees of retention varied across students. Finally, students agreed both treatments were beneficial for their word-learning. Overall findings from this study suggest that MV shows some promise for fostering deep word knowledge of academic vocabulary with multiple senses for middle schoolers with LD. However, more research is needed to further establish treatment efficacy. Implications and future research are discussed.

DEDICATION

For my wife, Deandra

My parents, David and Fay,

And my Charlottesville community

Thank you for your inspiration, your love, and your support.

ACKNOWLEDGEMENTS

Growing up, I never thought I would have the opportunity to complete a PhD. As I come to the end of this journey and reflect on how I got here, I am incredibly grateful for the continuous inspiration, guidance, and support of several individuals in my personal and professional community whom I would like to thank.

First, I want to thank the members of my dissertation committee for the continuous empowerment to think and write with intention, boldness, and creativity. In particular, I want to thank Dr. Michael Kennedy for teaching me as an undergraduate, staying in touch when I got into teaching, and guiding me with research presentations, publications and faculty positions as my doctoral adviser and dissertation chair. Next, I would like to thank Dr. Colby Hall for supporting me on published manuscripts, providing me opportunities to speak at conferences, and for continuously sharing her wisdom on literacy research and practice. Next, I would like to thank Dr. Mandy Rispoli for investing her time and energy teaching me about single case experimental design methodologies, guiding me through the data collection stage of this dissertation, and providing me opportunities to network with leading researchers in the field of single case design. Finally, I would like to thank Dr. Bill Therrien for his willingness to meet periodically to help me conceptualize my intervention in its early stages of development.

Next, I would like to thank a number of families in the greater Charlottesville area, students, and faculty both at UVA and around the nation. You have been so gracious with guided me, pouring confidence into me, and given me wisdom throughout this journey. Specifically, I would like to give a special thank you to the middle school students who were willing to participate in this experiment and their parents. I would also like to thank the UVA School of Education and Human Development for the Innovative, Developmental, Exploratory Awards (IDEAs) grant which provided key funding for this research project. Additionally, I want to thank my UVA colleagues for their support throughout this program. Specifically, thank you to earlier members of the STORMED lab (Dr. Victoria VanUitert, Dr. Lindsay Griendling, Dr. Rachel Kunemund) for your collaborations on manuscripts and your guidance on navigating the doctoral program and the job market. I also thank later members of the STORMED lab (Danielle Waterfield, Suzanne McClain, Nate Welker, Dr. Jamie Day, and Dr. Olivia Coleman) and others in my CISE cohort (Susan Aigotti, Dr. Alan McLucas, Isabel Vargas, Cassidi Richmond, Anna Yonas, John Ojeogwu, Dr. Lily Bentley, and Mery Guzman) for supporting with co-designing or providing feedback with lesson materials for the study and for the continuous encouragement throughout this dissertation process.

Regarding faculty, I would like to thank a number of individuals at UVA (Dr. Stanley Trent, Dr. Stephanie Van Hover, Dr. Vivian Wong, Dr. LaRon Scott, Dr. Lysandra Cook, and Dr. Bryan Cook) for giving me the permission and the tools to dream big and think critically, for providing guidance and support on writing assignments, and for supporting me on the job market. I would also like to thank individuals outside of UVA (Dr. Stephen Ciullo, Dr. Christopher Cormier and Dr. Erica McCray) for providing me opportunities to serve and publish in the field of special education and for finding time in their busy schedules to give critical advice at key moments along the journey.

In my personal community, I want to thank my father, David McDonald for instilling in me the value of a good education, for the sacrifices he has made to help me access higher education, and for his continuous love and support. I also would like to thank my mother, Fay McDonald who is no longer on this earth, but has been watching over me through this entire process keeping me peaceful, restful, and safe during tribulations of life. Additionally, I would like to thank my sister, Sherie, for being a source of inspiration and role model for me in striving for excellence. And last, but most importantly, I would like to thank my incredible wife, Deandra, for her unconditional love, her encouragement through adverse times, and her strength to take on more, so that I could, for a time, focus on pursuing and obtaining this degree.

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Chapter 1: Introduction

Comprehension is the ultimate goal of reading, and critical for academic and life outcomes (Elleman & Oslund, 2019; Faggella-Luby & Deshler, 2008). Reading comprehension, defined by the RAND Report (2002) as “the process of simultaneously extracting and constructing meaning through interaction and involvement with written language,” involves the simultaneous, automatic activation of phonological, orthographic, and semantic knowledge for each word on the page. These lexical representations not only increase efficiency of word recognition, but also enhance the reader’s ability to engage in sentence- and discourse-level comprehension processes (Gough & Tunmer, 1986; Hall et al., 2019; Hoover & Gough, 1990; Perfetti & Stafura, 2014; Scarborough et al., 2009), en route to building a mental model (i.e., a situation model) of information in text (Hogan, 2014). As a result, deep knowledge of word meanings is instrumental for literacy development (Ahmed et al., 2016; Cromeley & Azevedo, 2007; Beck et al., 2013; Perfetti & Stafura, 2014).

Acquiring not only breadth but also depth of vocabulary knowledge is important for reading comprehension (Elleman et al., 2019; McKeown et al., 2017). Deep knowledge of a word’s meaning involves understanding not just the word’s definition but also how it is linked to semantic networks of information and how it can be used within multiple contexts (Stahl & Fairbanks, 1986; McKeown et al., 2018). From a theoretical perspective, Nagy & Scott (2000) contend that deep word-learning involves multiple facets of word knowledge, such as: (a) polysemy (i.e., words carry multiple, distinct senses that may be abstract and overlap in meaning; (b) incrementality (i.e., full word knowledge acquisition is a gradual process, largely developed through multiple exposures over time); and (c) multidimensionality (e.g., words are represented in spoken and written forms).

Academic Vocabulary and Secondary School Contexts

Students need even more depth and breadth of vocabulary knowledge to comprehend text and meet standards as they progress to the secondary grades. (Lesaux et al., 2014; Jones et al., 2019). This is in part because the language in texts becomes increasingly complex in the secondary grades (Bulgren et al., 2013; Nagy & Townsend, 2012; Swanson et al., 2016). It is also due to increased rigor of literacy standards embedded within content area curricula (e.g., Common Core State Standards [CCSS]; Bulgren et al., 2013; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; VanUitert et al., 2023). Acquiring and applying knowledge addressed in secondary-level, content area texts requires—among other high-level comprehension skills—a robust understanding of vocabulary frequently present in academic texts (Townsend et al., 2012). Knowledge of these words, which are often described as academic vocabulary (i.e., "words that appear frequently in texts across academic disciplines, but rarely occur in oral conversation," Lesaux et al., 2014, p. 1160) is critical for engaging with written and oral discourse within school contexts and contributes to literacy achievement in the secondary grades (Truckenmiller et al., 2019; Townsend et al., 2012 Uccelli et al., 2015).

Deep understanding of academic vocabulary in middle school grades may be especially important as middle school is a critical developmental stage for college and career readiness (Ciullo et al., 2016), yet the literacy development of adolescent learners in the U.S. remains a persistent challenge for K-12 education research, policy, and practice (Baye et al., 2019; Herrera et al., 2016). For instance, recent results from the 2022 National Assessment of Education Progress (NAEP) show that only roughly one out of every three eighth graders (i.e., 31%) are performing at or above a proficient level in reading, which is significantly lower than the proportion of students performing at that level in 2019 (*p* < .05; National Center for Education Statistics, 2022). In addition, data disaggregated by student subgroups reveal that only 34% of eighth graders without disabilities and 6% of eighth graders with disabilities demonstrated proficiency in reading. Results suggest that a majority of students with and without disabilities have difficulty navigating informational text, taking the author's perspective, making evidence-based claims, and demonstrating other literacy skills often required of students in academic contexts after the primary grades (Jones et al., 2019; Swanson et al., 2016).

LD and Reading Difficulties

Among students ages 3 through 21 receiving special education services, 33% have been identified as having specific learning disabilities (NCES, 2020a). The most common disability category in the U.S., learning disabilities (LD) are neurological disorder that influence comprehension and application of oral and/or written language, which affects academic achievement (Individuals with Disabilities Education [IDEA], 2018). Students with LD typically experience challenges in areas of reading, language, attention, verbal processing (e.g., phonological, orthographic, semantic), memory, and a host of other cognitive and/or behavioral domains (Swanson et al., 2013). Importantly, 80-90% of students with LD experience challenges developing literacy skills (Pullen et al., 2017). For adolescents with LD, literacy learning difficulties are often associated with undesirable consequences, including(a) lower rates of employment and fewer post-secondary education opportunities (Haber et al., 2016; Mazzotti et al., 2021) and (b) higher rates of school drop-out, incarceration, and recidivism (Doren et al., 2014; Wexler et al., 2014) relative to their peers without LD.

Students with LD may experience different types of reading difficulties (Adlof & Hogan, 2018; Brasseur-Hock et al., 2011; Catts et al., 2006; Hock et al., 2009). Some students demonstrate characteristics of “classic dyslexia” (i.e., they struggle to decode words despite having average or above average listening comprehension; Hogan et al., 2014, p. 200). Others demonstrate difficulties with language comprehension despite having average or above average word reading proficiency (Adlof & Hogan, 2018However, the vast majority of students with reading difficulties have concomitant challenges developing word reading fluency and language comprehension (Hall et al., 2022). It follows, then, that most students with LD demonstrate weaknesses in vocabulary knowledge. For instance, Hock et al. (2009) did a descriptive study to assess reading profiles for a diverse group of 345 eighth and ninth grade students, including those with LD. Results demonstrated that students with LD performed statistically lower than proficient readers on measures of vocabulary knowledge, fluency, word-level skills, and comprehension. Similarly, Brasseur-Hock et al. (2011) found that subgroups of below-average comprehenders with pervasive reading difficulties (i.e., including those with IEPs) also performed the lowest on vocabulary knowledge measures. Consequently, among other needs (e.g., word study, fluency instruction, etc.), many middle schoolers with LD would benefit greatly from explicit vocabulary instructional supports for acquiring word knowledge deeply and efficiently (Elleman et al., 2019; Solis et al., 2012; Vaughn & Fletcher, 2012).

Another noteworthy issue to consider is the co-occurrence of specific learning disabilities in reading (SLD) with attention-deficit/hyperactivity disorder (ADHD), as students with SLD in reading are more likely to also have ADHD than students without SLD (Roberts et al., 2015). In particular, attention difficulties notably influence comprehension difficulties for adolescent learners with ADHD (Stern & Shalev, 2013). Inattention during reading-related activities can be problematic as higher-level comprehension processes require the continuous engagement of one’s working memory to maintain and integrate multiple sources of information simultaneously when constructing a situation model of text (Parks et al., 2022). However, individuals with ADHD may struggle to employ working memory operations needed to accomplish comprehension-related tasks (Stewart & Austin, 2020). As a result, interrelated difficulties with reading and attention for many students with SLD and/or ADHD can influence their response to academic interventions (Roberts et al., 2015; Vaughn & Fletcher, 2012).

A Closer Look at Academic Vocabulary: Importance & Specific Issues of Acquisition

Academic vocabulary and other language features may be conceptualized as tools that facilitate academic thinking and engagement with disciplinary concepts and activities (Nagy & Townsend, 2012). As noted previously, academic language knowledge may be especially salient for adolescent learners who, in addition to encountering more rigorous academic tasks, increasingly encounter curricular texts and assessments with higher concentrations of low-frequency, abstract words and phrases, alongside other complex language structures (Hiebert et al., 2018; Truckenmiller et al., 2019; Wood et al., 2021).

Research substantiates the importance of academic vocabulary for achievement within and across content areas of schooling for older readers (Ahmed et al., 2016; Barr et al., 2019; Cromley & Azevedo, 2007; Townsend et al., 2012, 2016; Wood et al., 2021). For instance, Townsend and colleagues (2012) found that middle school students' academic word knowledge explained significant variance in standardized, content-area achievement measures over and above non-academic word knowledge. Likewise, Wood et al. (2021) found that the ability to produce academic words in writing significantly predicted reading comprehension for linguistically diverse middle grade learners (i.e., English learners and students with learning difficulties).

Additionally, the manner in which teachers address academic vocabulary and other language and literacy tools when delivering instruction influences student learning (DiCerbo et al., 2014; Kalinowski et al., 2020). Though a variety of research-based vocabulary instructional methods have been shown to be effective (Elleman et al., 2009; Jitendra et al., 2004; Truckenmiller et al., 2019; Wright & Cervetti, 2017), all approaches generally center on three main principles for building deep word learning (Beck et al., 2013) (a) providing both word definitions and contexts illustrating word meaning; (b) providing exposure to multiple and varied contexts; and (c) facilitating opportunities to integrate and apply word knowledge in an array of activities (see Chapter 2 for more details).

Considering General Academic Vocabulary and Polysemy

Despite existing research identifying effective approaches to academic vocabulary instruction, various student populations still demonstrate difficulties acquiring academic word knowledge (McKeown et al., 2017). One type of academic vocabulary–general academic vocabulary (GAV)–warrants distinct consideration (Lawrence et al., 2022). In contrast with discipline-specific vocabulary (e.g. *photosynthesis, renaissance, hypotenuse*) that is critical but does not occur frequently even in academic texts and discourse (Bauman & Graves, 2010), GAV (e.g. *variable, duration, function*) is prevalent in academic texts and discourse across content area (Townsend et al., 2012) For this reason, GAV knowledge is crucial for literacy development and supporting acquisition of discipline-specific concepts (DiCerbo et al., 2014; Nagy & Townsend, 2012). However, GAV words often receive less attention than domain-specific words in research and practice (Baumann & Graves, 2010; Hiebert & Lubliner, 2008), which can curb students' exposure to these high-utility words and, thus, limit overall vocabulary development (Lawrence et al., 2022; O'Connor et al., 2019).

A challenge with GAV development is the concept of polysemy (Cervetti et al., 2015).

Considered an important aspect of deep word knowledge (McKeown et al., 2017; Nagy & Scott, 2000), polysemy consists of the notion that word often have multiple, varied senses of meaning depending on context. Among existing theories for illustrating how polysemy works during wordlearning (Logan & Kieffer, 2021), one perspective confirmed by research assert that all meanings of a given word are rooted in one core meaning that grounds semantic connections across all polysemic senses of the word (Crossley et al., 2010; Frisson, 2009; Verspoor & Lowie, 2003). This is different from other forms of semantic ambiguity, such as homonyms, which represent words with the same spelling and sound but have entirely different meanings (e.g., *duck* as a noun versus *duck* as a verb; Hiebert et al., 2019).

When encountering a polysemic word, one first recruits the core meaning of the word in memory, before relying on context to select and integrate the appropriate sense (Frisson, 2015). However, GAV with multiple senses may be challenging to acquire because these words may represent senses separated by extensive distances in the semantic spectrum, yet visibly map onto the same representation (Logan & Kieffer, 2021). For example, in a casual context, the word *foundation* may represent a more concrete sense, or one that tends to be linked to multiple associated ideas in memory (e.g. *foundation* of a house; Li et al., 2020; McKeown et al., 2019). On the other hand, in a more formal or academic context, *foundation* may be intended to represent a more abstract sense, or one that is often associated with less contextual info from prior knowledge to be integrated during comprehension processes (e.g., *foundation* of a scientific theory; Crosson et al., 2019). As many GAV are encountered during challenging activities and within challenging texts (Nagy & Townsend, 2012; Wood et al., 2021), negotiating between multiple (e.g., concrete and abstract) senses of a given word in these contexts can cause confusion and high cognitive demand on a learner (Cervetti et al., 2015; Frisson et al., 2015), These challenges make it difficult for students to efficiently acquire word meanings incidentally (Lawrence et al., 2022).

Complexities associated with learning academic, polysemic words may be especially difficult for students with SLD who typically: (a) have fewer reading experiences and encounters with text that feature polysemous words; (b) often lack depth and breadth with diverse attributes of word knowledge; (c) struggle to infer or strategically deduce word meanings from context; and/or (d) experience issues with memory for storing and processing various pieces of information (Jitendra et al., 2004; Elleman et al., 2019; O'Connor et al., 2019; Swanson et al., 2009). For instance, according to the Cognitive Load Theory, complex concepts may be represented by element interactivity (i.e., the number of pieces of information that, due to their relatedness, must be processed simultaneously in memory; Sweller, 2020). The process of engaging with complex ideas places an intrinsic load on one's limited working memory capacity (Chandler & Sweller, 1991). In particular, the concept of polysemy in academic words exemplifies element interactivity because acquiring and applying deep knowledge of a polysemic, academic word requires the learner to hold distant but semantically-related pieces of information tied to a core meaning in working memory (Frisson, 2009, 2015; Logan & Kieffer, 2021). Therefore, it is reasonable to assert that, given characteristics of LD previously mentioned (e.g., working memory issues, lack of prior word knowledge, challenges with inferring word meanings from context), students with SLD in reading and/or language development may have distinct challenges with processing, acquiring, and storing multiple senses of novel, academic vocabulary.

Multimedia-Based Vocabulary Instructional Approaches

Fortunately, technology-enhanced practices are promising options for practitioners seeking to deliver effective GAV instruction to students with and without LD (Alqahtani et at al., 2020; Cheung & Slavin, 2013; Kim et al., 2017). Multimedia features (e.g., spoken and written words paired with images) can enhance instruction by reinforcing print-only information with multiple representations of content and meaning, which can improve processing of words and concepts (Dalton et al., 2011; Silverman et al., 2019). That is, seeing written sentence contexts that include a word, hearing sentences that include a word spoken aloud, and seeing images representing the word's meaning can reduce readers' cognitive demands, aid in memory recall/retention, and build breadth and depth of word knowledge acquisition (Burt et al., 2020; Lowman, 2014; Mayer, 2014; Mize et al., 2018).

Additionally, when multimedia features are introduced via technology, such technology can increase accessibility and exposure for learners by providing more practice opportunities to build word knowledge in illustrative, meaningful, and motivating contexts (Adlof et al., 2019; Mize et al., 2018). Further, these technological features can be flexibly and feasibly delivered in a variety of formats and settings (e.g., standalone/mobile devices afterschool, teacher-delivered applications during school, etc., [Kennedy et al., 2022; Lowman, 2014]), which can make them useful supplements to other critical language and literacy practices occurring in typical classroom settings (Fehr et al., 2012; Silverman et al., 2020).

Emerging research evidence about the effects of interventions that integrate multimedia and evidence-based vocabulary instructional practices show encouraging gains for adolescents with LD on proximal measures of word knowledge (Kuder, 2017; Mize et al., 2018). However, no multimedia vocabulary instructional interventions have systematically employed theory-grounded multimedia principles with specific attention to nuances in meaning of general academic vocabulary (e.g., polysemy; Lawrence et al., 2022). There is a need for further research on high-utility, multimedia, evidence-based approaches to foster the acquisition and maintenance in memory of deep, flexible representations of general academic vocabulary for middle school students with LD.

Current Study

Introducing MultiVision

MultiVision (**Multi**media **V**ocabulary **I**nstruction for Words with Multiple **S**enses With**i**n and Acr**o**ss Co**n**texts) (MV) is an innovative, teacher-delivered approach to providing effective and feasible GAV instruction to adolescents with specific learning disabilities (SLD) in reading and/or language development. A novel iteration of extant approaches to building word knowledge (Kennedy et al., 2014, 2015), MV incorporates explicit instruction principles (Archer & Hughes, 2011), multimedia learning theories (Mayer, 2020), and other components shown to be effective in previous research for supporting general academic vocabulary knowledge (Lawrence et al., 2015, 2022; McKeown et al., 2018; O’Connor et al., 2019). In particular, aligned with emerging research (McKeown et al., 2018), MV incorporates systematic instruction (e.g., explicit introductions, multiple practice opportunities with feedback, review etc.; see Chapter 3 Procedures) on polysemy as a key aspect of word knowledge depth. Together, these components provide students structured, illustrative, and meaningful interactions with high-utility academic words (see Chapter 2 for more details). It is theorized that: (a) explicitly introducing students to novel GAV words via an approach that uses visual images to represent word meanings; (b) providing systematic practice using words in varied contexts; and (c) engaging in open-ended discussion and reflection will increase depth (i.e., flexibility and precision around polysemic senses) and retention of students' GAV word knowledge, which can contribute to middle schoolers' language and literacy development and academic achievement across content areas (Townsend et al., 2012; Truckenmiller et al., 2019).

Study Purpose & Significance

Despite the importance of general academic vocabulary knowledge for academic achievement, there is a dearth of intervention studies examining specific approaches for building this type of word knowledge for middle school populations with LD (O'Connor et al., 2022; Lawrence et al., 2022), including those with multimedia features (Weng et al., 2014). Moreover, designing and evaluating evidence-based practices is a complex endeavor that, among other demands, requires substantial amounts of time, effort, and financial resources for successful implementation (Cook & Odom, 2014). Certain single case design methods (e.g., adapted alternating treatment designs) may be especially useful for testing the efficacy and relative superiority of evidence-based treatments with minimal expense of time and resources (Ledford & Gast, 2018; Shepley et al., 2020), which can be a helpful avenue for initial experimentation, prior to larger-scale studies (Horner, 2005). This includes comparing iterations of the same intervention to refine existing approaches (Ledford & Gast, 2018). See Chapter 3 for more details.

Therefore, the purpose of this study is to examine the initial efficacy of an adaptation of an existing multimedia approach. Specifically, the study will assess the effects and perceived utility of an approach to multimedia vocabulary instruction (i.e., one that considers polysemic senses of academic vocabulary), relative to an established treatment without these features, on depth of academic word knowledge for middle school learners with SLD in reading and/or language development. Doing so will extend the current knowledge base about the effects of

GAV instruction for students with LD and help confirm which components of treatment are perceived as beneficial from the perspective of study participants (Snodgrass et al., 2018). Research questions are as follows:

1. Do multimedia approaches to academic vocabulary instruction yield greater gains and retention on assessments of GAV with multiple senses for middle schoolers with SLD, relative to a baseline condition?

2. Does an adapted multimedia approach to academic vocabulary instruction (i.e., one that considers polysemic senses of meaning) yield greater gains in depth of word-learning relative to an existing multimedia approach without these features?

3. To what extent do participating students perceive both treatments to be socially valid?

Chapter 2: Review of the Literature

Though decades of research have examined the effects of vocabulary instruction on outcomes for typically developing or diverse samples of elementary-grade students (Wright & Cervett, 2017), there is considerably less evidence surrounding the effects of vocabulary instructional interventions on vocabulary knowledge for middle schoolers with LD (Elleman et al., 2019), and even less research exploring the effects of multimedia approaches to academic vocabulary instruction for middle school students (Kuder, 2017; Mize et al., 2018). Knowledge about the effects of academic vocabulary instruction is important, given recent emphases on building academic language and literacy in curriculum standards (Bulgren et al., 2013) and the prevalence of academic language in content area discourse (DiCerbo et al., 2014; Kalinowski et al., 2020).In particular, this chapter will elaborate theoretical and empirical foundations that undergird the conceptual framework of the intervention to be examined (Figure 1). It will begin by discussing explicit instruction as a foundational approach for promoting literacy outcomes (e.g., vocabulary knowledge) for various student populations (Archer & Hughes, 2011), including secondary students with learning disabilities. Next, it will introduce widely-established principles for vocabulary instruction (Beck et al., 2013), and synthesize the knowledge base of academic vocabulary intervention research for middle schoolers with LD that aligns with these approaches. Likewise, the chapter will provide an overview of empirical support for multimedia academic vocabulary practices for middle schoolers with LD, which includes the introduction of a promising framework in this literature (Mayer, 2020), and establish evidence for its effectiveness in supporting academic vocabulary acquisition for middle schoolers with LD.

After reviewing the literature, this chapter will then elaborate on how theoretical and empirical foundations are integrated in an illustration of the conceptual framework for the featured intervention of this study (i.e., MultiVision), and discuss how this present approach will contribute to the extant knowledge base of academic vocabulary instruction. Finally, it will overview the current study and discuss further implications for the education field at large.

Theoretical and Empirical Foundations

Foundations of Explicit Instruction

Explicit instruction (EI) can be defined as a repertoire of high-leverage routines used to design and implement effective instruction through "clarity of language and purpose, and reduction of cognitive load" (Hughes et al., 2017, p. 4; McLeskey et al., 2017).

EI is informed by several, interrelated frameworks of learning, including but not limited to direct instruction, cognitive strategy instruction, and academic learning time (Hughes et al., 2017; Mathews & Cohen, 2022; Swanson & Hoskyn, 1998). Although variations exist (Kammenui et al., 1995), direct instruction approaches have centered on structured pedagogical routines that incorporate modeling, guided practice, and independent opportunities (Gersten et al., 1986). In the area of literacy, these routines typically involve teacher-led delivery formats and multiple instances of student practice to support students' acquisition of discrete subskills or concepts (Kaldenberg et al., 2015; Rupley et al., 2009). Cognitive strategies are heuristics that make mental procedures visible for learners as they engage with high-level comprehension tasks (Gajria et al., 2007; Jitendra et al., 2011). As such, implementation of cognitive strategies requires the teacher to explain general meaning-making processes with clarity and purpose for the benefit of the learner (Jitendra et al., 2011; McLeskey et al., 2017). Academic learning time is the amount of quality learning time that students participate in academic tasks for, at an optimal level of difficulty (Archer & Hughes, 2011). Increasing academic learning time (e.g., organized, and efficient lessons, selection of high-utility, appropriate content) consistently improves achievement (Archer & Hughes, 2011; Mathews & Cohen, 2022). These EI frameworks are embedded in several elements of effective instruction (e.g., provide guided practice, use clear and consistent language, etc. [Archer & Hughes, 2011]). See Table 2 for more details.

Empirical Support for Explicit Instruction and Literacy Development

Components of explicit instruction are prevalent in language and literacy intervention research for students with reading difficulties, including those with LD (Edmonds et al., 2009; Elleman et al., 2019; Filderman et al., 2022; Marulis & Neuman, 2013; Solis et al., 2012). For example, in their meta-analysis of vocabulary interventions for students with language impairments and other predictors of reading difficulties, Marulis & Neuman (2013) found that vocabulary interventions implementing explicit instructional routines were significantly more effective than those that did not (g=0.61).

Moreover, multiple systematic reviews demonstrate that principles of explicit vocabulary instruction (e.g., direct instruction cognitive strategy instruction) are beneficial for older students with LD (Jitendra et al., 2004; Kuder, 2017). For example, in a systematic review of research on vocabulary instructional supports for students with LD in grades 4-12, Jitendra et al.2004 found that studies of interventions that included direct instruction of vocabulary yielded large effects on immediate and follow-up assessments (e.g., ES=0.97). Similarly, ten studies evaluating cognitive strategy approaches for teaching vocabulary words yielded large effects on immediate (mean ES= 1.10), and follow-up (mean ES= 0.94) assessments. More recently, Kuder (2017) found similar gains for students with LD. For instance, three studies of interventions that incorporated systematic, direct instruction yielded effect sizes ranging from 1.12 to 1.97. Additionally, four other studies of instructional approaches that integrated cognitive strategies also demonstrated large effects, ranging from 0.83 to effects greater than two standard deviations.

Foundations of Bringing Words to Life

In their seminal work, *Bringing Words to Life*, Beck and colleagues (2002, 2013) introduced an instructional approach for fostering breadth and depth of word knowledge to support reading comprehension (Perfetti & Stafura, 2014; Sanchez & O'Connor, 2021). Beck and colleagues' approach supports the notion that, given the complex nature of vocabulary knowledge (McKeown et al., 2017; Nagy & Scott, 2000), applying knowledge of a word efficiently during literacy-related tasks requires that the learners' knowledge of that word is decontextualized. In other words, one's understanding of a word should ideally be connected to other words, as well as numerous forms of meaning and experiences (i.e., flexibility and depth of knowledge), rather than being dependent upon one specific context for retrieval (Adlof et al., 2019; Mezynski, 1983; Stahl & Fairbanks, 1986). As a result of these premises, Beck et al. (2013)'s framework centers on three instructional components for fostering quality word-learning experiences: (a) providing both definitional and contextual information around word meaning; (b) exposing students to multiple and varied contexts of word usage; and (c) fostering active processing and sensemaking routines that advance past rote recall to include interactive discussion and various knowledge applications of newly-acquired word meanings.

Empirical Support for Bringing Words To Life

Beck et al. (2013)'s framework has been substantiated in research on word-learning and comprehension (Beck, 1982; McKeown et al., 1983). Beck et al. (1982) conducted a group experiment design to evaluate the efficacy of a multi-faceted approach for building precise, deep, flexible, and fluent/automatic word knowledge in a manner that operationalized principles mentioned in Beck et al. (2013). This investigation was carried out in a general education ELA setting with 27 4^{th} graders and their teachers. Main features of the instructional program included: (a) explicit introductions to word meanings, pronunciations, spellings, and contexts, (b) engagement with semantic networks of concepts within and between target vocabulary; (c) various discussion-based, knowledge application tasks (e.g., sentence-generation and context-based predictions) that integrate word meanings across multiple contexts; (d) word-association games for building speedy retrieval of word meanings; and (e) systematic variance of word-learning encounters to account for effect of word exposure on vocabulary development. These routines were mainly implemented via direct instruction for roughly 104 words during 30-minute lessons, across 5 months.

Results showed that, relative to a control group of peers, students receiving treatment made significant gains on custom assessments of word-learning accuracy, fluency of retrieval at the word and sentence levels, and quality of oral recall of passage-length text with taught words embedded (effect sizes were not reported). Additionally, students in treatment made encouraging gains relative to control students on standardized tests of vocabulary and reading comprehension. In a subsequent study, McKeown and colleagues (1983) replicated findings from Beck et al. (1982). Authors of both investigations asserted that comprehensive approaches to vocabulary instruction aligned with principles mentioned (e.g., Beck et al., 2013) can support acquisition of deep, precise, and efficient word knowledge that can be readily applied to higher, comprehension-related tasks.

Academic Vocabulary Intervention Research for Middle Schoolers with LD

Numerous academic vocabulary instructional practices incorporated in interventions tested with adolescent learners (i.e., including middle schoolers with LD; Baye et al., 2019; Elleman et al., 2009, 2019; Kuder, 2017; Lowe et al., 2018; Truckenmiller et al., 2019; Wright & Cervetti, 2017) demonstrate strong alignment with principles articled by Beck et al. (2013). These practices include: (a) systematic selection of high-utility academic words; (b) direct instruction; (c) instruction in independent word-learning strategies (e.g., morphological analysis); (d) development of semantic networks; (e) morphological word parts; (f) applications of word use through discussion and/or writing; (g) use of keyword mnemonics strategies; (h) and multi-component interventions (e.g., vocabulary and comprehension approaches).

Empirical Support for Domain-Specific Vocabulary Instruction

Though less evidence exists for vocabulary supports for middle schoolers with disabilities than those without (Elleman et al., 2019), empirical research suggests multiple benefits of domain-specific academic vocabulary instruction for adolescents with LD in content area settings (Ciullo et al., 2020; Kaldenberg et al., 2015; Kuder, 2017; Powell et al., 2021; Rizzo & Taylor, 2016; Therrien et al., 2011). Infused with evidence-based vocabulary practices for deep and flexible word-learning (Beck et al., 2013; Elleman et al., 2019; McKeown et al., 2018), these content-specific interventions for middle school students with LD have yielded a range of effects on researcher-developed measures of vocabulary knowledge, content learning, and content area reading comprehension (Bos & Anders, 1990, 1992; Fore et al., 2007; Hughes & Frederick, 2006; King-Sears et al., 1992; Lowe et al., 2019). In multiple experiments, middle schoolers with LD have shown retention of word-learning gains between 1 and 7 weeks after intervention (Bos & Anders, 1990, 1992; Hughes & Frederick, 2006; King-Sears et al., 1992; Lowe et al., 2019).

Fore and colleagues (2007) conducted a multiple baseline study to compare the relative impacts of two different instructional approaches for fostering the mathematics vocabulary of middle schoolers with LD. The concept model condition featured direct introductions of word meanings, guided practice and discussion understanding and connecting semantic features, examples, and non-examples. The baseline condition involved dictionary look-up of target words and practice writing definitions in sentences. Both forms of instruction were implemented by a special education teacher in 20-minute lessons of 45 math words total for six seventh graders in a special education resource room for 9 weeks. Results showed all 6 students performed substantially better on accuracy probes of content-specific vocabulary when receiving concept model instruction than when receiving basic, direct instruction only. This was most evident in visual analyses showing immediate changes in level in data paths between the two treatments across participants. Authors concluded a functional relationship existed between the concept model approach and word-learning accuracy of math vocabulary for study participants.

Hughes & Fredrick (2006) did a multiple probe design to evaluate the efficacy of a multicomponent intervention consisting of peer-tutoring and constant time delay for developing the content-specific vocabulary knowledge of three students with LD in an inclusive, sixth-grade, Language Arts classroom. Instructional components of the intervention involved student tutors and tutees engaging in rapid exercises to build fluency of retrieval (e.g., Beck et al., 1982; Stahl & Fairbanks, 1986). Tutors used flashcards to directly introduce definitions and associated words. Tutees then verbally rehearsed this information with immediate, corrective feedback from tutors after each response. In later sessions, tutors introduced definitions with a 5-second delay to provide tutees opportunities to recall target vocabulary definitions with increased accuracy and speed. Tutors and tutees would then switch roles halfway through a session and repeat procedures, thereby providing both students enhanced practice and exposure to word representations.

After teachers trained students, this multicomponent, peer-mediated procedure occurred in 16-minute sessions with heterogeneous pairs of students with and without LD for a short duration (e.g., roughly 2 weeks), and with acquisition of 15 domain-specific words. Hughes and Fredrick (2006) found that two out of three students with LD mastered all words, and all students mastered a majority of words. This was evident in visual graphs denoting high, immediate changes in level with relatively low variability between baseline and treatment phases. Additionally, most students maintained all target words seven weeks after treatment. Results suggested a functional relation between the multicomponent vocabulary procedure and acquisition and maintenance of content area vocabulary for two out of three students with LD. Further, it was discovered that these students learned words at a comparable rate as their peers without LD.

Bos and Anders (1990, 1992) carried out comparative investigations with multiple treatments to examine the relative effectiveness of different theory-grounded approaches to vocabulary instruction for developing word knowledge and comprehension for middle schoolers with LD in science domains. In Study 1, all four featured conditions comprised direct instruction and practice with word meanings before and after passage-level reading of science text. However, three of the four conditions also involved varied uses of graphic organizers and semantic networking (i.e., semantic mapping, semantic feature analysis, semantic/syntactic feature analysis) to foster deep word-learning typical of research-informed frameworks previously described (Beck et al., 2013).

Bos & Anders (1990) randomly assigned 61 students with LD to receive either one of these three combination conditions or a comparison condition with simple, direct instruction exercises that comprised oral recitations of definitions and memorization. Interventions were delivered in three, 50-minute sessions in special education settings as part of a total study duration of 7 weeks. Findings demonstrated large effects on word knowledge and comprehension measures for students receiving combination treatments, relative to those receiving basic, direct instruction only (ES = 1.35). Additionally, these gains were maintained four weeks later with moderate effects in all three treatments, relative to comparison (ES = 0.47). Authors also noted that students in combination treatments used more content-specific vocabulary, relative to peers in comparison when prompted to write what they know about featured science topics. In another study that incorporated cooperative learning with equivalent vocabulary treatments, Bos & Anders (1992) replicated these large effects on word learning.

King-Sears et al. (1992) did a within-subjects design study with three treatment conditions to examine the relative impacts of different types of keyword mnemonic strategies for promoting acquisition and retention of 48 science words for 37 six, seventh, and eighth graders with LD. Among various approaches to mnemonic devices that have been validated for students with LD in science domains (Kaldenberg et al., 2015; Therrien et al., 2011), two iterations of keyword mnemonic strategy instruction were examined. In line with previous studies (e.g., Fulk et al., 1992; Mastropieri et al., 1985, 1992; McLoone et al., 1986; Scruggs et al., 1985), both keyword mnemonic treatments leveraged student knowledge of familiar words and concepts to establish auditory and pictorial connections with novel vocabulary, thereby enhancing one's ability to retrieve, acquire and retain target vocabulary. However, one approach involved delivery of keyword mnemonics through direct instruction with the teacher providing keyword and image-based associations, whereas a second approach promoted students' independent construction of these associations through cognitive strategy instruction.

Special education teachers were randomly assigned to implement one of these two treatments, or basic direct instruction only, which involved verbal rehearsal and brief visuals. Practices were delivered in roughly 15-minute lessons in pull-out settings over four weeks. Results showed that, in later weeks of intervention, the teacher-led approach to providing mnemonic information was statistically more effective for students' science vocabulary acquisition than student-constructed approaches and direct instruction only, although effect sizes were not reported. Additionally, on matching-task maintenance probes administered four weeks after treatment, students receiving either mnemonic-centered approach retained significantly more word knowledge than students receiving direct instruction only.

In a more recent study, Lowe et al. (2019) conducted a within-subjects design to evaluate the efficacy of *Word Discovery*, a vocabulary intervention that fosters student understanding and awareness of various phonological and semantic aspects of word knowledge to enhance word-learning experiences for adolescents with specific language impairments. In particular, *Word Discovery* comprises: (a) explicit instruction in developing morphological and contextual analysis skills; (b) semantic networking activities that includes links to affixes, syllables, and rhyming words; (c) word play games to develop lexical fluency across semantic and phonological attributes; and (d) opportunities to apply word knowledge with personal experiences and self-generated definitions. Lowe and colleagues assigned science teachers to deliver *Word Discovery* for a set of 10 content-specific words, deliver business-as-usual instruction for a second set of 10 words, and included a control set of words that did not receive instruction. Treatments were implemented in roughly 50-minute sessions over four weeks for 78 students with specific language difficulties, ranging from 11 to 14 years old. Authors found that, when students received *Word Discovery*, they statistically outperformed pre-intervention scores on multiple measures of expressive vocabulary with large effects (d= 1.09; d= 0.96), and average scores were consistently higher than when receiving business-as-usual vocabulary instruction. Further, these gains were maintained 5 weeks after intervention.

Empirical Support for General Academic Vocabulary Instruction

There are fewer experiments examining interventions that incorporate GAV than those examining approaches that solely incorporate domain-specific vocabulary (Baumann & Graves, 2010; Nagy & Townsend, 2012). Yet, like content-specific vocabulary interventions, GAV interventions for middle school LD populations have yielded a range of effects on custom measures of vocabulary, content-learning, and researcher-developed measures of comprehension with embedded taught words (Brown et al., 2016; Hua et al., 2020; Lawrence et al., 2014, 2015; O’Connor et al., 2015, 2019, 2021, 2022; Sanchez & O’Connor, 2021; Snow et al., 2009; Swanson et al., 2015; Wang et al., 2023; Wanzek et al., 2016). Additionally, in some cases, these word-learning gains have maintained from one week up to one year after intervention (Lawrence et al., 2014; O’Connor et al., 2019, 2021, 2022). Further, some programs targeting GAV have also impacted far-transfer outcomes, such as generalized vocabulary knowledge of words not taught (Brown et al., 2016; O’Connor et al., 2021, 2022), and demonstrated significant associations with standardized assessments examining global reading comprehension skills (Snow et al., 2009).

Brown et al. (2016) conducted two single case, multiple baseline design experiments to evaluate the impact of a morphemic approach to vocabulary instruction for supporting acquisition of academic word knowledge and sentence-level comprehension for middle schoolers primarily with LD. Instructional routines involved direct instruction of common prefixes, practice linking prefixes with root word meanings to build morphemic analysis skills, and interactive discussion and practice integrating prefixed word meanings in sentence contexts.

In Study 1, the researcher delivered prefix instruction only to six students in 30- to 45minute, daily lessons in a resource room over eight weeks. A functional relation between intervention and word knowledge mastery for the majority of participants was illustrated largely due to visual analyses depicting immediate and substantial changes in level between treatment and baseline phases for the vast majority of participants. These gains were sustained at least one week after treatment. Investigators replicated procedures from Study 1 with a second group of four learners and added word meaning integration and sentence context exercises described above. Findings from Study 2 replicated the word knowledge gains reported in Study 1 and extended Study 1 by demonstrating positive gains for the Year 2 cohort on a pre-post measure that assessed comprehension of taught, prefixed words in sentence-level contexts.

Hua and colleagues (2020) conducted a single case, adapted-alternating treatment design to examine the comparative effects of two forms of literacy instruction (i.e., one that included evidence-based vocabulary routines and one that did not) for supporting academic word knowledge and comprehension for middle schoolers with disabilities who also presented with reading difficulties. While one treatment featured explicit instruction with application of a paraphrasing reading comprehension strategy, the other treatment includes these components along with evidence-based vocabulary approaches, in alignment with frameworks previously mentioned (Beck et al., 2013). Specifically, this included direct instruction of academic word meanings, integration of word knowledge in multiple contexts during interactive discussions, and reflections on word meanings that connect with personal experiences. As students engaged with these routines, they were also provided graphic organizers as content enhancement tools for promoting visual representations and semantic relationships among novel words and concepts.

Both treatments were delivered by a special education teacher and implemented in 45–50-minute sessions per day to six seventh graders in a pull-out setting for 6 weeks on 24 target words (i.e., including vocabulary derived from informational texts centered on sports, animals, and other general topics). From multiple-choice, pre-post assessments of vocabulary knowledge, authors found that the multicomponent intervention with vocabulary instruction had a significant impact on students' word-learning on average, relative to treatment in strategy instruction only. In a series of trials, O'Connor et al. (2019, 2021, 2022) examined the efficacy of RAVE (McKeown et al., 2018), but with specific modifications for populations of middle school students with disabilities (primarily LD) who were also English learners in special education settings. Titled *Creating Habits that Accelerate the Academic Language of Students* (CHAAOS), this program adapts RAVE by reducing the quantity of words taught in a given week and incorporating explicit instruction (i.e., modeling, guided practice, faded prompts with feedback) around spellings, pronunciation, knowledge integration, and writing activities as intensive routines for students with LD. In Year 1, CHAAOS was implemented by special education teachers in daily 15-minute lessons over 12 weeks. Researchers found large effects on receptive measures of academic vocabulary taught (e.g., ES = 0.70); word-learning gains were maintained from 4 to 24 weeks after study completion. Further, effects from Year 1 were replicated with English-monolingual, sixth-grade students with disabilities (Sanchez & O'Connor, 2021).

Year 2 of CHAAOS showed similar effects to Year 1 with a seventh-grade population that involved students from Year 1 learning a new set of academic words. Additionally, treatment effects showed significant distal gains in general vocabulary knowledge with these seventh graders in Year 2 (O'Connor et al., 2021; effect sizes were not reported). Finally, in Year 3, CHAAOS eighthgraders receiving a third set of academic vocabulary demonstrated comparable effects on both proximal and distal assessments administered in past studies while also showing gains on an updated, expressive vocabulary assessment that was more sensitive to varied student responses (ES = 0.32) (O'Connor et al., 2022).

In addition to approaches mentioned, other intervention studies targeting outcomes for middle schoolers with LD have incorporated GAV instruction within the context of the social studies domain (O'Connor et al., 2015; Wang et al., 2023). These types of instructional approaches are particularly important, given that facility with GAV and other aspects of academic language supports one's engagement with and acquisition of domain-specific concepts (Nagy & Townsend, 2012). With multiple experimental trials, Vaughn and colleagues evaluated the impacts of *Promoting Acceleration of Comprehension and Content through Text* (PACT), a multicomponent, content area reading program for delivering enhanced literacy and knowledge-building instruction feasibly in inclusive, secondary social studies settings (Swanson et al., 2015; Vaughn et al., 2013, 2015; Wanzek et al., 2016; Wang et al., 2023). Within a multidimensional framework focused on content acquisition, text reading, comprehension and engagement, PACT features an essential vocabulary routine that initially consists of: (a) direct introductions of select GAV and domain-specific word meanings; (b) provision of synonyms and examples with visual supports; and (c) brief discussions around words in sentence contexts. Additionally, students are exposed to these high-utility academic words during critical readings, team-based applications, and other content area literacy activities to build deep, sophisticated word knowledge. Initial vocabulary instruction is generally implemented in 20-minute sessions by social studies teachers before being reviewed and applied in later literacy routines across multiple cycles over the course of 6 to 10 weeks.

To examine PACT effects for students with LD in these experiments, Swanson et al. (2015) conducted a secondary data analysis of PACT effects on content knowledge and reading outcomes for 72 middle schoolers with disabilities from two randomized controlled trials (Vaughn et al., 2013, 2015). Authors found modest effects on a content acquisition assessment that consisted of essential, taught vocabulary (ES= 0.26) and similar effects on a researcher-developed measure tapping students' comprehension of social studies texts embedding target words and concepts (ES= 0.34). Likewise, in a quasi-experimental trial, Wanzek and colleagues (2016) discovered moderate effects on a similar content knowledge measure (ES= 0.51) and found PACT elicited similar responses to treatment within a cohort of multilingual learners with LD and English monolingual individuals with LD.

Further, Wang et al. (2023) conducted a secondary data analysis of previous PACT studies assessing the differential impact of PACT between students with and without LD, as well as associations between multiple literacy constructs. Their analyses confirmed that students with LD benefitted similarly from PACT as peers without disabilities on measures of academic vocabulary knowledge and other reading assessments (i.e., social studies reading comprehension).

Like Vaughn and colleagues (2013), O'Connor et al. (2015) designed and evaluated the efficacy of a multicomponent literacy instructional approach for improving the content-area achievement of middle schoolers with LD within the social studies domain. O'Connor and colleagues (2015) carried out a within-subject design in a collaborative research format with teachers and students to develop the efficacy and utility of *Building Reading Interventions*

*Designed for General Education Subject*s (BRIDGES)- a multifaceted literacy program for intensively supporting general academic vocabulary, domain-specific social studies vocabulary, and other content-specific reading skills for students with LD in history classrooms. Like other effective vocabulary instructional approaches (Beck et al., 2013; Lawrence et al., 2014), BRIDGES consisted of explicit word meaning introductions with student-friendly language, applying both general and domain-specific word knowledge during interactive discussion around historical topics, and integrating learned content in multiple text contexts at varied reading levels to build literacy skills. These procedures were incorporated alongside multisyllabic decoding and domain-specific, reading comprehension strategies that relied on knowledge of academic vocabulary (e.g., identifying cause-and effect relationships in history texts using signal words). Researchers and practitioners designed vocabulary portions of this program to be implemented 8 to 15 minutes daily, over roughly 10 weeks, alongside other reading instruction (i.e., decoding and comprehension strategy around key words) for 38 eighth graders, many of whom had LD and EL designations. Results revealed significant gains on custom, expressive word knowledge measures (effect sizes were not reported). Findings also demonstrated gains in text comprehension (i.e., comprehension of short social studies passages), decoding skills, strategy development, and history knowledge.

Beyond multicomponent programs that consider GAV in particular domains, approaches that integrate GAV *across* authentic content-area domains can foster deeper word knowledge by generalizing representations of meaning to broader contexts and situations (Nagy & Townsend, 2012; O'Connor et al., 2019). In line with this notion, Lawrence et al. (2014) conducted a secondary data analysis of a quasi-experiment examining differential and sustained impacts of *Word Generation* (WG)—a multifaceted, cross-content area vocabulary instructional program designed to provide supportive, deep academic word-learning experiences for a diverse populations of adolescents with reading difficulties in urban settings (Hwang et al., 2015; Jones et al., 2019; Lawrence et al., 2012, 2014, 2015, 2017; Snow et al., 2009). In addition to evidence-based academic vocabulary practices previously discussed (i.e., direct instruction, word-learning strategies, knowledge applications, etc.), WG consists of learner engagement with words via controversial, motivating text contexts, interactive debates, and cross-content area activities. Lawrence and colleagues (2014) investigated WG implemented by general education teachers in daily 15-minute lessons, over 2 school years for a large sample of middle schoolers with and without LD and other special needs. Authors found that students with and without disabilities benefitted from WG relative to peers in a comparison group (effect sizes were not reported), and both student groups maintained word-learning gains one year after intervention.

Empirical Support for Polysemy and Academic Word-Learning

Though the research base determining the influences of polysemy on student knowledge of academic vocabulary is small, a few studies show both learning challenges and opportunities around acquiring this depth of knowledge (Cervetti et al., 2015; Lawrence et al., 2022; McKeown et al., 2018). In a non-experimental study, Cervetti and colleagues (2015) conducted a secondary data analysis applying multiple regression models to examine characteristics of word-learning difficulty (e.g., polysemy, frequency, complexity etc.) that influence the word knowledge and word-learning gains of elementary and upper-elementary students. Authors collected several years of multiple-choice vocabulary pretest and posttest data from a series of efficacy trials on the beneficial impacts of an integrated science and literacy program.

Results showed that, as a word feature, polysemy negatively predicted student pre-test vocabulary performance across grade levels. Authors concluded that, prior to receiving any vocabulary instruction, students experienced difficulty understanding and applying academic science words (e.g., energy) that had both common and specialized senses. This was particularly true of younger elementary students in the sample. However, analyses of the post-test indicated that polysemy emerged as a significant predictor of students' gains in science word-learning. Research findings suggested that, despite an absence of systematic instruction around polysemy, student exposure to polysemous words in the content area literacy program enabled them to incidentally acquire knowledge of such words, particularly after developing a semantic network of simpler vocabulary embedded within the program.

Like Cervetti and colleagues (2015), Lawrence et al. (2022) similarly employed multivariate models in a non-experimental study examining relationships between features of word-learning difficulty (e.g., polysemy, frequency, etc.) and middle schoolers' performance on a multiple-choice posttest of general academic word knowledge. This investigation was a secondary data analysis of a prior Word Generation efficacy trial implemented over several months. Authors found that students, on average, were significantly more accurate in demonstrating word knowledge on items featuring academic words with multiple senses than on items that featured words with less senses. According to authors, results suggested that student partial knowledge of words with multiple senses (i.e., knowledge of at least one sense of a target word), which may have been acquired incidentally during the larger intervention, positively influenced their accuracy on the word knowledge posttest. Although these findings are encouraging, it is important to note that the majority of students assessed in this study were typical readers and students with disabilities were not included in the sample. Nonetheless, authors suggested that, given the potential impacts of polysemy on word-learning, direct instruction of polysemic word features could be a worthwhile topic for future research.Only one experimental study exists on the design of systematic instruction around polysemy to support middle schoolers' acquisition of general academic vocabulary. In this investigation, McKeown and colleagues (2018) expanded upon previous vocabulary instructional frameworks (Beck et al., 1982; McKeown et al., 1983), by conducting a 2-year quasi-experimental study to examine the impact that a comprehensive vocabulary program had on literacy outcomes for 105 6th grade students and 108 7th grade students in ELA classrooms. Their intervention, *Robust Academic Vocabulary Encounters* (RAVE) stemmed from a theoretical perspective titled the "word-learning burden" (p.576). In line with Beck et al. (2013)'s approach, McKeown and colleagues argued that the goal of deep word-learning should be to acquire precision, flexibility, and depth of knowledge towards a decontextualized understanding ((Adlof et al., 2019; Mezynski, 1983). However, McKeown et al. (2018) extended the Beck et al. (2013) approach by claiming that depth of word knowledge is further built through cumulative experiences with polysemy and other language patterns (e.g., morphology, syntax) that provide more clarity and nuance for depicting academic contexts in which words are used. Authors argue this depth of knowledge (i.e., polysemy and other language patterns) lessens the cognitive load for inference-making and word-meaning integrations during comprehension of academic text (McKeown et al., 2017).

Informed by the word-learning burden, the RAVE program emphasized student knowledge of academic words and their multiple senses (i.e., polysemy) across various contexts. In addition to incorporating principles that support deep wordlearning as articulated by Beck et al., (2013), the program incorporated direct instruction and guided practice around core meanings and polysemic senses of general academic vocabulary, as well as morphological problem-solving for select, morphological root forms of target words through sixth and seventh grade. Each year, treatment components were implemented in teacher-led formats for roughly

100 words in 10-20 minute lessons per day, across 5 months. Though methodological issues prevented authors from reporting effect sizes reliably, after implementing this long-term treatment for one year, authors found that students receiving treatment significantly outperformed the control group on experimenter-designed assessments of depth of word knowledge (i.e., including polysemy), lexical access, and morphological awareness.

In Year 2, McKeown and colleagues discovered positive student gains relative to a control group on local text comprehension. Finally, though authors admitted to an underpowered design, students receiving RAVE over two years made significant gains on a standardized measure of reading comprehension between pre and post-tests relative to students in control over two years. Preliminary findings indicated that engaging with general academic vocabulary via approaches aligned with earlier studies (Beck, 1982; McKeown, 1983), and with considerations towards specific features of academic vocabulary (e.g., morphological roots, polysemy) over an extended period of time could yield various near and far-transfer literacy gains that included deep, precise, and flexible knowledge of general academic vocabulary.

Empirical Support for Multimedia Academic Vocabulary Instruction

Multimedia features have been integrated with numerous technological approaches for supporting the academic, language, and literacy needs of students with disabilities. Specific types include: (a) various computer-assisted and read-aloud technologies (Weng et al., 2014; Stetter & Hughes, 2010; Wood et al., 2018); (b) video modeling (Ok et al., 2022); (c) game-based and virtual learning environments (Israel et al., 2016; Kellems et al., 2020; Okolo et al., 2011); and (d) mobile devices and touch-based tools (Cumming et al., 2017; Ok et al., 2017).

Although research on technology-based vocabulary interventions is heterogeneous and relatively scarce compared to other areas of literacy (Alqahtani et al., 2020; Jamshidifarsani et al., 2019), this line of research has encouraging findings that warrant further investigation. In particular, scholars have asserted that "innovative" programs that advance the knowledge base of technology-mediated practices forward beyond surface-level presentations of content, or simple, rote tasks may be particularly promising (Cheung & Slavin, 2013, p. 12; Kuder, 2017). Specifically, practices that intentionally incorporate multimedia features with evidence-based practices show potential (Mize et al., 2018). However, few of these studies explicitly target word-learning outcomes for middle schoolers with LD (Herbert & Murdock, 1994; Kuder, 2017; Wood et al., 2012; Xin & Rieth, 2001).

Herbert & Murdock (1994) conducted an adapted alternating treatment design to determine the differential impacts of three different modes of a standalone, word-learning computer program on the vocabulary development of sixth-graders with language-learning difficulties. The software, titled *Word Attack Plus*, provided students with multiple practice opportunities with target word meanings and sentence contexts. The following modes were used to present information and routines: (a) synthesized speech (i.e., computer-generated narration); (b) digitized speech (i.e., pre-recording of human voice as narration); and (c) routines with no audio narration component. Conditions were alternated over a brief period of 6 sessions with three students exploring 25 words each. Results showed that, when students received some form of audio narration along with word-learning routines, their vocabulary knowledge increased relative to baseline (i.e., PND = 72% for synthesized speech, PND = 61% for digitized speech) and two of three students learned better with audio narration with digitized speech.

Xin & Rieth (2001) did a pre-post group experiment design evaluating the use of video technology for enhancing the vocabulary knowledge and comprehension skills of sixth graders and other students with LD. The video experimental condition involved: (a) initial exposure to word meanings with animated pictures and audio; (b) interactive discussions around word meanings in sentence contexts; and (c) brief text reading for further refinement of word knowledge in passage contexts. Students were provided repeated exposure to video time points illustrating target words throughout these word-learning routines to augment student understanding. The non-video condition included identical routines as the video condition, except that initial exposure to words was through a whole-class read-aloud of passage text and no opportunities for students to access video content. Treatments were implemented by special education teachers in resource-room settings over 6 weeks in 30-minute lesson segments targeting 30 total words with 76 individuals with LD. Findings revealed that students receiving the video-assisted condition significantly outperformed their counterparts in the comparison group on custom, word-association measures, and had higher scores on comprehension-related outcomes (effect sizes not reported).

Wood et al. (2012) employed a simultaneous treatment design to compare the relative efficacies of a whole-word approach and morphology-based approach to vocabulary instruction on word knowledge acquisition and generalization outcomes for middle schoolers, including those with LD. These supports were delivered in a peer-mediated format with multimodal enhancements. After training sessions on tutoring norms, peer-led procedures in the whole-word condition involved practice integrating key word meanings in sentence contexts followed by provision of definitions with verbal rehearsal. In a morphology-based condition, student tutors carried out the same procedures as the whole-word approach but also explicitly introduced and verbally rehearsed meanings of common affixes and roots embedded in target vocabulary. For both conditions, researchers designed computer-assisted components that involved scripted lessons using multimedia slides, visual cues, and audio read-alouds of target vocabulary and sentence contexts to aid student understanding and pacing throughout the session

Peer tutoring sessions involving dyads of eight students total lasted seven minutes daily in a pull-out setting, as students explored roughly100 words over 14 weeks. Authors suggested a functional relationship existed between morphological instruction and vocabulary acquisition, as visual analyses revealed seven out of eight students demonstrated a notably steeper trend for words acquired in the morphological condition, relative to the whole-word condition. Additionally, authors found positive effects on generalization of knowledge in favor of morphology instruction, as all eight students performed with higher accuracy on questions involving novel words with learned word parts.

Foundations of Cognitive Theory of Multimedia Learning (CTML)

Though multiple theoretical frameworks exist that integrate multimedia applications in support of students' language and literacy development (Kennedy & Boyle, 2017; Silverman et al., 2019), a particularly beneficial approach for students with special needs is Mayer's Cognitive Theory of Multimedia Learning (CTML). According to this framework, learning experiences are maximized when multimedia instruction is systematically designed to present visual and audio features of novel content that closely align with the ways in which learners cognitively process, learn, and retain information.

CTML is derived from multiple frameworks, including the dual-coding theory (Clark & Paivio, 1991; Paivio, 1990), working memory models and cognitive load theory (Baddley, 1992; Chandler & Sweller, 1991), as well as principles of active learning (Mayer, 2010, 2014; Wittrock, 1989). From these frameworks, three foundational assumptions emerge (i.e., dual channel, limited capacity, and active processing). The dual channel assumption claims that learners acquire content via two separate modes of processing: a verbal channel and a non-verbal channel (Clark & Paivio, 1991; Paivio, 1990).

The limited capacity assumption contends that each learner's channel has a finite amount of information that can be retained in working memory within a given moment (Baddley, 1992; Chandler & Sweller, 1991). Finally, the active processing assumption asserts that a learner engages in active cognitive functions to select, organize and integrate new information with prior knowledge in order to construct mental models (Mayer, 2010, 2014). As such, effective implementation of CTML centers on three main objectives to promote meaningful learning: fostering essential processing (i.e., one's ability to acquire core content), supporting generative processing (i.e., one's ability to make meaning from content), and reducing extraneous processing (i.e., extra efforts geared towards understanding unnecessary details) (Mayer, 2020).

CTML objectives are attained via instructional principles that may serve as guidelines for designing and presenting multimedia instruction in line with CTML. For instance, one instructional principle for fostering essential processing is segmenting (i.e., dividing a presentation into manageable parts that can be learned in order). An instructional principle for supporting generative processing is multimedia (i.e., using words and pictures to aid in learning is better than words alone). Finally, an instructional principle for supporting reduction of extraneous processing is coherence (i.e., eliminate non-essential information from the presentation). See Table 1 for more details.

Empirical Support for CTML and Vocabulary Instruction

Multiple vocabulary intervention studies have employed Mayer's CTML framework to enrich the word-learning experiences of middle school students with LD (Griendling et al., 2023; Lowman & Dressler, 2016; Kennedy et al., 2018; VanUitert et al., 2020, 2023). Lowman &

Dressler (2016 conducted a 4-week, within-subjects experimental study to determine whether a standalone multimedia device embedding evidence-based vocabulary practices could enhance the learning of 24 tier 2 vocabulary words (i.e., words prevalent in written text but not common in everyday conversation; McKeown, 2019) for 12 fifth graders and sixth graders with specific language impairments (SLI). In a control condition, students were asked to read narrative text independently with no vocabulary support. In the treatment condition, independent reading was supplemented by podcasts (i.e., *vodcasts*) that delivered 15-minute, explicit vocabulary lessons via standalone, mobile devices (i.e. I-pods) that contained pre-recorded video and audio presentations grounded in theoretical frameworks of multimedia learning (e.g., coherent arrangement of spoken words and images; Mayer, 2020).

Content Acquisition Podcasts for Students (CAP-S). Similar to Lowman & Dressler (2016), Kennedy and colleagues (e.g., 2014, 2015, 2018, 2022) carried out a series of experiments examining a systematic integration of explicit vocabulary routines with CTML learning principles. Titled Content Acquisition Podcasts for Students (CAP-S), this word-learning intervention consists of "multimedia-based instructional modules" (Kennedy et al., 2015, p. 26) presented via PowerPoint slides and delivered in roughly 15-minute lessons of explicit vocabulary instruction. CAP-S slides primarily apply CTML by using vivid imagery tightly organized around selective text, and by encouraging auditory narration of this content to be clear, succinct, and to avoid redundancy. Along with CTML instructional design principles, CAP-S incorporates elements of an explicit instruction framework designed to maximize student learning of novel skills and concepts (e.g., segmenting complex information, reviewing prior knowledge, frequent practice examples, etc. [Archer & Hughes, 2011]).

CAP-S has been substantiated with positive outcomes in eight experiments that include diverse learner populations with and without disabilities (Griendling et al., 2023; Kennedy et al., 2014 , 2015, 2018 , 2022; McDonald et al., 2023; VanUitert et al., 2020, 2023). In the first study, Kennedy and colleagues (2014) examined whether CAP-S that incorporated elements of Universal Design for Learning could improve the performance of 141 tenth graders with and without disabilities on curriculum-based measures of social studies vocabulary knowledge. Students with disabilities (d = 1.84; d = 1.32) and students without disabilities (d = .95; d = .61) who received CAP-S delivered by their social studies teachers over 8 weeks learned 81 target words more efficiently than their counterparts who received BAU instruction.

Kennedy et al. (2015) examined the relative effects of three multimedia, evidence-based vocabulary instructional practices on the word learning of 279 high schoolers with and without disabilities. Treatment conditions included: (a) explicit instruction with theory-based multimedia; (b) keyword mnemonic strategy instruction with theory-based multimedia; and (c) explicit instruction, keyword mnemonic strategy instruction, and theory-based multimedia. Multimedia instruction with no theoretical grounding served as a comparison condition. CAP-S was delivered as a series of pre-recorded, standalone devices for fostering students' abilities to independently learn 30 social studies words over 3 weeks. While results indicated no statistically significant differences in effects of the three treatment conditions, only the group of students with and without disabilities who engaged with explicit instruction, mnemonic keyword strategies, and theory-based multimedia significantly outperformed the comparison condition on the curriculum-based post-test (d = 1.97) and maintenance measures (d = 2.40) of word knowledge.

In a more recent investigation, Kennedy et al. (2022) evaluated the impact of CAP-S relative to (a) a commercial, online word-learning application (i.e., Infercabulary) and (b) BAU instruction on the vocabulary performance of 656 fifth grade students with and without disabilities in a general education setting. While both conditions explored 100 words over roughly 8 weeks, Infercabulary was student-directed, guiding learners to make inferences about word meanings via on-screen visuals, captions, and audio features in a standalone delivery format (Kennedy et al., 2020). Meanwhile, CAP-S slides were delivered by ELA teachers in a whole-group format. Authors found that students in both technology-mediated treatments statistically outperformed counterparts in a BAU condition on three receptive measures of word knowledge (d = 1.25; d = 1.72; d = 1.20).

With a secondary data analysis of Kennedy et al. (2022), McDonald and colleagues (2023) employed a randomized control trial to evaluate the impacts of CAP-S, relative to BAU instruction on researcher-developed and standardized measures of word knowledge for a linguistically diverse sample of 418, Grade 5 students (i.e., including current ELs and non-EL peers that comprised multilingual learners and English-monolingual peers) within rural school contexts. Hierarchical linear modeling indicated statistically significant and meaningful effects on a custom measure of word learning (d=0.79), as well as small but statistically significant effects on a standardized assessment of word knowledge (d=0.04). Further, on the custom vocabulary measure, treatment-by-language interactions suggested ELs benefited more than non-ELs from CAP-S instruction, relative to their counterparts in the BAU condition.

CAP-S for Middle Schoolers with LD. Within the academic discipline of science, VanUitert et al. (2020) found that, among a sample of 43 middle school students, SWD's benefitted from pre-recorded, standalone CAP-S presentations of 56 target science vocabulary, as students showed positive gains on multiple proximal assessments of science vocabulary words administered over 10 weeks (d = .62; d = 1.13; d = .51; d = .73). SWD's also outperformed their peers receiving BAU instruction on expressive measures of science word knowledge (*d* = 1.45; *d* = 1.07; *d* = 1.57; *d* = 1.11), relative to classmates who received BAU instruction.

Kennedy et al. (2018) incorporated CAP-S into an overarching PD initiative that used technology-based coaching tools to improve middle school teachers' capacity to implement evidence-based vocabulary instruction in science classrooms. Students taught by educators who received the multimedia PD intervention scored significantly higher than peers in a comparison condition on three curriculum-based measures (*d* = .33; d = .73; *d* = .70) and a distal assessment of science content knowledge (*d* =.54).

VanUitert and colleagues (2023) conducted a secondary data analysis of Kennedy et al. (2018) that used multilevel modeling to explore associations between: (a) students' indirect exposure to CAP-D (i.e., via their teachers' use of CAP-S and CAP-PD); (b) content-learning and vocabulary outcomes; and (c) whether these effects varied by disability status. Authors confirmed Kennedy et al. (2018) results by illustrating students receiving indirect exposure to the CAP-PD package statistically outperformed peers without exposure on global measures of science achievement (*d* =.93). Researchers also found that students with IEPs receiving indirect exposure performed significantly greater than students with IEPs and students without IEPs that did not receive exposure. Finally, results revealed that students' growth in science word-learning was significantly associated with their science content-learning.

Griendling et al. (2023) also did a secondary data analysis of Kennedy et al. (2018) by investigating vocabulary and content knowledge acquisition for students with varying intersectional identities (i.e., exceptional learners from racial/ethnic, minoritized backgrounds as well as those from socioeconomically disadvantaged households) yielded similar gains. Specifically, students with special needs from marginalized, racial/ethnic backgrounds statistically outperformed their counterparts in a comparison on all three curriculum-based measures (*d* = .26; d = .1.24; *d* = .91) as well as the distal assessment of science content knowledge (*d* =1.39). Similar gains were made for intersectional learners from socioeconomically disadvantaged backgrounds on these proximal measures (*d* = .35; d = .68; *d* = .85), and the distal science measure (*d* =.64).

What is Missing in the Knowledge Base of Academic Vocabulary Instruction for Middle Schoolers with LD

Though research on academic vocabulary instruction for middle schoolers exists, there remains a need for continued research in supports for middle schoolers with LD (Elleman et al., 2019; Lawrence et al., 2022). In particular, facility with general academic vocabulary and language features are critical for the content area achievement of various learner populations (Barr et al., 2019; Uccelli et al., 2015). However, few studies outside of those focused on multilingual learners target knowledge of general academic vocabulary specifically for middle schoolers with LD (Lawrence et al., 2014; Truckenmiller et al., 2019).

Another deficiency within the knowledge base is the uncertainty behind the effects of distinct instructional components of treatment, as many general academic word-learning programs are multicomponent (e.g., Lesaux et al., 2014; Snow et al., 2009). Similarly, with regards to multimedia alternatives, specific instructional and design features underlying intervention effectiveness are rarely reported for many multimedia literacy interventions as well (Weng et al., 2014). In particular, few investigations compare differential effects of different types of multimedia instructional components on students' word-learning outcomes (Silverman et al., 2019). Additionally, though polysemy is considered a critical source of word-learning difficulty that affects students' literacy performance (Lawrence et al., 2022; Logan & Kieffer, 2021), few vocabulary experiments systematically target this aspect of word knowledge (McKeown et al., 2018). This includes a lack of attention towards measures that tap polysemy as a form of word knowledge depth (Crosson et al., 2019).

Although it has been established that an array of approaches to vocabulary instruction for students with LD can be helpful depending on one's instructional objectives (Bryant et al., 2003; Elleman et al., 2019), isolating impacts of specific approaches to general academic vocabulary instruction may be beneficial for confirming what works best and for whom (Lesaux et al., 2014; Reed et al., 2013). Consequently, there is a need to develop and determine the efficacy of distinct components to general academic vocabulary instruction. In particular, this may include intervention studies that address polysemy as a critical source of academic word-learning difficulty (Lawrence et al., 2022), and that leverage specific multimedia instructional approaches for supporting students' deep acquisition of target vocabulary (Silverman et al., 2019).

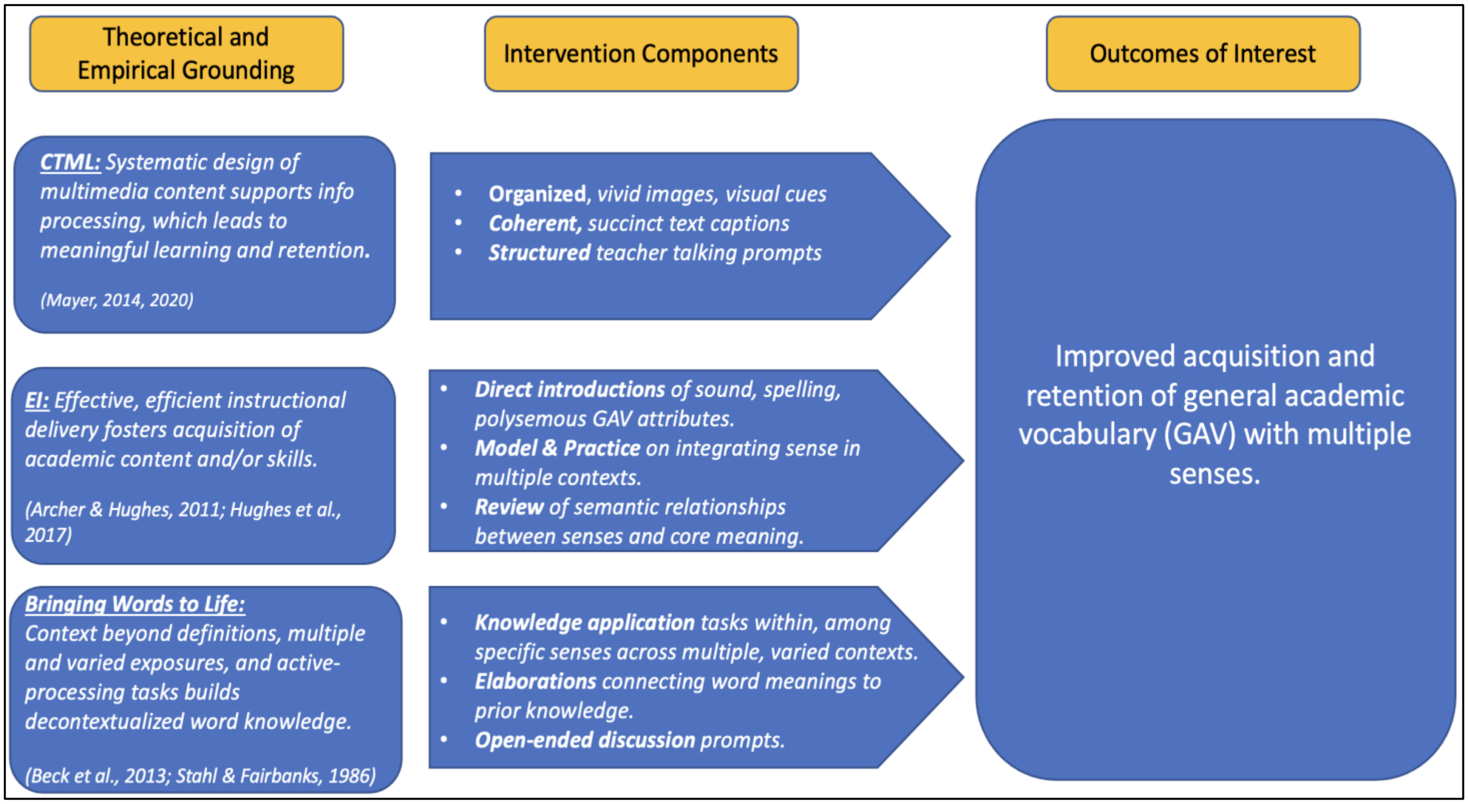
Conducting single case design studies is one method for determining the relative superiority of evidence-based treatments (Ledford & Gast, 2018). This includes comparing iterations of the same intervention to refine existing approaches (Shepley et al., 2020). Therefore, the present investigation expanded the knowledge base by using a single case design to examine the relative, distinct impacts of two research-informed multimedia instructional supports (i.e., one that considers polysemy and one that does not), on building and retaining knowledge of general academic vocabulary words for middle school students with LD.

Conceptual Framework

Figure 1 below displays the conceptual framework that outlines theoretical and empirical bases for MultiVision, which is informed by foundational literature discussed in Chapter 2. MultiVision integrates multiple frameworks and intervention components designed to build and sustain deep, precise, and flexible knowledge of high-utility GAV words for middle school students with LD.

Figure 1

Conceptual Framework for MultiVision



Note. MultiVision = Multimedia Vocabulary Instruction for Words with Multiple Senses Within and Across Contexts. CTML= Mayer's Cognitive Theory of Multimedia Learning. EI= Explicit Instruction.

First, MV slides and teacher scripts are specifically designed with theory-grounded principles of multimedia instruction that, when appropriately implemented (e.g., integrated with evidence-based approaches), enhance information processing, learning, and retention (Kuder, 2017; Mayer, 2014, 2020). MV demonstrates these principles via close alignment of images and scripted narration, coherent and succinct text captions, elimination of redundant information, and other procedures (see Table 1 below for more details).

Table 1

Instructional Design Principles of Mayer's (2020) Cognitive Theory of Multimedia Learning

Instructional Goal	Instructional Design Principles (Mayer, 2020)	Principles Integrated in MV & CAP-S
Reduce extraneous processing	Coherence principle (N = 18; ES = 0.86)	Each MV and CAP-S slide comprises only essential words, pictures, and instructor (scripted) speech.
	Signaling principle (N = 15; ES = 0.69)	MV and CAP-S feature recurring explicit cues that signal transitions between sections (e.g.,practice, review)
	Redundancy principle (N = 5; ES = 0.72)	MV and CAP-S contain mostly images, to be presented by the teacher, and text for essential/generative processing only.
	Spatial contiguity principle (N = 9; ES = 0.82)	MV and CAP-S on-screen text and images are displayed in close proximity to each other.
	Temporal contiguity principle (N = 8; ES = 1.31)	MV and CAP-S contain scripted speech presented in time with words and images.
Manage essential processing	Pre-training principle (N = 10; ES = 0.78)	MV and CAP-S slides begin with a purpose for word-learning.
	Modality principle (N = 18; ES = 1.00)	MV and CAP-S slides feature images to be presented orally by the teacher. On-screen text provided for essential/generative processing only.
Foster generative processing	Personalization principle (N = 13; ES = 1.00)	Teachers present MV and CAP-S using a conversational style with students.
	Voice principle (N = 6; ES = 0.74)	Teachers present MV and CAP-S, rather than a computer-generated voice.
	Multimedia principle (N = 13; ES = 1.35)	MV and CAP-S slides contain words with pictures.
	Generative activity principle (N = 37; ES = 0.71)	MV and CAP-S slides feature instructional prompts designed to foster word learning.

Note. Adapted from Kennedy et al. (2015). N = the number of tests conducted for each principle; ES = the median effect size found for each principle

Second, MV includes key principles of explicit instruction that support effective and efficient acquisition of academic skills (Archer & Hughes, 2011; Hughes et al., 2017), and demonstrate empirical evidence for supporting the vocabulary development of students with learning difficulties (Jitendra et al., 2004; Kuder, 2017; Marulis & Neuman, 2013). MV executes these elements by modeling word meaning integrations, providing multiple guided practice opportunities, immediate feedback, and other procedures (see Table 2 below for more details).

Finally, MV incorporates Beck et al. (2013)'s research-informed frameworks towards supporting students' deep understanding and retention of academic, polysemous words (McKeown et al., 2018). Some of these practices embedded in MV instructional routines include (a) situating word definitions and senses within meaningful contexts; (b) providing exposure to multiple and varied examples of word meanings and senses; (c) and interactive discussions for connecting word meanings and senses with personal experiences (See Table 3 below for more details).

Table 2

Key Elements of Explicit Instruction

Element	Description	Integrated in MV & CAP-S
Segment complex skills	Teach complex concepts in small steps to reduce cognitive overload and help students synthesize skills.	MV & CAP-S model integration of word meaning in image contexts, before students do so independently
Design organized and focused lessons	Make optimal use of instructional time by developing organized, on-topic, and well-sequenced lessons.	MV & CAP-S slides are scripted, and contain visual cues signaling lesson transitions.
State the goal(s) of the lesson and your expectations	Clearly explain to students what they are going to learn and why it is important.	MV and CAP-S slides begin with a goal and purpose for word-learning.
Review skills and knowledge	Deliver/activate student (prior) knowledge before beginning instruction, and review relevant information	MV and CAP-S review taught word meanings and build/activate knowledge of essential concepts for word-learning throughout lesson.
Use clear and concise language	Use consistent and unambiguous language to reduce confusion.	MV and CAP-S describe word meanings and concepts with student-friendly language.
Provide guided practice	Guide students through a range of practice opportunities, gradually fading the level of support over time.	MV & CAP-S provide multiple guided practice opportunities through structured, active discussions with teacher. Later exercises are more independent.

Table 2 continued

Require frequent responses	High-level student-teacher interaction via questioning that prompts student action.	MV & CAP-S provide frequent opportunities for student to respond throughout word-learning exercises.
Monitor student performance	Carefully monitor students to verify understanding, making instructional adjustments as needed.	MV & CAP-S script prompts teacher to monitor student understanding during practice stages, and to adjust instructional decisions as needed.
Provide immediate, affirmative, and corrective feedback	Provide feedback to students as quickly as possible to reduce practicing errors and ensure success.	MV & CAP-S script prompts teacher to provide immediate, affirmative, and/or corrective feedback as appropriate.
Provide distributed practice	Use multiple, distributed practice attempts to address issues of retention and automaticity.	MV & CAP-S provide range of examples for developing fluency and retention of word knowledge.
Focus instruction on critical content	Teach skills, strategies, vocabulary, concepts that empower students for future learning and match their instructional needs.	MV and CAP-S focus instruction around high-utility, general academic vocabulary.
Provide step-by-step demonstrations	Model the skill and clarify decision-making processes by thinking aloud as you perform the skill.	MV and CAP-S model word meaning integrations by thinking aloud how to make sense of initial image context illustrating target word meaning.

Note. Informed by critical elements described in Archer & Hughes (2011) and Hughes et al. (2017). MV deviates from CAP-S in that its focus is on teaching target word core meaning as well as connections and practice with specific senses of meaning. This distinct emphasis is present across explicit instruction principles above.

Table 3

Bringing Words to Life: Vocabulary Instructional Principles

Principles	Integrated in MV & CAP-S
Provide definitional *and* contextual information around word meaning.	MV & CAP-S situate word definitions in meaningful, illustrative (i.e., image-based) contexts.
Provide multiple *and* varied contexts to practice word-learning.	MV & CAP-S include multiple word-learning practice examples.
Foster student active processing, (i.e., sensemaking) with word meanings	MV & CAP-S involve active discussion (i.e., including structured justifications) for integrating word meanings, and opportunities to connect word knowledge to personal experiences

Note. Informed by critical elements described in Beck et al. (2013). MV deviates from CAP-S in that its focus is on teaching target word core meaning as well as connections and practice with specific senses of meaning. This distinct emphasis is present across explicit instruction principles above.

Interventions that integrate (a) multimedia features and (b) evidence-based vocabulary practices show encouraging gains for adolescents with and without disabilities on proximal measures of word knowledge (Adlof et al., 2019; Kuder, 2017; Mize et al., 2018). However, little research exists that evaluates these interventions (or modified versions of these interventions) with middle-school students with LD. (Elleman et al., 2019; Truckenmiller et al., 2019). MV's intervention expands current approaches (e.g., CAP-S) by systematically employing theory-grounded multimedia principles with specific attention to polysemy in general academic vocabulary (Lawrence et al., 2022), and by providing illustrative, meaningful, and instructional contexts for promoting deep word-learning (Beck et al., 2013). In particular, this includes: (a) explicit instruction routines (e.g., building and activating knowledge, guided practice, review) for supporting student understanding of polysemic senses of target vocabulary; (b) varied exposure to core word meanings and senses across coherent, image-based and text-based contexts; and (c) structured discussion and sensemaking activities for supporting acquisition and retention of multiple senses of meaning (see Chapter 3 for more details).

Study Overview

The purpose of this experiment was to evaluate the initial efficacy of MultiVision (MV)—a novel approach to general academic vocabulary instruction for middle schoolers with LD. These aims were carried out by using a single case, adapted alternating treatment design (AATD) to compare a treatment condition involving MV, to a second treatment condition involving CAP-S, relative to a baseline condition with no treatment. Treatment efficacy for MV was examined via formative probes and maintenance measures of deep academic vocabulary knowledge that included multiple senses of meaning. Additionally, students' perspectives on procedures and general effects of treatments were examined via participant responses on social validity assessments (see Chapter 3 Methods section). The systematic arrangement of theoretical and research-based components from this investigation yielded three research-informed hypotheses pertaining to the experiment and two more hypotheses associated with social validity outcomes. They are discussed in subsections below.

Research-Informed Hypotheses

Hypothesis 1: On treatment effects for acquisition of GAV with multiple senses for middle schoolers with SLD.

First, it was hypothesized that both MultiVision and CAP-S would yield greater gains in acquisition of GAV with multiple senses than the baseline condition and that there would be a functional relationship between either treatment and student word-learning, relative to baseline. This hypothesis was informed by evidence-based approaches for supporting middle schoolers' understandings of academic vocabulary (O'Connor et al., 2022; Truckenmiller et al., 2019). In the current experiment, both MV and CAP-S instruction provided student-friendly introductions with opportunities to practice integrating and applying word meanings in contexts. Further, these routines were augmented with multimedia slides containing images arranged with words to provide students with multiple representations of content. Together, these components can help support learners' access to complex, abstract vocabulary (Burt et al., 2020; Mize et al., 2018).

Hypothesis 2: On retention of word-learning gains for middle schoolers with SLD

Second, it was hypothesized that both treatments would maintain respective word-learning gains across student participants. This argument corresponds to previous research that demonstrated adolescents with SLD retained knowledge of taught academic words for at least three or four weeks after receiving treatment Kennedy et al., 2015; O'Connor et al., 2019).

Hypothesis 3: On differential effects and relative superiority of treatments.

Third, it was hypothesized that MultiVision would yield greater gains in depth of word-learning for academic vocabulary with multiple senses relative to CAP-S and demonstrate superiority over the CAP-S treatment. This assertion stems from scholarship demonstrating that students improved their depth of word-learning and other comprehension-related skills when they received systematic exposure and practice with polysemy as a critical feature of academic vocabulary (McKeown et al., 2018). In line with this research, MV provides explicit introductions, practice, and knowledge application on polysemy as a key language feature of academic vocabulary throughout all evidence-based routines in the lesson. This explicit exposure to polysemy is the critical element that distinguished MV from the CAP-S treatment in the present investigation.

Hypotheses 4 and 5: On social validity of treatments

In addition to hypotheses centered on experimental outcomes, two more research-informed hypotheses were established for outcomes pertaining to social validity of treatment. For these outcomes, it was hypothesized that students would perceive both MV and CAP-S as beneficial to their word-learning and that MV would be perceived as more beneficial compared to CAP-S. The first claim stems from scholarship showing the impact that various approaches to academic vocabulary instruction can have on adolescent learners' literacy and school achievement (Adlof et al., 2019; Lowman & Dressler, 2016; Kennedy et al., 2015; Truckenmiller et al., 2019). Similarly, the second claim is in line with literature suggesting the importance of direct instruction on polysemy for advancing students' knowledge of general academic vocabulary (Lawrence et al., 2022; McKeown et al., 2018).

Results associated with research questions and hypotheses from this investigation can extend current knowledge of the effects of multimodal approaches to academic vocabulary learning (Kuder, 2017; Truckenmiller et al., 2019). Findings may also reveal instructional insights regarding approaches for supporting efficient and effective academic word-learning for middle schoolers with LD across content areas (Elleman et al., 2019). Finally, confirming the social validity of treatment from a student perspective can help build a case for the translatability of MV to practice in authentic educational settings in future investigations (Horner et al., 2005; Reed et al., 2013; Solari et al., 2020).

Chapter 3: Methodology

Participants and Setting

Three middle school students participated in this study. They were recruited via social media (i.e., Twitter) and paper ads. The initial inclusion criteria for study participation included: (a) enrollment in a middle school grade, (b) having a formal diagnosis of SLD and received IEP services for reading and/or language development, (c) demonstrating word-learning difficulties as measured via screening procedures (described below), (d) having parent/guardian consent, (e) having access to a computer with internet access and Zoom application, (f) having basic computer-usage skills, and (g) having sufficient verbal and visual skills to orally respond to question prompts. However, to obtain a desired sample of at least three student participants, the principal investigator (PI) broadened the inclusion criteria to include fifth-grade as an eligible middle-grade, given that one's knowledge of academic vocabulary and language are critical in these classroom contexts as well (Uccelli et al., 2015).

Additionally, to confirm eligibility, participants were screened for reading difficulty due to low vocabulary knowledge to ensure they match the profile of an adolescent learner with word-learning difficulties. Specifically, students' initial receptive knowledge of general vocabulary knowledge of words not taught was assessed using the CORE vocabulary screener—a an untimed, standardized instrument that measures students' understanding of 30 grade-appropriate academic vocabulary words (Diamond & Thornes, 2008). Applied in past experiments (e.g., Kennedy et al., 2020), this measure requires students to read the featured word for each item, followed by three words that are somewhat related words. From these associated words, they select the answer choice that is most similar in meaning to the featured word. For example, if a featured word is *challenging*, then three related words might be *violent, sad,* *difficult*. Each item is worth one point, and predetermined, grade-appropriate benchmarks are used to assist practitioners in identifying students at risk for word-learning difficulties. Scores ranging from 0-14 illustrates a need for intensive support, scores of 15-22 shows a need for strategic support, and scores of 23-30 shows students are meeting grade-level expectations with vocabulary knowledge. In the present study, students who scored 15 and above were typically excluded. However, to obtain a desired student sample, the principal investigator (PI) broadened this inclusion criterion to include students showing a need for strategic support who scored no more than three points higher than a 14. Researchers calculated the reliability coefficient at pre-test to be .87. Student raw scores are displayed in Table 4 below. Sample items from this instrument are illustrated in Appendix A.

This pilot efficacy study was conducted in a one-to-one, remote-learning environment after school during the fall and spring semesters of a typical school year. Sessions occurred via Zoom (www.zoom.us) and were delivered by the PI (or me).

Student Demographic Information

Jason was a 13-year old, Black male with SLD in reading (as reported on an eligibility survey). He was in seventh grade and attended a public middle school in the Southeastern region of the United States. Jason loved basketball and was heavily involved in after-school homework clubs and other activities.

Tommy was a 14-year old, Caucasian male with SLD in reading. His parents also reported he had ADHD and, on an eligibility survey, described it as a “secondary disability”. Tommy was in eighth grade and attended a public middle school in the Southeastern region of the United States. Tommy’s score on the CORE vocabulary screener was slightly higher than the intensive-support range of 14 as he obtained a raw score of 17. However, this score met the broadened inclusion criteria (mentioned above) for him to participate in the study. Like Jason, Tommy was involved in sports and often had afterschool soccer and/or basketball practice throughout the fall and spring semesters.

Kimberly was an 11-year old, Black female with an SLD in reading. She was a fifth grader who attended a private school in the Southeastern region of the United States. Like other student participants, Kimberly was frequently involved in afterschool activities throughout the year.

Materials

Multimedia Presentation Slides

All experimental phases (i.e., baseline, intervention, and maintenance sessions) were implemented using Microsoft PowerPoint presentation slides. They consisted of visuals, text, and various software-based editing and formatting features (e.g., highlighter, arrows, circles) to develop illustrative contexts surrounding target word meanings for word-learning activities. In line with research on effective vocabulary instruction (Beck et al., 2013; Elleman et al., 2019), topics of word use for both treatments involved familiar, relevant examples for adolescents (e.g., activities in and around middle school) that illustrated core meanings of target words.

Word Sets

Ensuring comparability of difficulty across word-learning sets used in this study was critical for maintaining internal validity in AATD research (Ledford & Gast, 2018). Informed by prior vocabulary research with AATD designs (Savaiano et al., 2016), A series of word selection procedures were employed to confirm word complexity was consistent across target vocabulary. 196 general academic words were collected from empirically-validated word sets from past studies (Coxhead, 2000; McKeown et al., 2018). Then, to help ensure word sets had comparable levels of difficulty, target items were examined along three dimensions of complexity associated with word-learning difficulty (i.e., word frequency, number of letters, and number of syllables; Lawrence et al., 2022).

Establishing comparability by word frequency involved four steps. First, the Brown corpus was used to identify the frequency absolute score (i.e., the number of times a word is present in the corpus) for each word. This corpus had been established as a valid and reliable source for identifying characteristics of vocabulary present in school contexts (Hiebert et al., 2018; Lawrence et al., 2022). Words were then organized in ascending order based on their frequency level. Next, the list was divided into frequency quartiles, which helped cluster relatively homogenous frequency scores together (e.g., 2 to 9; 10 to 19; 20 to 29, etc.). Then, 62 words were selected from the largest frequency quartile (i.e., those with a frequency score of 2 to 9) to move on to the next phase of selection. To establish comparability based on the number of letters in each word, basic software (i.e., Microsoft Word) was used to track the number of letters for each word. Steps used for identifying words that were homogeneous based on frequency were then repeated, which resulted in 44 words to be examined for the third phase of selection. To establish comparability based on the number of syllables in each word, a free, online syllable counter was used (How Many Syllables, 2023). Steps used for determining frequency levels and letter lengths for each word were then repeated, which resulted in a pool of 42 eligible words to be randomly selected for the study. After establishing comparability, 24 words were randomly selected to be used for pre-assessment. Six extra words were also randomly selected in case of replacement during the Vocabulary Knowledge Scale (see pre-assessments section). This total list of 30 words is displayed in Appendix I.

Pre-assessments

Multiple pre-assessments were administered to provide descriptive insights on students' word-reading skills and prior experiences with target vocabulary (Jozwik et al., 2021; Tarar et al., 2015). Administrative procedures for these two instruments are discussed in the Procedures section below.

Test of Word Reading Efficiency (TOWRE-2)

Test of Word Reading Efficiency- Second Edition (TOWRE-2) measures students' ability to read real words and nonwords with accuracy and fluency (Tarar et al., 2015; Torgesen et al., 2012). During the first subtest (i.e., Sight Word Efficiency), a vertical list of real words was provided that gradually increase in difficulty (e.g., increased syllable length, less frequent, etc.) to individual students. The student was then asked to correctly read all words within a 45-second time limit. In the second subtest (i.e., Phonemic Decoding Efficiency), the student was asked to pronounce a list of nonwords that also increased in difficulty (i.e., increasingly complex phonemes) to assess their decoding capabilities. The participant's score for each subtest was the total number of words (or nonwords) correctly read out loud within 45 seconds. Items that were skipped, read incorrectly, or hesitations of over 3 seconds by the participant were marked as errors. Predetermined normative scores (e.g., percentile ranks, scaled scores) were used to interpret student performance. Findings from administration with norming samples suggest high reliability for the Sight Word Efficiency subtest (i.e., .91) and the Phonemic Decoding Efficiency subtest (i.e., .92) (Tarar et al., 2015). All students scored in the "poor" performance range (i.e., 70-79) on Sight Word Efficiency and Phonemic Decoding Efficiency subtests (Torgesen et al., 2012). Students' scaled scores across subtests are displayed in Table 4 below. Sample items from subtests of this instrument are illustrated in Appendix B and Appendix C, respectively.

Vocabulary Knowledge Scale (VKS)

In addition to the TOWRE-2, a pre-assessment was administered that helped ensure target words used in the study were unknown to all participants. Student prior word knowledge was assessed using an empirically validated instrument that allows students to self-report their varying degrees of existing vocabulary knowledge, titled *Vocabulary Knowledge Scale* (VKS; Paribakht & Wesche, 1997). Applied in prior intervention work (Jozwik et al., 2021), this assessment required students to individually rate their word knowledge on a scale of 1-5. Ratings included the following: (a) “1- I do not remember having seen this word before”; (b) “2- I have seen this word before, but I do not know what it means”; (c) “3- I have seen this word before, and I think it means”; (d) “4- I know this word”, and recall the definition; and (e) “5-I can use this word in a sentence” and demonstrate this skill. Any reported, correct uses of the word, in addition to or instead of its core meaning, was considered a correct response. A score of 3 or greater served as an indicator that a student had sufficient prior knowledge to confound results. In these cases, and consistent with routines from past vocabulary intervention research (Savaiano et al., 2016), the target word was replaced with another word randomly selected from the reserved set (see Materials section above). Students’ self-reported average scores from this pre-assessment are displayed in Table 4 below. A sample item from this instrument are illustrated in Appendix D.

Table 4

Participant History Table

	Jason	**Tommy**	**Kimberly**
Age (in years)	13	14	11
Grade	7	8	5
Special Education Identification	SLD	SLD, ADHD	SLD
Race/ethnicity	Black/African American	White/European American	Black/African American
Gender	Male	Male	Female
CORE Vocabulary* (raw score)	14 (intensive)	17 (strategic)	13 (intensive)
TOWRE-2*			
SWE Scaled Score	72 (poor)	78 (poor)	71 (poor)
PDE Scaled Score	73 (poor)	77 (poor)	72 (poor)
TWRE Index	71 (poor)	76 (poor)	70 (poor)
VKS* (average self-reported score per student)	1.58	2.31	1.27

Note. Outcomes from this table reflect demographic variables in the study that account for participant history entering into experimental procedures. SLD= IEP status of specific learning disability in reading and/or language development. ADHD = IEP status of attention-deficit/hyperactivity disorder. CORE= standardized vocabulary instrument used to screen for word-learning difficulty. TOWRE-2= Test of Word Reading Efficiency- standardized measure of student word-reading and decoding efficiency. VKS = Vocabulary Knowledge scale is a custom measure of students' self-reported, prior word knowledge. *= These scores should be interpreted with caution given that screener and pre-assessments were delivered in a remote-learning environment (i.e., on-screen, rather than in person).

Experimental Design

A single-case, adapted-alternating treatments design (AATD) was conducted to examine the comparative effects of two approaches for supporting students' GAV knowledge described below. In an AATD design, once stability has been established at baseline, the experimental phase is introduced. This phase comprises two or more treatments being rapidly alternated to support an individual's development of a target behavior (e.g., word-learning) with comparable levels of difficulty and controlling for contextual factors (e.g., session duration, settings) (Ledford & Gast, 2018). The AATD design allows researchers to examine the efficacy of instructional approaches on non-reversible student behaviors (e.g., academic skills), as well as the comparative superiority of interventions in a relatively short period of time (Shepley et al., 2020; Sindelar, 1985). In this study, the AATD design included three phases (i.e., baseline, intervention, and maintenance phases) with two intervention conditions: Content Acquisition Podcasts for Students (CAP-S) and MultiVision (MV).

Dependent Variables

The primary dependent variable in this pilot efficacy study was the general academic vocabulary knowledge gained and retained in each treatment condition, relative to baseline. This outcome variable was interpreted as an indicator of overall intervention efficacy and was operationalized using two researcher-developed assessments: intervention probes and maintenance probes. A second dependent variable of interest involved a custom, social validity measure of multiple dimensions of treatment by student participants.

Measures

Word-Learning Probes

This study comprised a total of 24 intervention probes with one corresponding to each lesson that featured one of 24 target words. Students' overall achievement on probes were measured by response accuracy on an assortment of six multiple-choice items for each probe (i.e., 144 items total across 24 words) that assessed student's receptive knowledge of target word meanings. (Kennedy et al., 2020; Lawrence et al., 2022; McKeown et al., 2018). Consequently, each intervention probe was worth six points in total. Mastery criterion for response accuracy is further discussed in the Procedures section below. The first item in this probe was used to assess students' basic understanding of the core meaning of target vocabulary. With other versions administered in prior intervention work (Kennedy et al., 2020), this task provided a student with a given target word as a stem. Then, students were asked to identify the best descriptor, among five choices (i.e., correct answer, three distractors, and "I don't know"). In past studies, the reliability coefficient for this measure was .83 (Kennedy et al., 2020).

The second and third tasks, respectively, of this intervention probe were used to assess student understanding of one specific sense of a given target word as a measure of knowledge depth (Crosson et al., 2019). With other versions administered in prior intervention work (Lawrence et al., 2022), this assessment provided a student with a target word used in a sentence that indicated a novel example of a specific use that was learned. Students were then asked to comprehend the sentence illustrating the target word meaning and choose between five choices (e.g., correct answer, two distractors, "none of these choices", and "I don't know"). One of these choices was an appropriate synonym for the target word's sense of meaning. Based on past studies, the internal consistency for this measure has ranged between .81 and .93 (Lawrence et al., 2022). The fourth and fifth tasks, featuring the second sense of a given target word, consisted of parallel procedures to the second and third items previously mentioned.

As another item representing depth of word-learning, the sixth item of the intervention probe was used to assess student recognition of both senses of a given target general academic vocabulary word simultaneously. With other versions administered in prior intervention work (McKeown et al., 2018), this assessment displayed four sentences with the target word embedded and asked students to identify which sentences use the target word appropriately. Two of the choices exemplified each of two uses of the target word, two other sentences were distractors, and one remaining option was “none of these choices”. To get the question correct, students had to correctly identify *both* uses. There were no opportunities for partial credit. This was an adaptation of a prior assessment, for which the reliability coefficient was reported as .91 (McKeown et al., 2018). Finally, two additional items randomly selected from a control set of eight untaught words were embedded in intervention probes (see Procedures section below for more details). A sample probe illustrating all six item types along with two embedded control items for a total of 8 items for this probe can be seen in Appendix E.

Further, baseline and maintenance probes were administered to students to measure initial knowledge and retention of word knowledge, respectively. These assessments were delivered in an similar manner as intervention probes previously described. However, baseline and maintenance probes carried nine items from intermixed word sets along with two embedded control items. Further details are discussed in the Procedures section below.

Social Validity

Social validity of both treatments were administered to examine intervention procedures and results (Leko, 2014; Snodgrass et al., 2018; Wolf, 1978) specifically from a student perspective (Lindo & Elleman, 2010). Adapted from prior intervention work (Jozwik et al., 2021), this assessment, in total, involved administering four Likert-style survey items, and three open-ended response prompts to student participants at the end of the investigation. Students indicated whether they “agree”, “sort of agree”, or “do not agree” to each of the Likert-style items. On select items, open-ended response prompts were embedded for students to verbally elaborate or explain their initial choices. Question topics included (a)the extent that students felt they learned from the lessons (i.e., if they were satisfied with results); (b) the extent that students perceived learning with words *and* pictures was more beneficial than learning without pictures and explaining why; (c) the extent that students felt it was beneficial to learn both uses of a word and explaining why; and (d) the extent that students perceived MV lessons to be more beneficial than CAP-S lessons and explaining why. An example of this measure is displayed in Appendix G.

Data Analysis Plan

Visual Analysis

To establish experimenter control with this single case design, visual analysis of data was implemented to assess patterns of responding within and across study phases (Kratochwill et al., 2013). Doing so allowed for an evaluation of “the presence of a functional relation” between independent variables (i.e., instructional approaches) and dependent variables (i.e., word knowledge acquired and maintained on baseline, intervention, and maintenance probes, respectively; Ledford & Gast, 2018). An analysis of a basic effect was conducted between baseline and intervention phases using visual inspection of level, trend, variability, overlap and immediacy. Raw scores from word knowledge probes conducted during baseline, intervention, and maintenance sessions were collected and graphed using GraphPad software.

Supplementing Visual Analysis

Though visual analysis is the most common approach for analyzing data in single case research, various forms of statistical analysis can be used to supplement visual inspection of data (Maggin et al., 2019; Manalov & Onghena, 2018; Pustejovsky et al., 2019). These statistics may assist in increased objectivity and clarity when interpreting effects of treatment (Maggin et al., 2019; Manalov et al., 2022). As a result, two effect-size metrics were employed with visual analyses to further evaluate: (a) the magnitude and consistency of separation; (b) overlap; and (c) the relative superiority between data series (Manalov & Onghena, 2018; Parker et al., 2011). These metrics are discussed below.

Tau-U. As a supplement to visual analyses, the Tau-U effect size metric was used to evaluate the degree of non-overlap of data between phases and conditions (Parker et al., 2011). The Tau-U involves pairwise comparisons of data between successive phases. It may be conceptualized as the proportion of data that show improvement when comparing each data point in one phase to all others ahead of it in time in a later phase after controlling for trend in the earlier phase (Brossart et al., 2014; Maggin et al., 2019; Parker et al., 2011). Distinct from traditional measures of overlap (e.g., PND), the Tau-U approach is less sensitive to outliers in data series and considers multiple points of overlap between phases (Maggin et et al., 2019; Pustejovsky et al., 2019). In this study, an online calculator (http://singlecaseresearch.org/calculators) was used to produce Tau-U estimates of overlap between baseline, intervention comparison, and maintenance phases, as well as alternating treatment conditions for each participant. Further, in line with scholarship (Maggin et al., 2019), Tau-U values exceeding 0.90 were considered large. Values in between 0.60 and 0.90 were considered moderate. Finally, values below 0.60 were considered small.

Average difference between successive observations (ADISO). Finally, ADISO procedures were used to obtain specific estimates of consistency of separation over time as well as to quantify the comparative superiority between alternating treatments (Manalov et al., 2022). ADISO may be conceptualized as the weighted average of mean differences calculated from adjacent segments of data that correspond to each of two conditions being compared (e.g., AA mean score relative to BB mean score in the next alternation). Beyond the magnitude of an effect, this metric allows one to quantify the consistency of separation between treatments in raw score units over time as well as the percentage of adjacent comparisons for which one condition is superior to another (i.e., overall ordinal quantification [ADISO-O]; Manalov & Onghena, 2018). For these reasons, both ADISO and ADISO-O procedures were employed to further examine data series from alternating treatment conditions across individual participants.

Analyzing Social Validity

To evaluate data from the social validity measure, two types of analyses were conducted. First, descriptive statistics (i.e., means and standard deviations) were used to summarize raw scores of ordinal data from student responses on Likert-style items in the assessment. These calculations were completed using Stata software. Responses were double-coded to ensure reliability. Second, qualitative coding procedures (e.g., value coding; Miles et al., 2014) were used to uncover themes from students' open-ended responses on the assessment.

Procedures

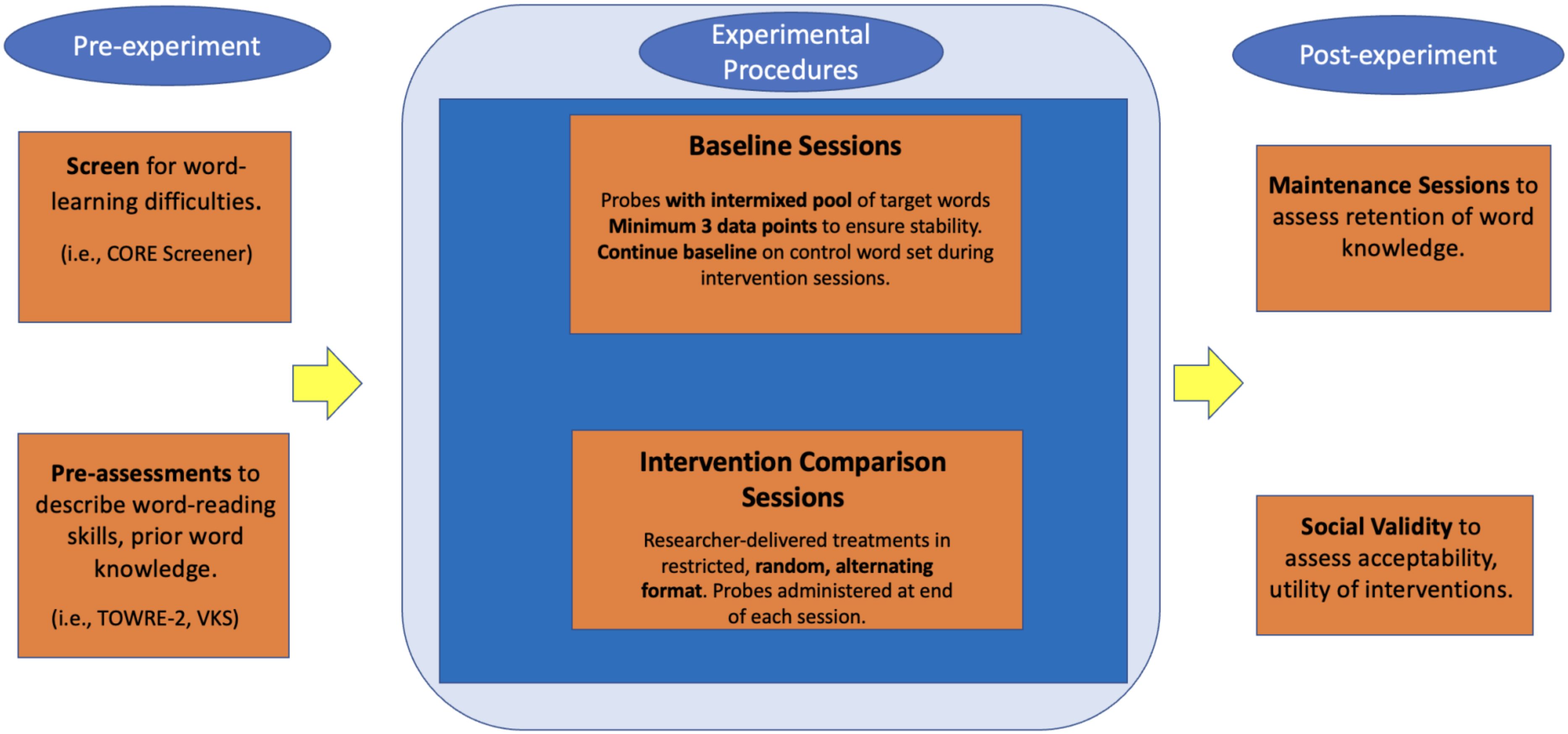
Although no explicit standards currently exist for conducting quality adapted alternating treatment designs, Shepley et al. (2020) conducted a systematic review to establish, "an initial indication of the quality of AATDs in the peer-reviewed literature" (p. 227). In service of their findings, authors used peer-reviewed articles and other scholarly sources to determine quality indicators for designing rigorous AATD studies. This includes: (a) ensuring target skills skill (e.g., word-learning) are of comparable levels of difficulty for the learner; (b) counterbalancing sets of the target skill across participants; (c) providing a comparison phase with sufficient visual evidence in data paths to determine relative superiority between two conditions (e.g., relative efficiency based on predetermined criterion); (d) using systematic routines for establishing procedural fidelity and interobserver agreement; (e) having a control set of the target skill applied throughout the experiment that does not receive treatment on target behaviors; (f) providing clear descriptions of participants' learning history; and (g) having appropriate inclusion criteria. Additionally, while not required for AATD research, authors noted that having a baseline phase could contribute to guards against history and maturation effects. Consequently, these quality indicators were applied in the present investigation.

Further, methodological considerations were enacted based on guidelines and recommendations for designing high-quality single case experiments (Kratochwill et al., 2013, 2023; Ledford & Gast, 2018). For example, in alignment with rigorous standards for conducting alternating treatment designs, each alternating treatment consisted of at least five data points and no more than two consecutive data points per alternating treatment during comparison sessions (Kratochwill et al., 2023; Manalov et al., 2022). There was also a minimum of three data points for baseline sessions, in alignment with scholarly recommendations specifically for AATD designs (Ledford & Gast, 2018).

This section comprises a detailed discussion of each of the following experimental procedures: (a) administering pre-assessments, (b) baseline sessions, (c) intervention comparison sessions, and (d) maintenance and social validity sessions. See Figure 2 below for an overview of these procedures. See Appendix J for a sample timeline of experimental procedures conducted for a student participant.

Figure 2

Single Case Research Design Model: Adapted Alternating Treatments



Note. CORE= Consortium on Reading Excellence Vocabulary screener. TOWRE-2= Test of Word Reading Efficiency, Second edition. VKS= Vocabulary Knowledge Scale.

Administering Pre-assessments

Pre-assessments were conducted after initial screening, but before baseline sessions. An electronic version of each assessment was delivered individually to each student participant, within two separate, 25-minute sessions over Zoom (i.e., one session allocated to each pre-assessment, respectively). The first five minutes of each pre-assessment session was used as a student check-in to build rapport between PI and student participant so that students were less likely to attrit from the experiment. After completing the two pre-assessments, the student began baseline sessions.

Baseline Sessions

After administration of pre-assessments, the baseline phase involved initial probes of target words to be taught during intervention comparison sessions. In particular, for each probe, 11 items in total (i.e., nine from intermixed target word sets and two from control set) were randomly selected from the pool of possible items corresponding to intervention probes during the intervention comparison phase (see Intervention Probes section above). Items were intermixed representing words from various word sets to increase validity of measurement (Wolery et al., 2018). These 11-item assessments were administered in a similar format to intervention probes (see Dependent Variables section). As subjects participated in a baseline probe, they were given positive feedback (e.g., well done) to help guard against artificial deflation of participant responses in this phase. Additionally, the first five minutes of each baseline session was used as a student check-in to build rapport between PI and student participant so that students were less likely to attrit from the experiment. At least three, 11-item baseline probes were administered to ensure stability (Ledford & Gast, 2018). If stability had not been attained by the third probe, random selection of items would continue for further assessment. Additionally, to guard against maturation and history effects for the AATD design, continuing baseline data were collected at various times throughout the intervention comparison sessions. Specifically, two randomly selected items from a control set of eight untaught words were embedded in intervention probes throughout the intervention comparison phase (Wolery et al., 2018). Once stability was established at baseline, participants entered into the intervention comparison phase.

Intervention Comparison Sessions

The intervention comparison phase comprised two alternating treatments: ***CAP-S*** (**C**ontent **A**cquisition **P**odcasts for **S**tudents) and ***Multi-Vision*** (**Multi**media-based **V**ocabulary **I**nstruction for Multiple **S**ense words with**i**n and acr**o**ss Co**n**texts) (MV). Both treatments integrate multimedia features with several instructional routines that have been established for fostering deep word-learning in line with previous literature (see Chapter 2). Instructional sessions for both treatments included four main stages of instruction: (a) introduction, (b) modeling, (c) practice, and (d) reflection.

MultiVision (MV) Instruction. In the introduction stage of the lesson, the instructor starts with a lesson overview of key lesson components for exploring a target word (e.g., introducing word meaning, practice, personal connections, etc.), as well as lesson goals to establish purpose and relevance (i.e., knowing these words can help students read and write better in middle school). An illustration of the lesson overview page for MV is illustrated in Figure 3 below. The instructor then introduces the word in isolation and guides the student with spelling and sounding out the word to support the learner in making explicit connections between these two representations.

During the modeling stage, the instructor provides the target word's student-friendly definition and models how to make meaning out of an initial image-based context that illustrates this definition (i.e., thinking aloud and making observations about essential details of a picture that convey contextual information surrounding word meaning). A sample screenshot from this segment of the lesson is displayed in Figure 4 below. After this routine, the instructor delivers background knowledge to support the learner in understanding the basics of how polysemy works and in making connections with prior knowledge. Specifically, this involves elaborating on multiple uses of everyday tools generally familiar to middle schoolers (e.g., cell phones can be used to text and call friends), which are similar to how words, as tools, have slightly different uses (i.e., senses of meaning) that vary depending on context. The instructor then transitions to the practice stage of the lesson by inviting the student to explore these features associated with the target word.

In the practice stage, the instructor delivers both open-ended and structured discussion prompts that engage students in multiple and varied practice opportunities to make meaning of image-based contexts depicting specific senses of the target word and integrate knowledge of the target word's meaning with this contextual information. This includes asking students about key details they notice in captioned pictures illustrating different senses of the target word's meaning. For instance, given the target word *distort,* which means *to make something different from the way it really is*, image-based contexts in this MV practice stage will depict varied senses of this core meaning (i.e., one sense is to make something look or sound different, while another sense is to change facts so they are no longer true).

The MV practice stage also consists of open-ended prompts that require students to justify how an image appropriately illustrates the target word's meaning. Students are provided immediate feedback on their responses and, if needed, open-ended prompts are followed up by direct questions that scaffold students' reasoning by guiding them to reflect on specific details or by providing choice responses. Sample screenshots from slides on open-ended prompts (i.e., asking students what they initially notice and asking why an image demonstrates a specific sense) for two distinct senses of meaning of *distort* are displayed in Figure 5 and Figure 6 below, respectively. The practice stage then concludes with an explicit review of how these recently explored, varied senses of meaning are linked to the core meaning of the target word previously discussed in the modeling stage. During this exercise, the instructor provides students with an open-ended question asking the learner to make connections between the two senses of meaning and the shared core meaning of the target word (i.e., asking the student what these two uses of the target word have in common). Additionally, if needed, this open-ended prompt is followed up by a direct question designed to scaffold students' thinking on these connections. After practicing each example with feedback, the instructor reviews the target word meaning and its connection with the specific sense being shown with the learner.

Finally, in the reflection stage, the instructor facilitates students' application of their target word knowledge to their personal experiences. Specifically, first the instructor asks the learner to reflect on a time in their life that illustrates the target word's meaning and to provide a brief oral narration of this experience. Then, the instructor asks direct, follow-up questions that specifically require the learner to reflect on key aspects of the target word's meaning and integrate its meaning in their life situation. An illustration of this task is displayed in Figure 7 below.

Figure 3

Sample from Introduction Stage: Lesson Overview

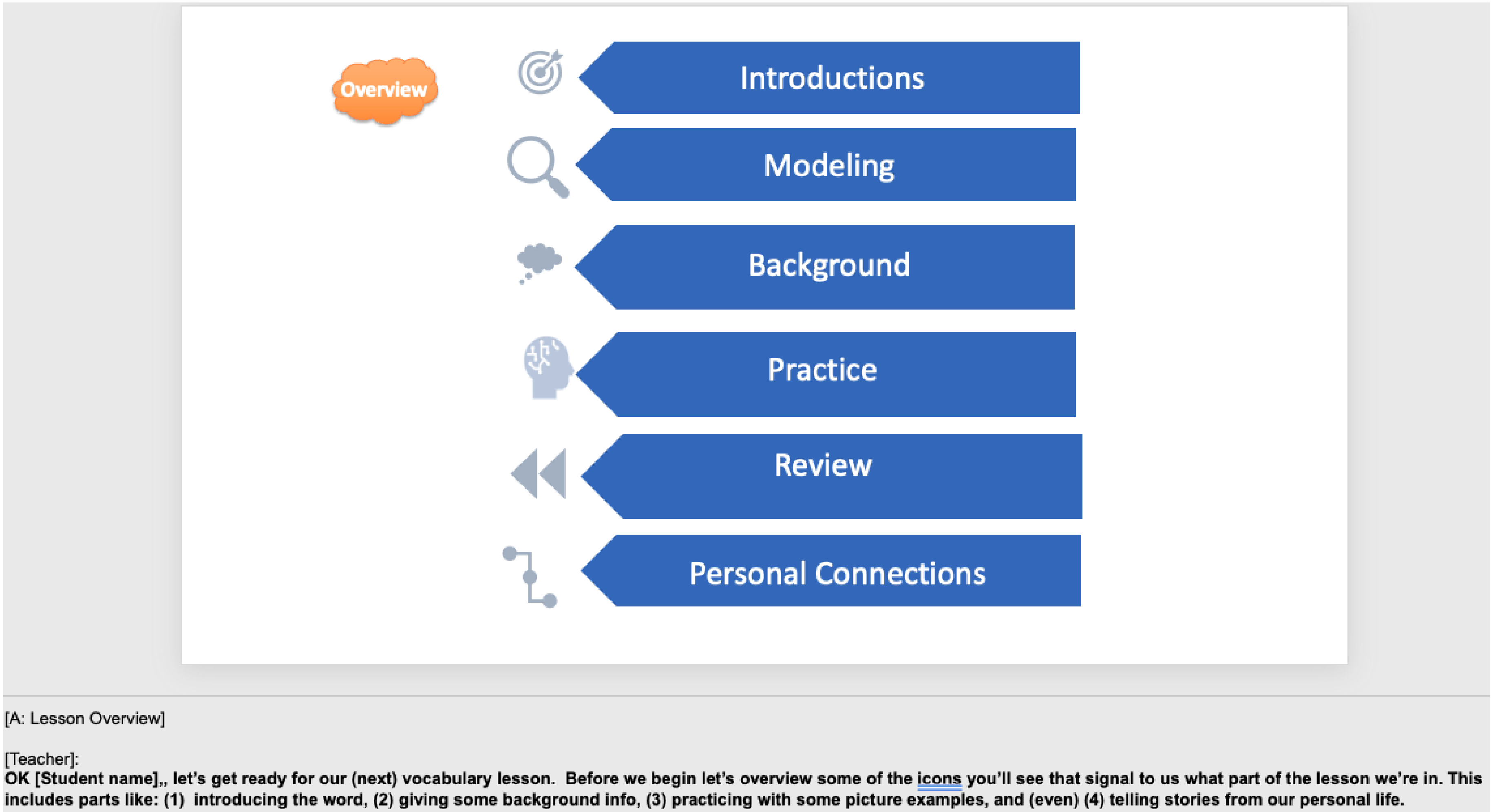


Figure 4

Sample from Modeling Stage: Progression of Slides to Explicitly Teach Meaning-Making from Image Context

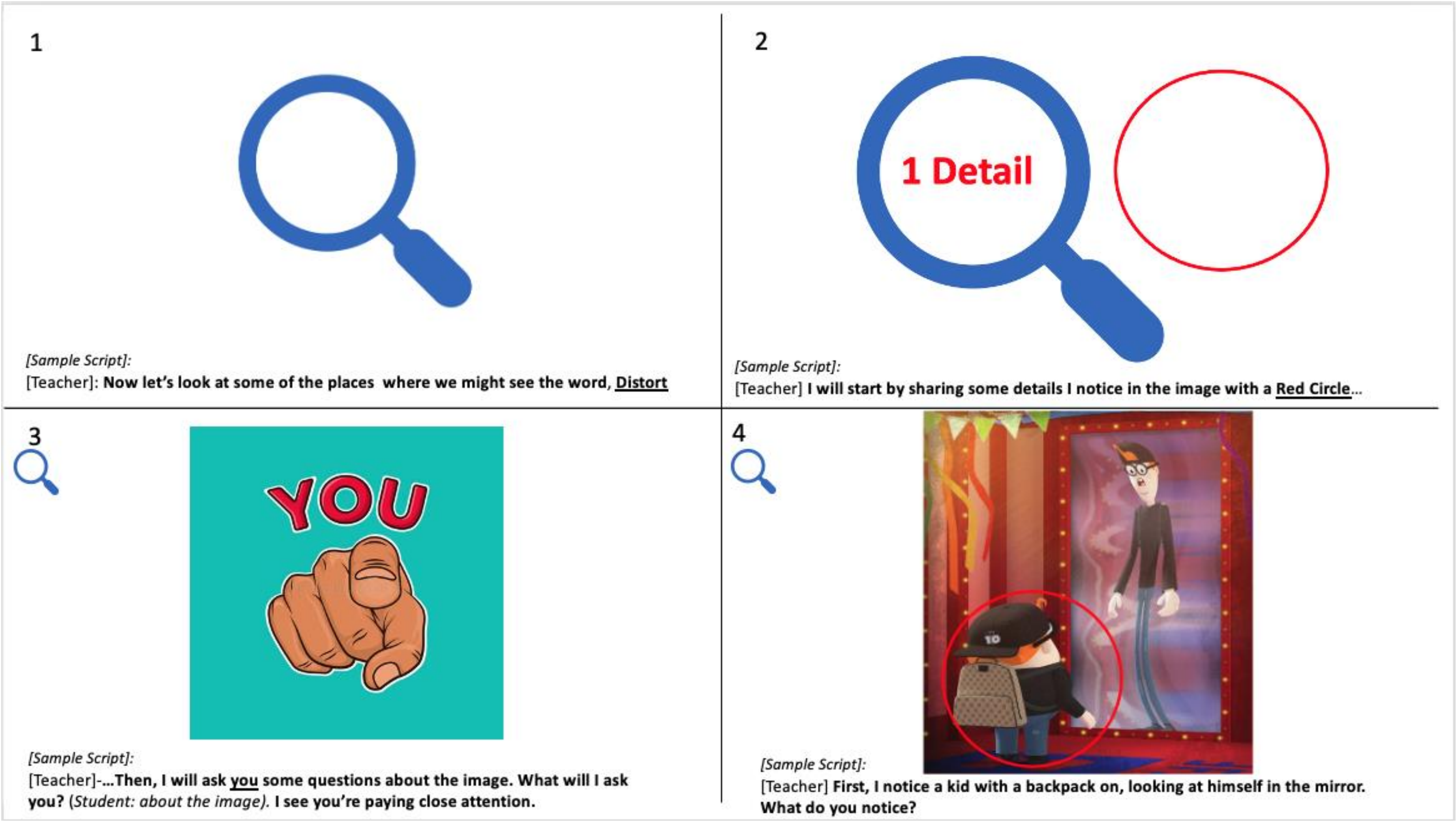


Figure 5

Sample from Practice Stage: Progression of Slides to Ask What Students Notice for Sense 2 of Distort

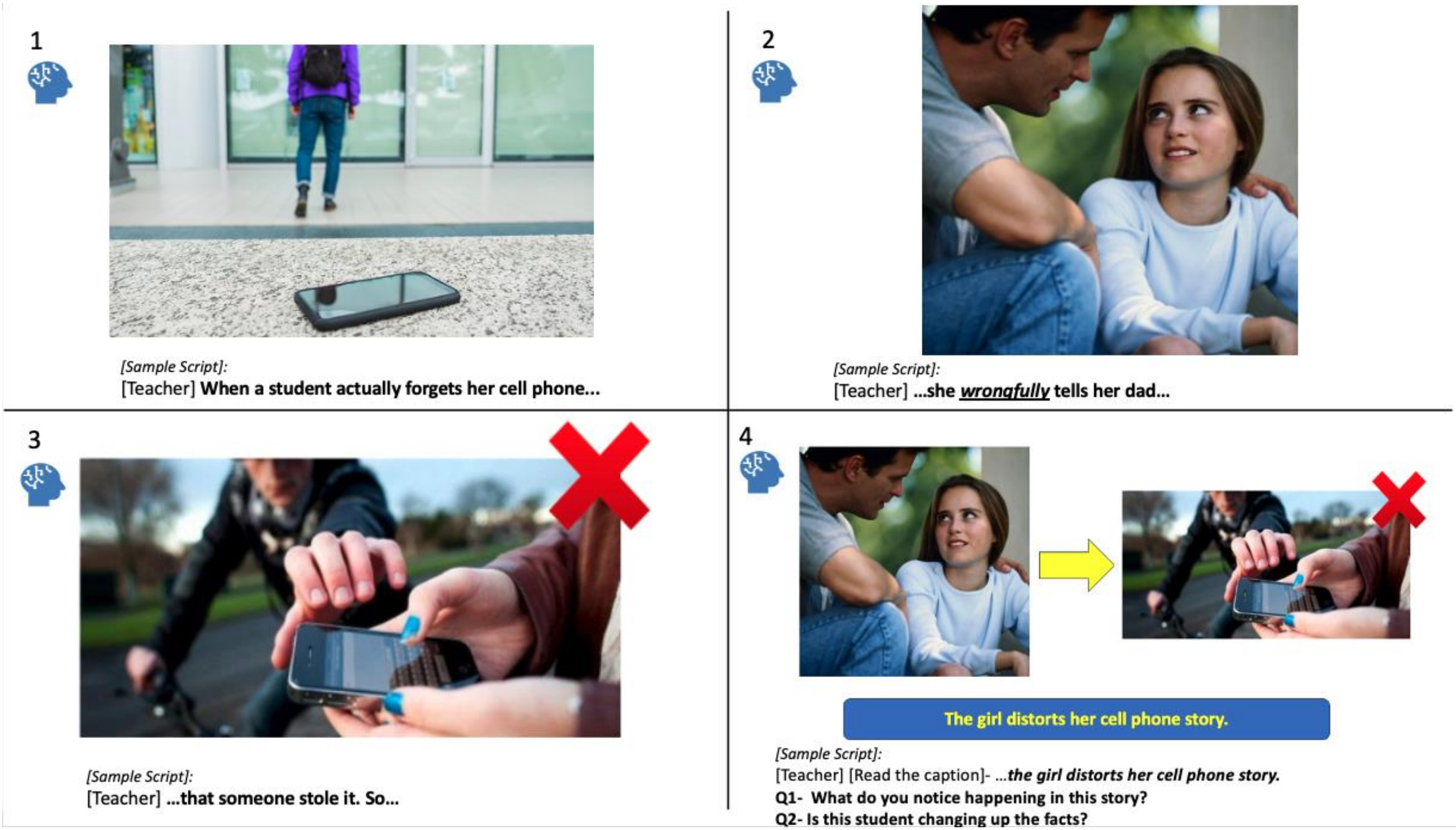
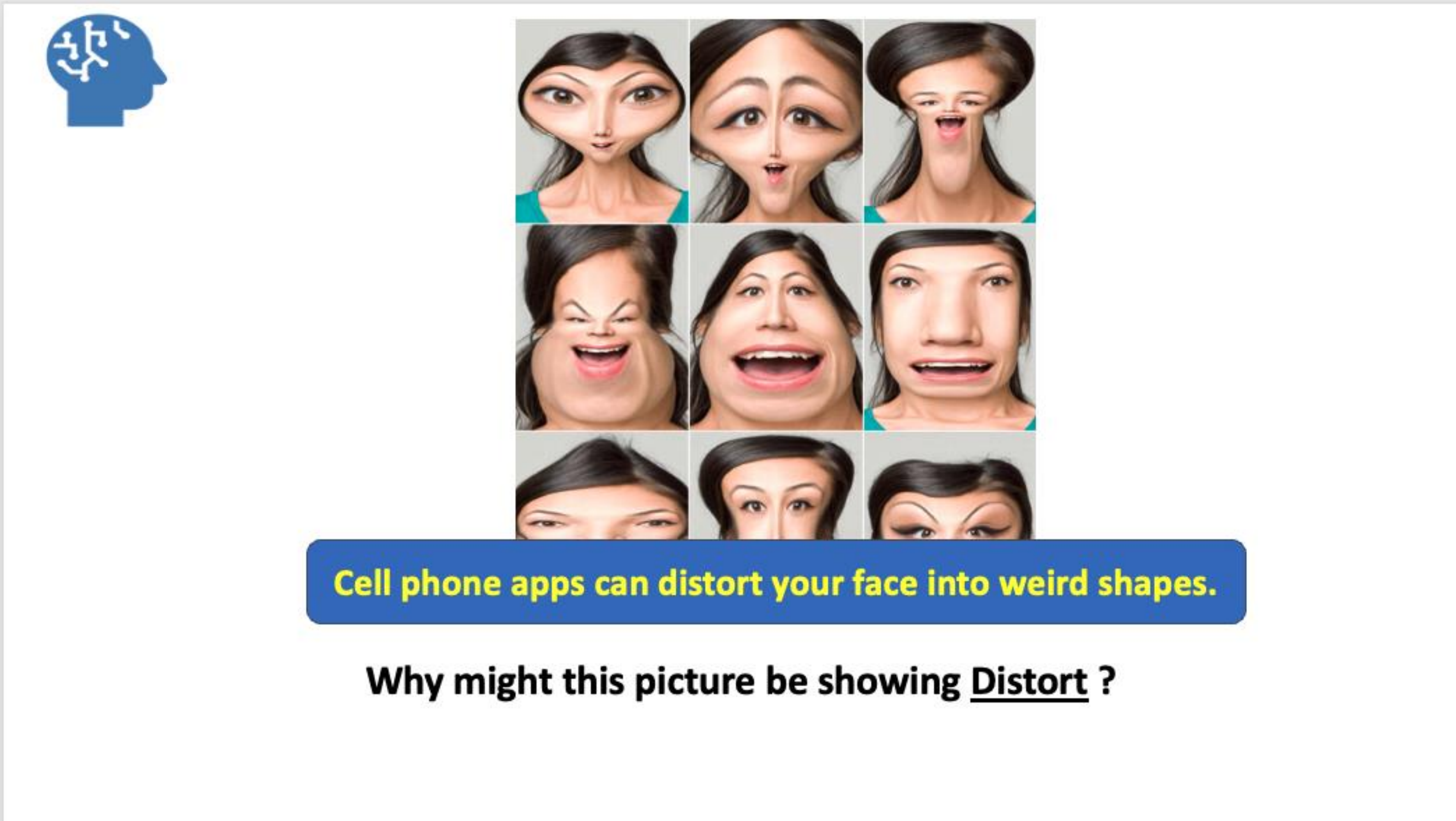


Figure 6

Sample from Practice Stage: Asking for Student Justifications with Sense 1 of Distort



[C: Open Justification]

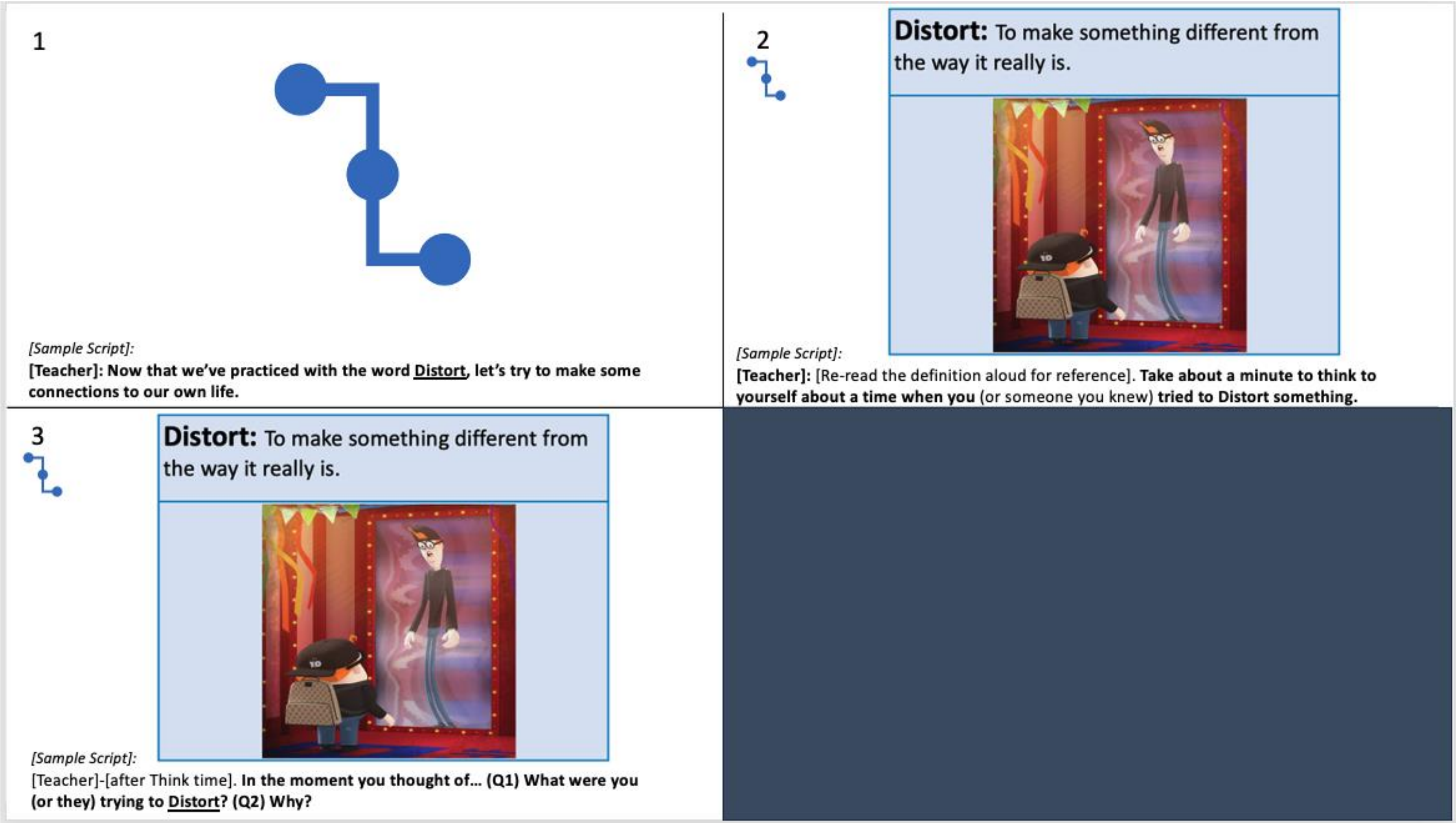
[Teacher]: [after caption has been read]: **Why might this picture be showing Distort?**

[IF KID IS **CORRECT** WITH OPEN-JUSTIFICATION (**correct** if reason is **relevant** to target sense of meaning)
- [Teacher]: **Excellent reasoning!** [CLICK THREE SLIDES for Recap slides]

[IF KID IS **INCORRECT** WITH OPEN-JUSTIFICATION (**incorrect** if reason is **irrelevant** to target sense of meaning)
- [Teacher]: **Not quite- let's think more carefully** [go to NEXT SLIDE- Direct Questioning to scaffold student reasoning]

Figure 7

Sample from Reflection Stage: Supporting Application of Word Knowledge to Personal Experiences



Content Acquisition Podcasts for Students (CAP-S) Instruction. The CAP-S approach represents the other main treatment in this AATD experiment. It contains introduction and reflection stages that are equivalent to routines discussed in MV. However, CAP-S modeling and practice stages deviate from MV in critical ways. In the modeling stage, the instructor delivers relevant content to support the learner in activating prior knowledge before being introduced to the target word meaning. However, there is no explicit mention of varied senses of meaning (i.e., polysemy) to consider. Other components of the modeling stage are equivalent to those present in MV (i.e., providing student-friendly definitions and modeling meaning-making with image-based contexts).

During the CAP-S practice stage, like in MV, the instructor uses both open-ended and structured discussion questions to facilitate student practice integrating word meanings with contextual information from images, and provides immediate feedback after student responses. However, unlike MV, the students are not exposed to contexts depicting varied senses of meaning. Rather, students are exposed to examples of only one sense of the target word's meaning and this sense is conveyed as the overall meaning of the target word. In other words, if *distort* means *to make something different from the way it really is*, the practice stage for CAP-S will only display images depicting one sense of the word, *distort* (i.e., to make something look or sound different [depicted in the image example of cell phone apps distorting one's face]; see Figure 6). During these practice opportunities, students are asked to determine whether an image is an appropriate example of the target word's meaning and, like MV, are asked to justify with direct, follow-up questions to help scaffold their response if necessary. The instructor reviews the target word meaning with the learner after practicing each example or non-example with feedback.

Each intervention was pre-assigned to one of three word sets. As target behaviors for this AATD experiment, word sets were: (a) non-reversible, (b) novel, (c) independent of one another, (d) functionally similar; and (e) of equal levels of difficulty (Ledford & Gast, 2018; Shepley et al., 2020). Word sets were counterbalanced across conditions among student participants to further assist in ensuring equivalence between target word sets (Shepley et al., 2020). Treatments were delivered to students in an alternating format within 20-30 minute sessions three sessions per week for approximately four to five weeks. The intervention phase duration for each student was artificially determined by an agreement between the PI and the parents to not exceed 20 intervention sessions for any individual student. Indeed, on multiple occasions, parents desired intervention sessions to be completed before the 20-session limit to be finished in time for upcoming extracurricular activities in students' schedules. Therefore, students' length of sessions in the intervention phase was relatively brief. For instance, Jason completed 10 intervention sessions and Tommy and Kimberly completed 12 intervention sessions before transitioning into the maintenance phase.

An intervention probe was delivered at the end of each instructional session assessing students' knowledge of the target word taught (see Measures section). In addition, on each probe, students were exposed to a control set of two items that assessed knowledge of untaught words. These embedded items represented data for a continuing baseline (see Baseline Sessions section above; Ledford & Gast, 2018).

Maintenance and Social Validity Sessions

Starting the week after their last instructional session, each participant was given a series of up to three maintenance probes, delivered once a week for three weeks after the last intervention session. These assessments were administered in a similar manner to the baseline probes (see Baseline Sessions section) and included the same number of items (i.e., 11 total). However, items from intermixed target word sets were continuously selected at random until there was a comparable number of items representing words taught from each treatment (see Appendix F for sample materials). This was done to disaggregate maintenance scores and examine retention outcomes tied to each treatment during analyses. Additionally, like intervention probe procedures, two randomly selected items from the control set of untaught words were embedded as a continuing baseline during the maintenance phase. Finally, between the last intervention session and the first maintenance session, the social validity measure was administered (see Measures section).

Interobserver Agreement and Procedural Fidelity

To establish interobserver agreement (IOA) around students' performance throughout the experiment (Ledford & Gast, 2018), the principal investigator (PI) and a second observer used custom forms (see Appendix E, F, and G for data collection sheets that were also used for IOA) to collect data on participant responses from video recordings of roughly 33% of sessions for each experimental phase and all social validity sessions. In order to train the second observer, the PI showed him baseline, intervention, maintenance probe, and social validity survey examples and modeled how to listen for and record student responses. For observations, The PI and second rater independently observed and collected data from video recordings of the same sessions. A given observation focused on (a) confirming whether a participant provided an oral response to each multiple-choice question ; (b) identifying the vocalized answer choice for each question, and (c) grading overall performance based on percentage of correct responses for experimental probes. After sessions were observed by both raters, interobserver agreement was calculated for each session by dividing the number of identified agreements by the total number of student response opportunities (i.e., including agreements and disagreements) and then multiplying by 100 (Ledford & Gast, 2018).

Raters met sufficient agreement in scoring student responses and surpassed the 80% threshold recommended in literature (Ledford & Gast, 2018). Specifically, scoring for Jason's performance on probes throughout the investigation yielded 100% IOA during baseline, 100% during intervention, 100% during maintenance probes, and 100% on items from the social validity sessions. Scoring for Tommy's performance has identical agreement across phases and sessions. Finally, scoring for Kimberly's performance yielded 100% agreement during baseline probes, 86% agreement during intervention probes, 100% agreement during maintenance probes, and 100% on items from social validity sessions.

To ensure both treatments were implemented with accuracy relative to baseline, procedural fidelity was collected (Ledford & Gast, 2018). Especially given the rapid alternation of treatments in AATD designs, careful monitoring and documentation of procedural fidelity across conditions is necessary to guard against internal validity threats and to help determine intervention effects (Ledford & Gast, 2018). Similar to IOA methods, two independent observers coded approximately 33% of video-recorded sessions in the baseline phase, intervention comparison phase (i.e., at least 33% of sessions from each treatment condition within the phase), and 33% of sessions in the maintenance phase throughout the experiment. Specifically, documenting procedural fidelity involved monitoring the PI's adherence to essential steps in a given session using a procedural checklist of key routines for a given session. Checklists consisted of a dichotomous response format (e.g., yes or no) to confirm whether routines were properly executed in each session. Similar to IOA methods, training for procedural fidelity coding involved a demonstration of one MV session, CAP-S session, baseline session, and maintenance session, as well as modeling and guided practice on how to use the procedural fidelity coding sheet during these demonstrations. A sample procedural fidelity coding sheet including a sample checklist for each session type is displayed in Appendix H. Also like IOA methods, procedural fidelity for each session was calculated by dividing the number of identified agreements (i.e., routines correctly implemented) by the total number of routines and multiplying by 100.

Observers' levels of agreement on procedural fidelity surpassed the 80% threshold recommended in literature (Ledford & Gast, 2018). Specifically, scoring implementation during Jason's sessions yielded 100% agreement for baseline, 92% agreement for the intervention comparison phase , and 100% agreement for maintenance. Likewise, scoring implementation during Tommy's sessions yielded 100% agreement for baseline, 96% agreement for the intervention comparison phase, and 100% agreement for maintenance. Implementation scores for Kimberly were identical to ones completed for Tommy across phases. In addition to monitoring adherence to routines, the PI reviewed all videorecorded MV and CAP-S lessons to confirm that alternating treatments were delivered with comparable durations (Wolery et al., 2018). The average lesson duration for MV instruction was 14.29 minutes across students, whereas the average lesson duration for CAP-S instruction was marginally smaller with an average lesson duration of 13.51 minutes across students.

Chapter 4: Results

For this study, the present author examined whether receiving MultiVision would yield gains in measures of word-learning depth (i.e., regarding polysemy), relative to CAP-S and a baseline condition for middle schoolers with specific learning disabilities (SLD). The extent that these gains in depth of academic word knowledge may have retained up to three weeks after receiving treatment was also investigated. Additionally, the social validity of interventions from an adolescent learner's perspective was assessed.

To answer the first and second research questions, students' individual performances on multiple-choice probes were collected and graphed to visually inspect data both formatively and summatively within and across baseline, intervention, and maintenance phases (Ledford et al., 2018). As a supplement to visual analysis, effect size metrics (i.e., Tau-U and ADISO) were also employed to further examine (a) magnitude and consistency of separation between phases and alternating treatment conditions; and (b) relative superiority between treatments. To answer the third research question, a social validity survey was administered to gain insights into students' perceptions pertaining to intervention procedures and effects. In the following sections of this chapter, results corresponding to research questions from this investigation are elaborated.

Question 1: Do MultiVision and CAP-S approaches yield greater gains and retention on assessments of GAV with multiple senses for middle schoolers with SLD, relative to a baseline condition?

For the first research question of this investigation, overall experimental findings were encouraging. Generally, there was immediate, large, and consistent separation in all students' word-learning performances when receiving either MultiVision or CAP-S treatment, relative to baseline, and effects maintained to a certain degree for most participants. In this section, the word-learning performances of Jason, Tommy, and Kimberly on baseline, intervention, and maintenance probes will be reported. Scores will be represented in units of percentage accuracy on word-learning probes. Figures 8, 9, and 10 below illustrate graphical depictions of each participants’ word-learning performance throughout all phases of the investigation. Table 5 below illustrates descriptive statistics of students’ word-learning performance from vocabulary probes across phases and conditions.

Jason

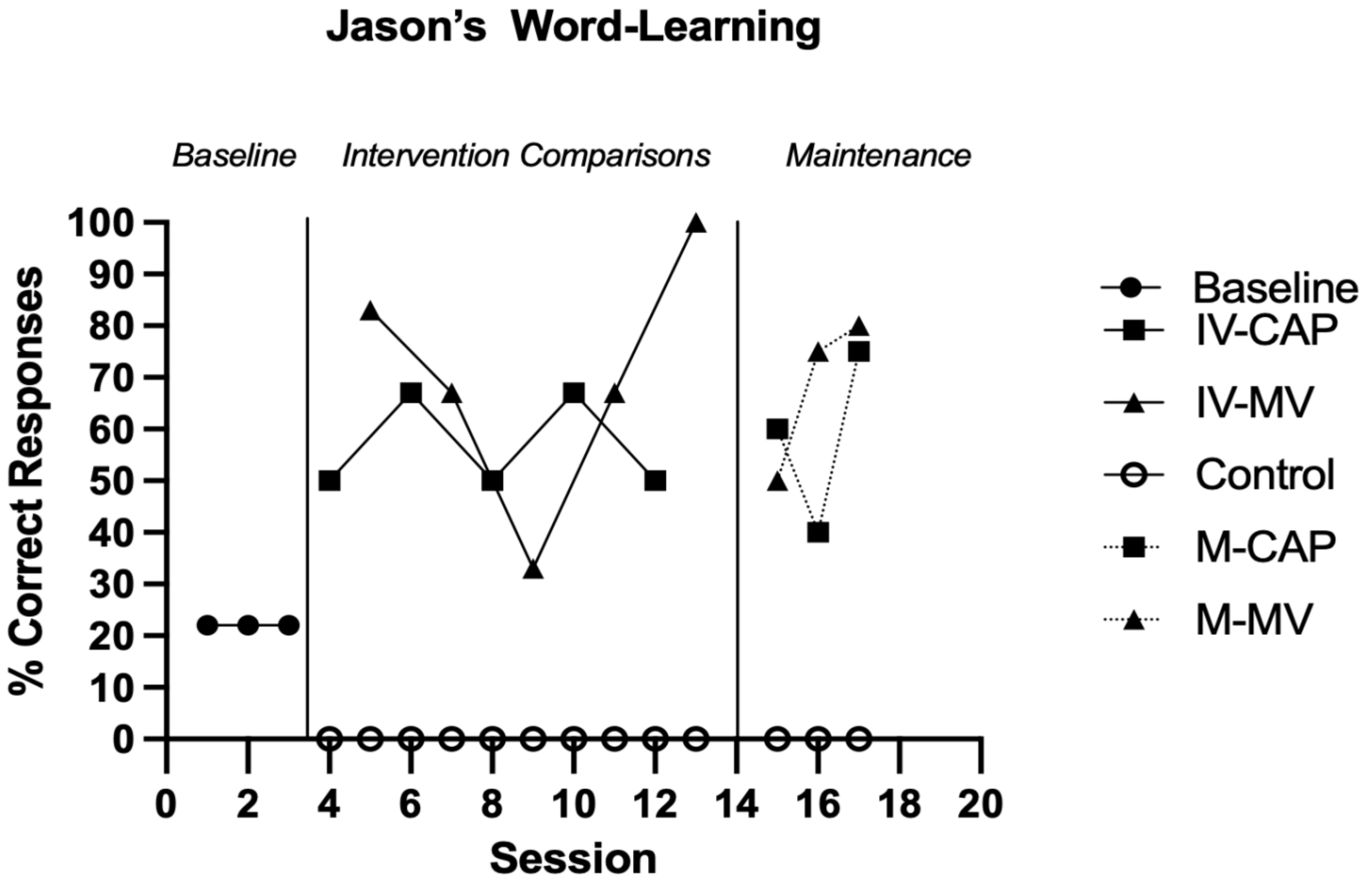
Baseline. Evaluation of Jason’s data within the baseline condition showed his performance was stable. Given three data points in the baseline phase for this AATD design (Ledford & Gast, 2018), Jason demonstrated consecutive scores of 22 percentage points (out of 100 percentage points total). There were also no level changes or trends present. As a result, there was sufficient stability to introduce alternating treatments for this participant.

Treatment. During the intervention comparison condition, employment of a stability envelope determined that data were variable for both treatments. Specifically, only 60 % of measurement occasions fell within the stability envelope for CAP-S and only 40% of measurement occasions fell within the stability envelope for MV. Nonetheless, multiple data characteristics demonstrate substantial differences between treatment and baseline performance. Specifically, estimates of median level change between conditions showed a positive improvement of 45 percentage points from baseline to MV sessions and 28 percentage points from baseline to CAP-S sessions on vocabulary probes assessing Jason’s word-learning accuracy. Additionally, immediacy of effects were shown with an absolute level change of 61 percentage points going from baseline to MV treatment and 28 percentage points going from baseline to CAP-S treatment. Further, Tau-U overlap estimates of Jason’s word-learning performance revealed a large increase in percentage accuracy on vocabulary probes of target words going from baseline to the MV condition (Tau-U= 1.00) and baseline to the CAP-S condition (Tau-U= 1.00). In total, although there is variability within the data series of the MV condition, immediate and notable differences in level and separation suggest a functional relationship exists between MV and word-learning, relative to the baseline condition. The same is also true for the CAP-S condition compared to baseline.

Maintenance. Though variability existed in Jason's performance on maintenance probes, results suggest Jason generally retained word-learning demonstrated in the intervention phase regardless of treatment. Estimates of median level change between intervention phase and maintenance phase data indicated a slight improvement of 8 percentage points on vocabulary probes within the MV condition. Likewise, estimates of median level change between intervention phase and maintenance phase data indicated a slight improvement of 10 percentage points within the CAP-S condition. It is worth noting that estimates of absolute level change between the final MV session score (i.e., 100) and the first MV maintenance session score (i.e., 50) revealed a large deterioration of 50 percentage points of accuracy on vocabulary probes. However, examining absolute level change within the MV maintenance condition revealed a large improvement of 30 percentage points between first and last performance scores, which minimizes the immediacy between phases that was initially shown. Further, Tau-U estimates showed large differences in magnitude going from baseline to either treatment (Tau-U= 1.00), which confirms Jason's high word-learning retention when receiving either MV or CAP-S.

Figure 8

Graph of Jason's Word-Learning Performance



Note. Student word-learning performance on baseline and maintenance probes was scored out of 9 (not including control items), whereas intervention probe performance was scored out of 6 (not including control items). As a result, the distribution of possible percentages of accuracy differs between the baseline phase or maintenance phase and the intervention phase.

Tommy

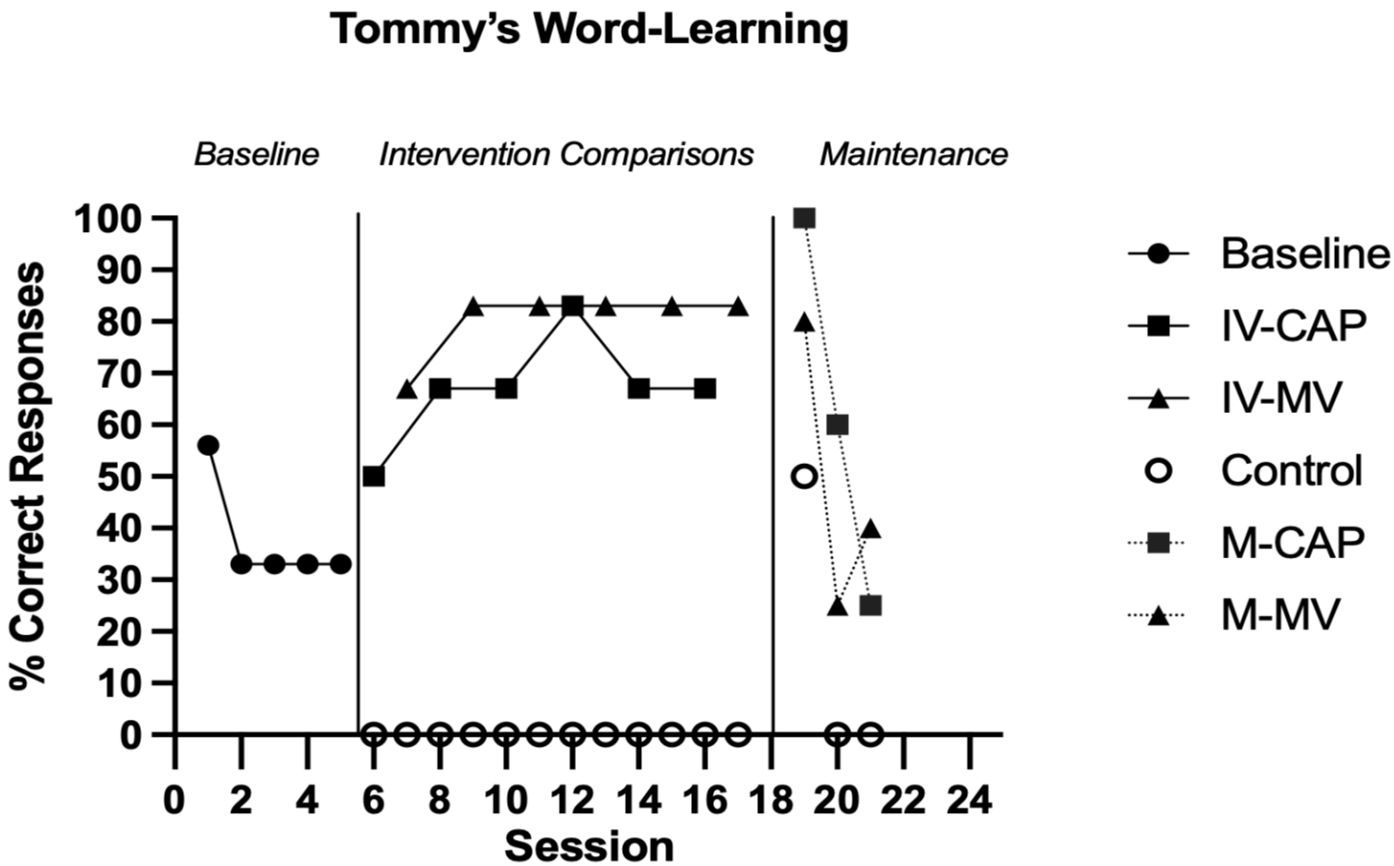
Baseline. Inspection of Tommy's data in the baseline condition showed his performance was generally stable. Given five data points of evidence (Ledford & Gast, 2018), Tommy demonstrated vocabulary scores of 56, 33, 33, 33, and 33 with an average score of 37.6 percentage points of accuracy. Additionally, 80% of measurement occasions in this condition fell within the stability envelope. Further, estimates of absolute level change between first and last values within the condition showed a deterioration of 23 percentage points. Consequently, introduction of alternating treatments was warranted.

Treatment. During the intervention comparison condition, data varied in stability by treatment. CAP-S data was somewhat variable as 67% of measurement occasions fell within the stability envelope. Meanwhile, for the MV condition, 83% of measurement occasions fell within the stability envelope. Given evaluations of word-learning across all conditions for Tommy, estimates of median level change between conditions showed a large, 50-point improvement in percentage accuracy from baseline to MV sessions and a 34-point improvement from baseline to CAP-S sessions. In addition, immediacy of effects were demonstrated with an absolute level change of 34 percentage points going from baseline to MV treatment and a small improvement of 17 percentage points going from baseline to CAP-S treatment. Further, Tau-U overlap estimates of Tommy's vocabulary performance revealed a large increase in percentage accuracy on vocabulary probes of target words going from baseline to the MV condition (Tau-U= 1.00) and baseline to the CAP-S condition (Tau-U= 0.93). Therefore, immediate, substantial differences in level, large separation between conditions, and stability across data paths suggest a functional relationship exists between MV and Tommy's word-learning, relative to baseline. Additionally, despite some variability within the CAP-S condition, immediate, notable differences in level and separation between CAP-S and baseline data paths overtime suggest a functional relationship also exists between CAP-S and Tommy's word-learning, relative to the baseline condition.

Maintenance. Results from maintenance probes suggest that Tommy's word-learning performance across treatments was highly variable. For instance, Tommy's CAP-S maintenance scores ranged from 25 to 100 percentage points. Likewise, his MV maintenance scores illustrated a large range from 25 to 80 percentage points. This instability could be a result of demographic characteristics that may have influenced Tommy's performance (see Chapter 5 for further details). Nonetheless, certain idiosyncrasies of data patterns across conditions warrant further discussion. For instance, despite high initial retention levels across treatments (i.e., 80 percentage points for MV and 100 percentage points for CAP-S), evaluations of absolute level change within the CAP-S maintenance condition revealed a 75-point deterioration between the first and last data values within this condition. Similarly, calculations of absolute level change within the MV maintenance condition showed a sharp decline of 40 percentage points between first and last data values. Additionally, Tau-U estimates of Tommy's vocabulary performance going from baseline to MV maintenance showed very small separation (Tau-U= 0.20). Similar results were present when examining differences between baseline and CAP-S maintenance (Tau-U= 0.33). In total, these patterns suggest that Tommy may have displayed minimal retention of target vocabulary regardless of treatment. However, substantial variability across conditions makes it difficult to make confident assertions about Tommy's performance in the maintenance phase.

Figure 9

Graph of Tommy's Word-Learning Performance



Note. Student word-learning performance on baseline and maintenance probes was scored out of 9 (not including control items), whereas intervention probe performance was scored out of 6 (not including control items). As a result, the distribution of possible percentages of accuracy differs between the baseline phase or maintenance phase and the intervention phase.

Kimberly

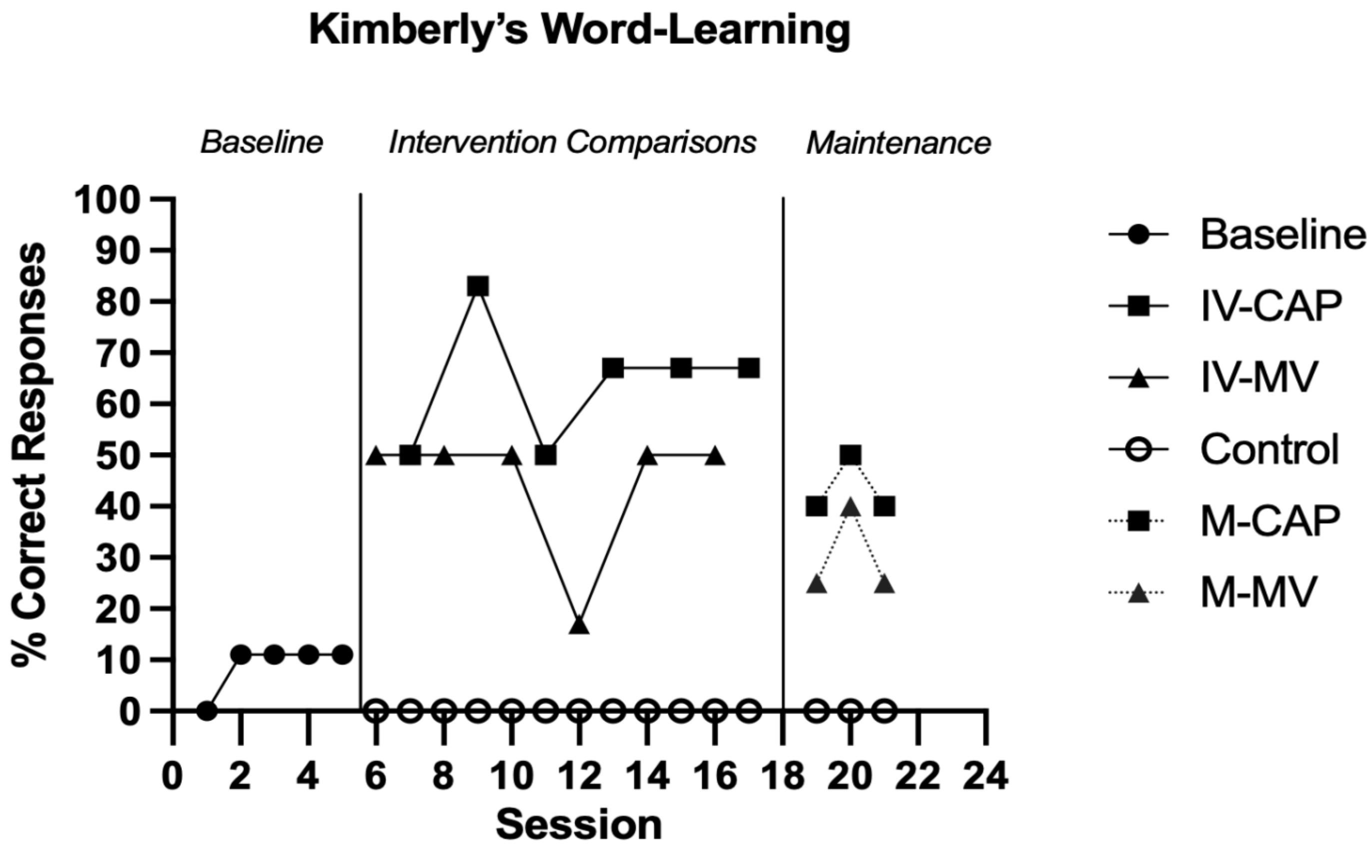
Baseline. Evaluation of Kimberly's performance showed data was generally stable in the baseline condition. Given five data points of evidence , Kimberly demonstrated scores of 0, 11, 11, 11, and 11 with an average score of 8.8 percentage points of accuracy. Further, 80% of measurement occasions in this condition fell within the stability envelope. As a result, introduction of alternating treatments was warranted.

Treatment. During the intervention comparison condition, data showed different degrees of stability between CAP-S and MV treatments. 83 % of measurement occasions fell within the stability envelope for MV, whereas only 50% of measurement occasions fell within the stability envelope for CAP-S. Despite this variability, several data characteristics showed notable differences in student performance when receiving either intervention compared to baseline. For instance, calculations of median level change between baseline and MV conditions indicated a positive improvement of 39 percentage points for Kimberly on vocabulary probes. Likewise, estimates of median level change between baseline and CAP-S indicated a large, 56-point improvement in percentage accuracy on vocabulary scores going from baseline to CAP-S. Additionally, calculations of absolute level change showed a 39-point improvement in vocabulary scores going from baseline to either treatment. Further, Tau-U estimates of Kimberly’s word-learning performance revealed large separation on vocabulary probes going from baseline to either intervention (Tau-U= 1.00). In total, although there is some variability within the CAP-S condition, immediate differences in level and large separation between treatments and baseline suggest a functional relationship exists between either treatment and Kimberly’s word-learning, relative to the baseline condition.

Maintenance. Though some variability existed in Kimberly’s performance on maintenance probes, evidence suggests she generally demonstrated low word-learning retention regardless of treatment. Specifically, estimates of both median level change and immediacy between phases revealed notable deteriorations of 25 percentage points from MV intervention phase to MV maintenance phase and 27 percentage points from CAP-S intervention sessions to CAP-S maintenance sessions on vocabulary probes assessing Kimberly’s word-learning accuracy. However, Tau-U overlap estimates revealed large separation between data series representing baseline and those representing either treatment condition (Tau-U= 1.00). Therefore, despite lower retention levels, Kimberly seemed to maintain some word-learning gains from both interventions.

Figure 10

Graph of Kimberly's Word-Learning Performance



Note. Student word-learning performance on baseline and maintenance probes was scored out of 9 (not including control items), whereas intervention probe performance was scored out of 6 (not including control items). As a result, the distribution of possible percentages of accuracy differs between the baseline phase or maintenance phase and the intervention phase.

Table 5

Descriptive Statistics of Students' Word-Learning Performance

		CAP-S		MV	
Participant	BL M (range)	INT M (range)	MAINT M (range)	INT M (range)	MAINT M (range)
Jason	22 (0)	56.8 (50-67)	58.3 (40-75)	70 (33-100)	68.3 (50-80)
Tommy	37.6 (33-56)	66.8 (50-83)	61.7 (25-100)	80.3 (67-83)	48.3 (25-80)
Kimberly	11 (0-11)	64 (50-83)	43.3 (40-50)	44.5 (17-50)	30 (25-40)

Note. Outcomes from this table reflect mean percentage scores depicting students' word-learning accuracy from vocabulary probes across baseline, intervention, and maintenance phases. BL= baseline mean. INT= intervention comparison phase mean for either the CAP-S or MV condition. MAINT= maintenance mean.

Question 2: Does MultiVision yield greater gains in depth of word-learning relative to CAP-S?

For the second research question of this investigation, experimental findings yielded mixed results. That is, MultiVision did not show consistent differences on word-learning over and above CAP-S for all participants. Rather, MV effects on word-learning varied across individuals. In this section, the magnitude and consistency of separation between alternating treatments for each student will be discussed.

For Jason, comparative differences between treatments in the intervention phase were minimal. Estimates of median level change between treatments indicated a slight positive improvement of 17 percentage points of accuracy on vocabulary probes going from CAP-S sessions to MV sessions. Additionally, Tau-U overlap estimates of Jason's performance only showed moderate improvement on vocabulary probes going from the CAP-S to the MV condition (Tau-U= 0.44). Further, ADISO estimates of separation across time (i.e., 33, 0, 17, 0,

50) showed inconsistent differences in Jason's word-learning performance between alternating treatment conditions and overall ordinal quantification estimates (ADISO-O) showed that neither treatment demonstrated superiority over the other on a majority of comparison opportunities. Therefore, although analyses between treatments indicate marginal differences in effects between CAP-S and MV, general variability and high instances of overlap between treatments prevent conclusions that MV is a relatively superior intervention for Jason's academic word-learning, relative to CAP-S.

For Tommy, treatment comparison results revealed small but distinct differences between interventions. Estimates of median level change between treatments indicated a slight improvement of 16 percentage points on vocabulary probes going from the CAP-S to the MV condition. However, Tau-U overlap estimates of Tommy's vocabulary performance showed a moderate degree of separation going from the CAP-S to the MV condition (Tau-U= 0.69). Also, ADISO estimates of separation across time (i.e., 17, 16, 16, 0, 16, 16) showed fairly consistent differences in Tommy's word-learning performance between alternating treatment conditions. Finally, ADISO-O estimates showed that MV demonstrated superiority on 83% of treatment comparisons, whereas CAP-S did not show superiority on any comparison opportunities. Therefore, moderate magnitude and consistency of separation as well as clear quantifications of superiority between treatment data paths suggest MV may indeed be a more beneficial treatment for Tommy's word-learning compared to CAP-S.

For Kimberly, direct comparisons between CAP-S and MV revealed a potential advantage in favor of CAP-S. Estimates of median level change between alternating treatments indicated a small deterioration of 17 percentage points of accuracy on vocabulary probes, going from CAP-S to MV treatment. Further, Tau-U estimates of Kimberly's vocabulary performance showed moderate differences going from the CAP-S to the MV condition (Tau-U= -0.72). ADISO estimates of separation across time (i.e., 0, 33, 0, 50, 17, 17) showed inconsistent differences in Kimberly's word-learning performance between alternating treatment conditions. However, ADISO-O estimates show that CAP-S demonstrated superiority on 67% of treatment comparisons, whereas MV did not show superiority on any comparison opportunities for Kimberly. In total, moderate separation between data paths, quantifications of CAP-S superiority, and small differences in level suggest CAP-S may be favorable for Kimberly's word-learning relative to MV. However, variability within the CAP-S condition makes it difficult to conclude that CAP-S is distinctly superior for Kimberly's word-learning relative to MV.

Question 3: To what extent do participating students perceive both treatments to be socially valid?

For the third research question of this investigation, overall findings showed high agreement among students regarding the social validity of treatment. In this section, student responses on Likert-style items and open-ended prompts pertaining to the social validity of treatment will be discussed. Results are displayed in Table 6 below.

According to results, all students agreed that they learned new words during vocabulary lessons (*M*= 3). Students also agreed that learning with words and pictures was better than with words alone (*M*= 3) because pictures seemed to help them think about target word meanings in context. Additionally, students agreed it was helpful to learn that words have different uses (*M*= 3) because it allowed them to feel more prepared to read, write, and join classroom discussions. Finally, after being prompted about the difference between the two treatments (i.e., MV taught that words had multiple senses whereas CAP-S taught the word meaning only), both Jason and Tommy stated "I don't know" to whether they felt MV or CAP-S was more beneficial.

Kimberly, however, disagreed that it was more helpful to learn with MV lessons than with CAP-S lessons because both approaches had pictures.

Table 6

Social Validity Results

Item	Jason	Tommy	Kimberly
I learned new words during these lessons.	3	3	3
I learned better with pictures than without pictures	3	3	3
(Why do you feel this way?):	"When I see the pictures, instead of thinking about what [the word meaning] will look like in my head, it's right there".	Pictures helped me make ideas in my mind- like what the word was used for.	The pictures made up what I was thinking [about the word] so I didn't have to.
It was helpful to learn that words have different uses.	3	3	3
(Why do you feel this way?):	"So, like, if I'm writing an essay or something, like if the word has two different meanings, I'm ready for it."	So I can, like, join different talks in class.	*"It was good to have the different uses, so I know which words I should use in a sentence".
It was ***more*** helpful to learn with MV lessons than with CAP-S lessons	N/A	N/A	1
(Why do you feel this way?):	"I don't know".	"I don't know. It didn't really matter to me."	"Both had pictures."

Note. 3 = Agree, 2 = Sort of, 1= Do Not Agree, N/A= interpreted as not applicable. *= in this case, Kimberly was speaking in the context of reading a book.

Chapter 5: Discussion

Vocabulary knowledge is an essential component of one's literacy development and is associated with improved school achievement and quality of life (Adlof et al., 2019; Townsend et al., 2012). However, acquiring sufficient depth of word knowledge for reading and other literacy-related activities is a difficult process that occurs over time (Elleman et al., 2019). To help navigate complex forms of written and oral discourse present within secondary classrooms (Jones et al., 2019; Nagy & Townsend, 2012; Truckenmiller et al., 2019), adolescent learners must be able to acquire deep, flexible, and precise understanding of high-utility academic vocabulary with multiple senses of meaning (McKeown et al., 2017). For many adolescents with disabilities, word-learning requires explicit support (Kuder, 2017; O'Connor et al., 2022). This may be especially true given the complexities associated with polysemic attributes of general academic vocabulary oftentimes present in middle-school text and academic discourse (McKeown et al., 2018). Fortunately, innovative approaches to word-learning that integrate evidence-based vocabulary instruction with multimedia features have emerged as promising options for mitigating word-learning issues for students with disabilities (Kuder, 2017; Mize et al., 2018). However, a lack of emphasis in both research and practice on polysemy surrounding academic vocabulary denies students' opportunities to acquire deep knowledge of these critical words (Lawrence et al., 2022).

In this investigation, a single-case, adapted alternating treatment design (AATD) was employed to assess the initial efficacy of MultiVision (MV) – an adapted multimedia approach for supporting deep knowledge acquisition of general academic vocabulary with polysemic features for middle schoolers with SLD. MV was compared to CAP-S, an established multimedia vocabulary instructional approach that did not incorporate instructional components accounting for polysemy. The effects and social validity of both treatments were assessed relative to a baseline condition featuring student exposure to untaught words. Systematic word selection procedures were conducted and sets were counterbalanced across participants to help ensure equivalence between target vocabulary. Data collections involved measures of students' word-learning accuracy and assessments of student perceptions around instructional approaches. Procedures generally consisted of (a) pre-assessments to screen for student word-learning difficulty, word-reading skills, and prior knowledge of target vocabulary; (b) administration of probes featuring words not yet taught in the baseline phase; (c) delivery of treatments with rapid alternation in the intervention comparison phase along with word-learning probes administered immediately after each session; (d) administration of follow-up probes up to three weeks after interventions were complete in the maintenance phase; and (e) administration of a social validity survey to gain insights on benefits of receiving interventions from students' perspectives. In the following section, findings corresponding to hypotheses from this investigation will be discussed and presented in relation to existing scholarship.

Interpreting Findings

Hypothesis 1: On treatment effects for acquisition of GAV with multiple senses for middle schoolers with SLD

First, it was hypothesized that both *MultiVision* and CAP-S would yield greater gains in acquisition of GAV with multiple senses than the baseline condition and that there would be a functional relationship between either treatment and student word-learning, relative to baseline. Though treatment data series varied in degrees of stability among participants, findings generally support this hypothesis. Results showed immediate, large changes in level and substantial separation on vocabulary probes for all students as they transitioned between baseline and either the MultiVision or CAP-S condition. As a result, data patterns suggest a functional relationship is present between receipt of either treatment and word-learning compared to the baseline condition.

Students' positive responses to MultiVision and CAP-S relative to baseline are expected as both treatments featured multiple evidence-based instructional routines designed to enhance academic word-learning experiences for middle schoolers with and without disabilities (O'Connor et al., 2022; Truckenmiller et al., 2019). Specifically, many of these studies examining general academic, word-learning outcomes for middle schoolers with LD involve (a) purposeful selection of a relatively small number of high-utility words; (b) explicit instruction (e.g., student-friendly definitions, modeling and practice opportunities across varied contexts with feedback*)*; and (c) knowledge-application activities to elaborate and extend word knowledge. Along with other literacy outcomes, these approaches have led to positive outcomes on various custom measures of vocabulary knowledge for middle schoolers with SLD (e.g., Lawrence et al., 2014; O'Connor et al., 2022).

Results also align with previous research on CAP-S and other innovative word-learning approaches that integrate multimedia features with evidence-based instructional routines (Kennedy et al., 2015; Silverman et al., 2019). For example, studies show that providing visual and/or auditory forms of content (e.g., visuals supporting word use in context, narration to support practice building lexical representations) can boost word-learning experiences for SWD's in part by providing access to multiple modes of sense-making around novel word meanings within and across contexts (Burt et al., 2020; Mize et al., 2018). Informed by research on academic vocabulary instructional routines as well as multimedia approaches (Mize et al., 2018; Truckenmiller et al., 2019), both MV and CAP-S consisted of several established vocabulary practices previously mentioned (e.g., selection of few high-utility words, explicit modeling, multiple practice opportunities to integrate meanings along with interactive discussion; Beck et al., 2013; Elleman et al., 2019) that were delivered with non-linguistic representations of words used in context to make abstract concepts (e.g., polysemic senses) more concrete. These multiple intervention components likely contributed to enhanced word-learning for all participants in the present investigation relative to baseline, regardless of treatment.

Hypothesis 2: On retention of word-learning gains for middle schoolers with SLD

For retention outcomes, it was hypothesized that both treatments would maintain respective word-learning gains across student participants. This hypothesis was partially confirmed. Overall, findings show that, regardless of treatment, intervention effects were maintained to some degree for two out of the three students. However, the degree of retention varied across participants. For example, in Jason's case, large differences in level with substantial separation from baseline to maintenance phase indicated clear retention regardless of word-learning approach. Meanwhile, Kimberly experienced similar differences in retention going from baseline to maintenance. However, her deteriorations in performance level going from intervention to maintenance suggests her retention from both treatment conditions was relatively small. Finally, Tommy's retention outcomes were highly variable. Substantial deteriorations of level within each condition and minimal separation from baseline indicates he ultimately may have experienced minimal retention. An in-depth discussion on these varied outcomes follows.

Results from Jason and Kimberly's maintenance data for both MV and CAP-S align with past vocabulary intervention research that shows word knowledge retention with similar student populations for a minimum of 3-4 weeks (Daniel et al., 2021). For instance, previous investigations of both multimedia and traditional approaches to academic vocabulary instruction revealed adolescents with SLD were able to retain word-learning gains ranging from one week to one year after receiving intervention (Kennedy et al., 2015; Lawrence et al., 2014; O'Connor et al., 2019). At the same time, compared with Jason, Kimberly's lower retention levels may be considered somewhat disappointing as reading comprehension is, in part, predicated on applying knowledge from prior word-learning experiences with depth, precision, and flexibility (Perfetti & Stafura, 2014). However, it is important to note that none of the vocabulary intervention studies examining maintenance involved measures assessing depth of word knowledge around polysemy. That both Jason and Kimberly, regardless of treatment, maintained a certain amount of vocabulary knowledge depth may ultimately be encouraging given the relatively short duration of treatment delivery of approximately four weeks for each student.

Whereas Jason and Kimberly showed some retention of word-learning, Tommy demonstrated inconsistent performance throughout the maintenance phase. Tommy's case of high variability in retention outcomes, may be partially explained by his co-occuring ADHD status. Research shows that students with inattention issues due to ADHD may have difficulty with sustained thinking on particular topics over time, which is necessary to integrate higher-order information for literacy-related tasks (Pullen et al., 2013; Stewart & Austin, 2020). As a result, individuals with ADHD often underperform on comprehension assessments relative to their typical peers (Stern & Shalev, 2013). In the present study, Tommy's inattention was evidenced by field notes describing him as seemingly "distracted" on more than one occasion during maintenance probes. This was not the case during intervention sessions. It is conceivable that the inattention Tommy seemed to exhibit as an individual with ADHD could have limited his ability to recall and integrate taught core meanings and specific senses of academic vocabulary during maintenance probes.

Despite Tommy's ADHD status being a potential explanation for his sporadic performance in maintenance, it is interesting to note that, at times, he seemed to display higher levels of retention for CAP-S than for MV. This is unexpected given MV demonstrated superiority on Tommy's word-learning over CAP-S during the intervention sessions. However, it has already been discussed that CAP-S instruction may have assisted students in building word knowledge depth despite a lack of explicit considerations for target word senses. Additionally, challenges surrounding the acquisition of two different senses within academic vocabulary have already been noted (Frisson, 2015;Logan & Kieffer, 2020). Consequently, Tommy's results may not be entirely surprising. Indeed, it may have been a relatively difficult endeavor for Tommy to recall multiple, polysemic dimensions of taught words (i.e., target word core meanings *and* their interrelated senses) on vocabulary probes multiple weeks after treatment compared to simply recalling core meanings alone and making reasonable inferences on items representing words that were taught using CAP-S. However, given Tommy's word-learning performance was highly variable across conditions during maintenance and that there were only three data points within the maintenance phase, this explanation is merely a conjecture and should be interpreted with extreme caution.

Hypothesis 3: On differential effects and relative superiority of treatments

A third hypothesis from this investigation was that *MultiVision* would yield greater gains in depth of word-learning for academic vocabulary with multiple senses relative to CAP-S and demonstrate superiority over the CAP-S treatment. This hypothesis was partially confirmed as results showed magnitude and consistency of separation between treatments as well as relative superiority among approaches that varied across students. For example, Tommy's word-learning performance showed consistent, moderate separation with high instances of superiority in favor of MV. This implies MV was a slightly more effective approach for his immediate gains in word-learning. Meanwhile, Jason's word-learning performance showed inconsistent, minimal separation with few instances of superiority, which demonstrates high comparability between MV and CAP-S. Further, Kimberly's performance showed moderate separation between treatments, but in favor of CAP-S. An in-depth discussion on these varied effects follows.

Tommy's positive response to the MV treatment relative CAP-S was expected. This is because, unlike CAP-S, MV incorporated systematic instruction for combatting semantic ambiguities (e.g., polysemy) inherent in academic vocabulary with multiple senses (Lawrence et al., 2022; Logan & Kieffer, 2021; McKeown et al., 2018). For instance, McKeown and colleagues (2018) demonstrated through their academic vocabulary program that providing direct instruction around polysemy and other language structures can support deeper word-learning in part by lessening the burden of inference-making and word-meaning integrations needed for text comprehension (McKeown et al., 2017). In the current study, MV provided explicit modeling, guided practice, and active discussions around polysemy within academic words with multiple senses. Exposure to these instructional components in particular may have freed up Tommy's capacities for word-meaning integrations during vocabulary probes, which yielded moderate separation in favor of MV.

On the other hand, for Jason and Kimberly, MV had, in some cases, comparable, and in other cases, smaller effects on word-learning than CAP-S. Though these varied effects may be contrary to the second hypothesis, they are understandable. Investigators of CTML-aligned approaches have demonstrated that systematically incorporating words and pictures into evidence-based vocabulary routines (e.g., aligning pictures with concise text while modeling and practicing with word meanings) can support acquisition of *deep* word knowledge for students with disabilities (Lowman & Dressler, 2016). When carefully arranged together, these instructional components may mitigate information-processing demands and free up cognitive resources for higher-level comprehension during word-learning experiences (Kennedy et al., 2015; Lowman & Dressler, 2016). In the current study, CAP-S instruction (along with MV instruction) carefully incorporated explicit vocabulary routines (e.g., modeling and practicing word-meaning integrations, interactive discussion) with multimedia presentation slides grounded in CTML instructional design principles (e.g., keeping images in close proximity to text in alignment with spatial contiguity principles; Mayer, 2020). Consequently, although specific target word senses were not taught in the CAP-S condition, it is possible that receiving CAP-S instruction allowed students to build depth with semantic networks of information (i.e., both visual and verbal) around the core meaning of target words. This enhanced word-learning experience may have enabled students to make inferences and word-meaning integrations on probe items that included untaught senses. However, it is important to note that performance with the CAP-S approach rarely exceeded 67 percentage points of accuracy for any student participant. This finding may indicate that, although comparable at times to MV, CAP-S alone may not have been sufficient for consistently supporting students' deep understandings of academic vocabulary with complex, multiple senses of meaning.

In Kimberly's individual case, MV also may not have been sufficient for building a deep understanding of academic words with multiple senses. Her inferior vocabulary performance when receiving MV relative to CAP-S can be explained in the context of literature on the complexities of learning academic, polysemous words (Cervetti et al., 2015; Frisson et al., 2015;

Logan & Kieffer, 2020). In particular, there can sometimes be a cognitive "cost" associated with transitioning between two concrete and abstract senses that represent the same word but are far across the semantic spectrum (Frisson et al., 2015, p. 22; Logan & Kieffer, 2021). This is perhaps illustrated in the McKeown et al. (2018) experiment previously described as authors' qualitative notes mentioned several occasions where accurate integration of abstract senses of target vocabulary was a prevailing source of difficulty for many of their middle school participants. Further, studies examining the influence of polysemic attributes of words on students' vocabulary acquisition indicate that younger students may be particularly vulnerable to challenges with learning academic words with abstract senses (Cervetti et al., 2015), and that one's ability to reflect on and integrate these types of language features may improve in later stages of adolescence (Logan & Kieffer, 2020). Given Kimberly's age as a younger middle schooler (i.e., 11; see Table 4), it is possible that negotiating between concrete and abstract senses of target words could have led to an overtaxed cognitive load during MV instruction (Sweller et al., 2020). These difficulties may have hindered her ability to integrate taught word meanings and senses with accuracy during intervention probes.

In general, the hypothesis that MV would lead to greater word-learning gains and show superiority over CAP-S was partially confirmed. However, it is important to note that MV instruction was only delivered over 4 weeks with these individuals with SLD. In contrast, McKeown et al., (2018) employed the RAVE intervention over roughly 22 weeks with typically-performing middle schoolers who continued to show difficulty navigating polysemic, academic words. Given complexities associated with learning academic vocabulary with varied senses for students without special needs (Cervetti et al., 2015; Lawrence et al., 2022), treatment comparison results from this current study remain somewhat encouraging. This is because MV showed immediate, distinct superiority on measures of word knowledge depth for at least one participant with SLD in this investigation. Although effects varied across students, these findings extend current scholarship by demonstrating the promise that innovative vocabulary instructional approaches (i.e., ones that intentionally incorporate CTML-grounded features with evidence-based practices centered on polysemy) can show in supporting depth of knowledge around general academic vocabulary with multiple senses for middle schoolers with SLD.

Hypotheses 4 and 5: On social validity of treatments

For social validity of treatments, it was hypothesized that students would perceive both MV and CAP-S procedures to be beneficial approaches for their word-learning. It was also hypothesized that students would perceive MV to be relatively more beneficial than CAP-S. Findings from the survey support the first hypothesis as mean score results show that (a) students agreed they learned new words; (b) students agreed they learned better with words and pictures than without pictures; and (c) students agreed it was helpful to learn that words have different uses. High ratings ($M=3$) with items assessing students' perceived benefits of treatment effectiveness aligns with research on academic vocabulary instructional approaches for improving word knowledge and school achievement (Adlof et al., 2019; Truckenmiller et al., 2019). Additionally, students demonstrated high average scores ($M=3$) on the perceived benefit of learning with words and pictures and shared multiple comments on their perceived ease of burden when learning with visuals across treatments. (see Table 6). These findings align with scholarship that demonstrates enhanced word-learning experiences for students with disabilities who receive CTML-grounded, multimedia approaches to vocabulary instruction (e.g., Lowman & Dressler, 2016; Kennedy et al., 2015). Further, high student scores ($M=3$) with items assessing the perceived benefits of learning vocabulary with different senses aligns with existing research that supports the use of systematic instruction on polysemy for building deep word knowledge of GAV with multiple senses (McKeown et al., 2018).

Although survey findings support the first hypothesis, findings do not confirm the second hypothesis as most students opted out of responding to whether they felt MV or CAP-S was more beneficial to them. Students' low participation on this item may be a product of procedural challenges. Specifically, asking this question required giving a relatively lengthy explanation around nuanced differences between both lesson types (see Appendix G for examiner directions). It is possible that both Jason and Tommy were either confused by the question or were too fatigued to answer it after listening to the explanation. On the other hand, Kimberly disagreed with the notion that MV was relatively more beneficial than CAP-S because both interventions incorporated pictures during instruction. This report suggests that Kimberly may have prioritized the visual component of instruction as a benefit over systematic instruction around polysemy. Though this finding was not expected, it is in line with research that demonstrates students' positive perceptions around learning novel vocabulary with visuals (Lowman, 2014).

Limitations

The present study involved key limitations. First, given that the study was conducted after school, there was an ongoing risk of instructional sessions conflicting with upcoming extracurricular activities later in the semester for all student participants. As a result, students' time for participating in the experiment was limited. These time constraints decreased the rigor of the experiment. For example, there were multiple data series that showed variability across participants. This includes Jason's performance during the MultiVision condition in the intervention phase, Kimberly's performance during the CAP-S condition in the intervention phase, and Tommy's performance in the maintenance phase. In accordance with research

(Ledford et al., 2018), it would have been highly recommended to continue collecting data to establish further stability in each of these instances. However, participant time constraints (e.g., students' parents pushing to finish sessions before certain dates) prevented ideal formative decisions to be made.

Additionally, with limited study duration, randomization schemes for order of intervention delivery were not able to be employed. This limitation eliminated the ability to control for possible cyclical variability or sequence effects as potential biases of treatment effects (Ledford & Gast, 2018). It also prevented opportunities for randomization tests of significance of effects during supplemental data analyses (Brossart et al., 2014; Manalov & Onghena, 2018).

Another main study limitation involved procedural issues at pre-assessment that led to internal validity threats in individual student data at specific time points. For instance, during Tommy's first baseline and his first maintenance session, he seemed to display unusually high levels of retention with control items corresponding to untaught words. In an attempt to provide a potential explanation for these idiosyncrasies in the data, probe materials were reviewed across all sessions of the experiment. Review of procedures during the first baseline and first maintenance probe sessions revealed that, by chance, Tommy was assigned a high proportion of control items corresponding to target words he may have partially known during the VKS pre-assessment. The VKS has been established in previous vocabulary intervention research (e.g., Jozwik et al., 2021). However, because this assessment is predicated on a student self-report, it is possible that Tommy underestimated his own prior knowledge with certain words on this measure. That is, he may have reported certain words as a "2" (e.g., "I've heard this word before but do not know what it means") when he should have graded them as a "3" (e.g., "I know the definition"). Therefore, procedural issues with the VKS pre-assessment may have led to an inflation of control item scores during first baseline and first maintenance sessions. This makes it difficult to accurately assess Tommy's word-learning retention during this experiment.

Implications

Acquiring sufficient depth of knowledge with academic vocabulary is associated with literacy success, school achievement, and other positive life outcomes for diverse, K-12 student populations (Adlof et al., 2019; Townsend et al., 2012, 2016). However, the knowledge base on effective approaches for building deep understandings of general academic vocabulary with multiple senses for middle schoolers is small (Lawrence et al., 2022). Recent investigations of approaches that integrate evidence-based practices with multimedia instructional frameworks have shown promise for supporting the vocabulary development of students with disabilities (Kuder, 2017; Mize et al., 2018). The present study contributes to this literature by assessing the initial efficacy of a theory-grounded multimedia vocabulary intervention that incorporates systematic instruction on polysemy as a critical feature of word knowledge depth for middle schoolers with SLD. Specifically, this was done by comparing the impacts of MV (i.e., an adapted multimedia instructional approach considering polysemy) with CAP-S (i.e., an established multimedia instructional approach with no specific attention to polysemy), relative to a baseline condition with no words taught. Findings from this investigation suggest that, regardless of treatment, integrating evidence-based word-learning practices with CTML-aligned multimedia features can support deep understanding and retention of academic words with multiple, abstract senses for middle schoolers with SLD. Further, in some cases and with some individuals, incorporating specific considerations around polysemy with the above, integrated approaches can be particularly advantageous for middle schoolers with SLD.

Although this experiment was not conducted in a typical school setting, preliminary findings from this study may provide implications for classroom teachers. For instance, deep word-learning gains were demonstrated when students received both MV and CAP-S lessons. In line with previous research (Elleman et al., 2019; Kuder, 2017; McKeown et al., 2018), this supports the notion that teaching a small number of high-utility words with evidence-based practices (i.e., explicitly introducing word meanings, providing multiple varied practice with word meanings across contexts, and providing interactive discussion and knowledge application tasks) in tandem with organized presentations of spoken/written words and pictures supports learning of academic vocabulary with multiple senses for middle schoolers with SLD over no instruction at all. Further, with both MV and CAP-S taking less than 20 minutes to deliver, either of these approaches could be feasibly incorporated as supplemental vocabulary lessons embedded within existing, content-learning activities in ELA and other academic subjects.

Additionally, varied results on the relative superiority of MV over CAP-S across students align with scholarship that adolescents with SLD indeed have diverse literacy-learning needs (Richmond et al., 2023). Therefore, the enhanced benefits of incorporating systematic polysemy instruction along with the above approaches for a middle schooler with SLD may depend on individual learner characteristics (e.g., age, intersections with other disability categories, student preference, etc.) When choosing to implement one multimedia-based vocabulary approach over the other, teachers should consider students' individual needs and preferences in their instructional decision-making.

Future Research

There is reason to be encouraged with the potential that *MultiVision* has for building depth of knowledge around academic words with multiple senses for middle schoolers with SLD. However, more research is needed to further prove intervention efficacy. First, the present study was conducted after school in a remote-learning environment. Technology-based vocabulary supports delivered as after-school supplements to in-class routines can be advantageous for striving readers (Fehr et al., 2012). However, since MV was delivered in this format, it is not certain whether this approach would be impactful in typical, content-area settings where adolescent students often encounter complex, academic vocabulary (Nagy & Townsend, 2012). Future investigations of MV should be conducted in authentic, content-area classrooms and delivered by classroom teachers with longer durations. Further, academic vocabulary instructional approaches are beneficial for a diverse range of student groups beyond those with disabilities in general education settings (Jones et al., 2019; Townsend et al., 2012; Truckenmiller et al., 2019). Consequently, later studies should involve group experimental trials examining the broad impact of MV for students with and without disabilities in inclusive settings. Doing so would improve both the population and ecological validity of this instructional approach (Reed et al., 2013).

A central goal of this pilot study was to establish initial efficacy for MV by comparing this adapted approach to an established multimedia tool (i.e., CAP-S), relative to a baseline condition. Although doing so yielded promising insights, there was no opportunity to evaluate the discrete contributions that the CTML-grounded element to multimedia instruction may have had on students’ deep learning of academic words with polysemic attributes. Future investigations should include multiple comparison conditions (e.g., evidence-based vocabulary approach with no CTML-aligned or polysemy instruction, CAP-S, and MV) to provide further insight into differential treatment effects between non-CTML and CTML-based instructional approaches for building deep word knowledge for GAV with multiple senses.

Another avenue for future research is to explore other methods for assessing depth of word learning. In the present study, a combination of empirically-validated approaches were embedded in vocabulary probes to tap students' depth of word-learning (see Chapter 3 for more details) However, assessing vocabulary knowledge depth is challenging for researchers because one's word knowledge involves multiple attributes within a word itself (e.g., form, meaning, use) as well as semantic information that the word is linked to (Crosson et al., 2019). As a result, there are multiple ways to operationalize and assess word knowledge depth beyond the methods used in this current investigation (McKeown et al., 2017). For instance, over and above measures of depth (e.g., polysemic senses) used in this current study, future investigations of MV might involve word association exercises that measure depth by assessing students' abilities to identify academic words that vary in degree of proximity to a target word's meaning (e.g., Carlo et al., 2004). Doing so could increase experimental validity and accuracy for examining the nature of students' depth of word-learning as a result of receiving treatment. Further, because word knowledge is linked to reading comprehension in numerous ways (Wright & Cervetti, 2017), future experiments may include instruments that assess students' comprehension of brief, expository text that incorporate taught academic word meanings (Lesaux et al., 2014). Given that knowledge of polysemy can influence text comprehension (Logan & Kieffer, 2020), employing these measures may also provide further insights into the relative superiority of multimedia vocabulary approaches that incorporate polysemy (e.g., MV) and those that do not (e.g., CAP-S).

Finally, although deep knowledge of academic vocabulary is important for adolescent learners' literacy development (Adlof et al., 2019; Townsend et al., 2016), facility with word-learning along with broader academic language structures may be a more optimal approach for supporting generalizable literacy outcomes (Uccelli et al., 2015). Further, recent research suggests technology (i.e., including multimodal technology) could be particularly helpful for building students' broader language and reading comprehension skills beyond word knowledge (Silverman et al., 2020). Therefore, in addition to considering polysemy, future studies on MV should consider systematic instruction around morphological features of academic vocabulary alongside syntactic features (e.g., nominalizations), discourse markers, and other elements of academic language in order to improve middle schoolers' global comprehension skills (Barr et al., 2019; Jones et al., 2019; Nagy & Townsend, 2012).

Conclusion

School achievement for K-12 adolescent student groups largely depends on the ability to understand and apply advanced language and literacy skills (Jones et al., 2019). Established as one of various components for supporting adolescents' reading comprehension (Ahmed et al., 2016; Cromeley & Azevedo, 2007), knowledge of academic vocabulary is critical for middle schoolers' literacy and achievement across content areas settings (Townsend et al., 2012, 2016; Truckenmiller et al., 2019). Although a variety of approaches exist for supporting students' word-learning (Wright & Cervetti, 2017), there is little empirical guidance for supporting deep, flexible, and precise understandings of general academic vocabulary (GAV) for middle schoolers with LD (O'Connor et al., 2022). Additionally, no studies have investigated systematic approaches for building knowledge of academic, polysemous vocabulary as a key area of word knowledge depth for middle schoolers with SLD. This pilot study examined the initial efficacy of an adapted, multimedia instructional approach that integrates evidence-based vocabulary routines and systematic instruction around polysemy to support deep knowledge of GAV with multiple senses for middle schoolers with SLD. In total, findings from this experiment illustrate that MultiVision (MV) shows potential advantages for fostering deep knowledge of academic words with multiple senses. However, results on MV's comparative superiority relative to CAP-S are inconclusive and vary across participants. Therefore, more research is needed with further adaptations to establish the efficacy and effectiveness of MV as an adapted, multimedia word-learning approach.

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.

Appendix A

Screenshot of CORE Vocabulary Screener Assessment Form for Grade 6

Name: ______________________________ **Date:**______________

CORE VOCABULARY SCREENING—FORM 6A

Sample

	Target			
	gesture	***entrance***	***towel***	***movement***
A 1	display	plot	show	bend
A 2	sentry	guard	blaze	habit
A 3	physician	blade	gallon	doctor
A 4	adore	cause	love	tap
A 5	summit	top	flight	lane
A 6	regulate	wrinkle	attend	control
A 7	error	knight	mistake	chain
A 8	conflict	battle	factory	marker
A 9	conceal	chew	hide	lead
A 10	applaud	stain	frown	clap
A 11	memorize	remember	flutter	obey
A 12	circular	least	steady	round
A 13	resign	absorb	quit	imagine
A 14	rapid	fast	inner	smoky
A 15	restricted	hired	whined	limited
A 16	core	alley	center	marsh
A 17	infant	baby	acorn	college
A 18	gracious	hairy	kind	unclear
A 19	absurd	fairly	glassy	silly
A 20	local	nearby	natural	responsible
A 21	odor	instant	smell	scenery
A 22	drench	lace	stoop	wet
A 23	decay	beg	rot	hug
A 24	request	type	cheat	ask
A 25	attire	clothing	drought	moth
A 26	moist	hopeful	damp	known
A 27	frequent	often	golden	halfway
A 28	peddle	grind	sell	wobble
A 29	terrifying	joyous	tilted	scary
A 30	typical	normal	playful	salty

correct: ______
incorrect: ______
no response: ______

Appendix B

Screenshot of TOWRE-2 Assessment Words: Sight Word Efficiency Online Form A

is	jump	inside	absentee
up	part	plane	advertise
cat	fast	pretty	pleasant
red	fine	famous	property
me	milk	children	distress
to	back	without	information
no	lost	finally	recession
we	find	strange	understand
he	paper	budget	emphasis
the	open	repress	confident
and	kind	contain	intuition
yes	able	justice	boisterous
of	shoes	morning	plausible
him	money	resolve	courageous
as	great	describe	alienate
book	father	garment	extinguish
was	river	business	prairie
help	space	qualify	limousine
then	short	potent	valentine
time	left	collapse	detective
wood	people	elements	recently
let	almost	pioneer	instruction
men	waves	remember	transient
baby	child	dangerous	phenomenon
new	strong	uniform	calculated
stop	crowd	necessary	alternative
work	better	problems	collective

Appendix C

Screenshot of TOWRE-2 Assessment Words: Phonemic Decoding Efficiency Online Form A

ip	stip	depate
ga	plin	glant
ko	frip	sploosh
ta	poth	dreker
om	vasp	ritlun
ig	meest	hedfert
ni	shlee	bremick
pim	guddy	nifpate
wum	skree	brinbert
lat	felly	clabom
baf	clirt	drepnort
din	sline	shrattec
nup	dreff	plofent
fet	prain	smucrit
bave	zint	pelnador
pate	bloot	fornalask
herm	trisk	fermabalt
dess	kelm	crenidmoke
chur	strone	emulbatate
knap	lunaf	strotalanted
tive	cratty	prilingdorfent
barp	trober	chunfendilt

Appendix D

Sample Vocabulary Knowledge Scale (VKS) for Distort

	Word: **Distort**
Rating	Self-report category
1	I do not remember having seen this word before.
2	I have seen this word before, but I do not know what it means.
3	I have seen this word before, and I think it means ___________
4	I know this word. It means ________________________
5	I can use this word in a sentence: ___________________________________

Appendix E

Intervention Probe Sample Materials

***Note-** Scoring directions, data collection/IOA sheet, and items from a sample intervention probe are below.

Intervention Probe- Directions

Scoring:

- **Record the total number of items** the examinee gets correct on this screener ***(see Data Collection Sheet below***)**.** Then **calculate percent accuracy.** Below, **mark all the items the examinee gets correct** with a **one (1)**, and mark all the items that are **incorrect** with a **zero (0)**.
- If the examinee **skips an item**, **mark the space with a slash (/) and count item as "no response"** (see data collection sheet below)
- **Mastery criterion** on a given probe is achieved when an examinee attains **100% accuracy**.

Intervention Probe- Examiner Data Collection Sheet

Student Fake Name:		Date: ___ Week:	Weekly[Overall)) Session Number:
Which Intervention?	MULTIVISION	**CAP-S**	[redacted]

Test Item	**Answer**
1.	**[B]**
2.	[**C**]
3.	**[A]**
4.	**[B[N]]**
5.	**[A, E]**
6.	**[D]**
Control Set	
7.	[**A,C**]
8.	**[A]**

 # correct (1): _____

 # incorrect (0): _____

 # no response (/): _____

% Accuracy: _____

***Control Item Score: _____**

Question 1:
What is the best description of "Refine" in this sentence?
"She refines her workout." (a) None of these choices. (b) Makes small changes to lose more weight. (c) I don't know. (d) She makes a workout plan. (e) She looks back at parts of her workout.
Question 2:
What is the best description of "Refine" in this sentence?
"He refines diamonds." (a) Searches for diamonds. (b) Digs up diamonds. (c) Cleans diamonds. (d) I don't know. (e) None of these choices.

Question 3:
What is the best description of "Refine" in this sentence?
"She refines her voice." (a) Works to be a stronger singer. (b) Makes sure to take care of their voice. (c) Loses their voice over time. (d) None of these choices (e) I don't know.
Question 4:
What is the best description of "Refine" in this sentence?
"The fire refines the gold." (a) Break the gold up into pieces. (b) None of these choices. (c) I don't know (d) Melt the gold. (e) Heat up the gold.

Question 5:
*Tell me the letter for all sentences below that correctly use the term **[Refine]**. There might be more than one right answer. Choices that you think are wrong should be left alone.*
(a) The chef **refines** their cooking after some practice. (b) It's good to **refine** your stomach after dinner. (c) He **refines** his aunt after not seeing her for a year. (d) None of these choices (e) Rather than **refine** the water, they keep it dirty.
Question 6:
Refine: *Tell me the best choice* (a) Look back on something (b) I don't know. (c) Change pieces of something. (d) Make something better. (e) Find something that was lost.

Question 7:
Tell me the letter for all sentences below that correctly use the term ***[Integrate].*** *There might be more than one right answer. Choices that you think are wrong should be left alone.*
(a) The teacher integrates new desks with old ones in her classroom. (b) It is important to integrate your mind before taking a test. (c) To tie your shoe, you must integrate both of your shoelaces. (d) None of these choices. (e) They integrate through the store looking for a new door knob.
Question 8:
What is the best description of "Orient" in this sentence?
"The soldiers orient to their army captain." (a) Get used to their army captain. (b) Follow their army captain's orders. (c) None of these choices. (d) Report news to their captain. (e) I don't know.

Appendix F

Baseline/Maintenance Probe Sample Materials

***Note-** Scoring directions, data collection/IOA sheet, and items from a sample maintenance probe are below. Baseline probes consisted of the same features. However, the Baseline probe did not label control items separately, and did not include a comparable number of items representing each treatment as the data collection sheet below indicates. The Baseline probe scoring also did not involve disaggregated scores by treatment (see Chapter 3 Maintenance and Social Validity section for explanation of balanced number of items and disaggregated scores).

Baseline/Maintenance Probe- Directions

Scoring:

- **Record the total number of items** the examinee gets correct on this screener (***see Data Collection Sheet below***)**.** Then **calculate percent accuracy.** Below, **mark all the items the examinee gets correct** with a **one (1)**, and mark all the items that are **incorrect** with a **zero (0)**.
- If the examinee **skips an item**, **mark the space with a slash (/) and count item as "no response"** (see data collection sheet below)

Baseline/Maintenance Probe- Data Collection Sheet

Student Fake Name:	Date: Week:	(Weekly[Overall]) Session Number:

Test Item	**Answer**
1.	**[E[N]], MV**
2.	**[D], CAPS**
3.	**[B, CAPS**
4.	**[A], MV**
5.	**[D], MV**
6.	**[C[N]], CAPS**
7.	**[E], MV**
8.	**[C], CAPS**
9.	**[A, D], MV**
Control Items	
10.	**[A[N]]**
11.	**[A]**

 # correct (1): _______

 # incorrect (0): _______

 # no response (/): _______

% Accuracy: _______

***Control Item Score:** _____

MV Maint. Accuracy: ___/5 = __%

CAP-S Maint. accuracy: ___/4= __%

Question 1:

What is the best description of "Invoke" in this sentence?

"The park police invoke the hunting laws."

(a) Change the hunting laws

(b) Reviews the hunting laws.

(c) I don't know.

(d) Gets rid of hunting laws.

(e) None of these choices.

Question 2:

Distort: *Tell me the best choice*

(a) Move something from place to place.

(b) Keep something the same as it really is.

(c) I don't know.

(d) Change something from the way it really is.

(e) Give up on something you are trying to do.

Question 3:

What is the best description of "Induce" in this sentence?

"Walking can induce pain."

(a) Causes your body to hurt worse.

(b) Make your body start hurting.

(c) Stops your body from hurting more.

(d) None of these choices

(e) I don't know

Question 4:

What is the best description of "Coherent" in this sentence?

"The student's question was coherent."

(a) She spoke it loud and clear.

(b) None of these choices.

(c) I don't know.

(d) She spoke softly to the teacher.

(e) She asked a smart question.

Question 5:

What is the best description of "Erode" in this sentence?

"His coolness at school erodes."

(a) I don't know.

(b) He loses his cool.

(c) None of these choices

(d) Becomes less cool after a while.

(e) Keeps being cool over the years.

<u>Question 6:</u>

What is the best description of "Presume" in this sentence?

"They presume the neighborhood is dangerous."

(a) They see and believe it is.

(b) I don't know.

(c) None of these choices.

(d) Someone tells them it is.

(e) They tell someone that it is.

<u>Question 7:</u>

What is the best description of "Confine" in this sentence?

"Cousins confine their talk to the past."

(a) Are happy talking about the past.

(b) I don't know.

(c) Begin to talk about the past.

(d) None of these choices.

(e) Just talk about the past.

<u>Question 8:</u>

What is the best description of "Refine" in this sentence?

"He refines diamonds."

(a) Searches for diamonds.

(b) Digs up diamonds.

(c) Cleans diamonds.

(d) I don't know.

(e) None of these choices.

<u>Question 9:</u>

Tell me the <u>letter</u> for <u>all</u> sentences below that <u>correctly</u> use the term ***[Intervene].*** *There might be more than one right answer. Choices that you think are wrong should be left alone.*

(a) The baby **<u>intervenes</u>** when mommy's talking.

(b) Many fans **<u>intervene</u>** around the big basketball game.

(c) After working for many years, she finally **<u>intervenes</u>**.

(d) When you have a bad day, a good friend will **<u>intervene</u>**.

(e) They **<u>intervene</u>** from school for the summer.

Question 10:
Tell me the letter for all sentences below that correctly use the term ***[Diminish].*** *There might be more than one right answer. Choices that you think are wrong should be left alone.*
(a) None of these choices. (b) After a long nap, her brother diminishes from his sleep. (c) The lifeguard diminishes as she steps into the pool. (d) The school fight diminishes the kids from having lunch. (e) People diminish trash into the waste backet when they are done.
Question 11:
What is the best description of "Exploit" in this sentence?
"Kings exploit their people." (a) Make them serve his kingdom unfairly. (b) Make them enjoy doing work for him. (c) Make them tired when doing the work. (d) I don't know (e) None of the above.

Appendix G

Sample Social Validity Measure

***Note-** Examiner directions, data collection/IOA sheet, and items from a sample social validity survey are below.

Social Validity Survey- Examiner's Directions

Scoring:

- **Record student responses as you go (*see Data Collection Sheet/Survey Form below*).**

Survey:

- **Say the following script directing student to complete survey items, starting with a blank computer screen:** *"Follow along as I read each item out loud. Then, think about whether you "agree", "sort of agree", or "do not agree" and share with me out loud. I may ask you to explain your answers on some items. Do you have any questions?"* (Answer any questions students have).

- **Present on screen the survey items** (***see Data Collection Sheet/Survey Form below***): *"Let's begin with the first item…"*

- **When you get to the final item, explain to the student the basic difference between MV lessons and CAP-S lessons by stating the following**: *"During our time together, you were taught vocabulary in two different ways. In the first way (titled MV), we said that words have different uses depending on the context they are in (show them example lesson slide as a reminder). In the second way (titled CAP-S), we didn't talk about all of that- instead, we just focused on learning the word meanings (show them example lesson slide as a reminder)"*. **Then, read the final item outloud.**
-

<u>Social Validity Survey- Form Example/Data Collection Sheet</u>

Student Fake Name:	Date Week:	Session Number:
[redacted]		

Items	"Agree"	"Sort of"	"Do Not Agree"
(1) I learned new words during these lessons.	3	2	1
[redacted]			
(2) I learned better with pictures than without pictures.	3	2	1
[Why do you feel this way?]:			
[redacted]			
(3) It was helpful to learn about how words have different uses.	3	2	1
[Why do you feel this way?]:			
[redacted]			
(4) It was more helpful to learn with MV lessons than with CAP-S lessons.	3	2	1
[Why do you feel this way?]:			
[redacted]			

Appendix H

Procedural Fidelity Coding Sheet

Procedural Fidelity Coding Directions.

1. *Complete Part I: Baseline checklist below for each assigned video.*

2. *Complete Part II: Maintenance checklist below for each assigned video.*

3. *Part III (Intervention Comparison Phase)*-- *Complete 1 checklist for each assigned video:*

Part I. Baseline & Part II. Maintenance Phase

Procedural Checklist

	Key Instructional Routines	**Reviewer Comment**
I. Baseline	-Instructor states question stem and answer choices clearly for each item (Yes/No)	
	-No instructional routines were provided during this session. (Yes/No).	
II. Maintenance	-Instructor states question stem and answer choices clearly for each item (Yes/No)	
	-No instructional routines were provided during this session. (Yes/No).	

III. Intervention Comparison Phase

Procedural Fidelity Checklist for MultiVision

Instructional Stages	**Key Instructional Routines**		**Reviewer Comment**
Introduction	-Provides Lesson Overview (Yes/No) -States Lesson Goal (Yes/No) -Introduces Word in Isolation (Yes/No) -Prompts spelling/sounding out word (Yes/No)		
Modeling	-Provides student-friendly definition (Yes/No) -Models with Image Context (Yes/No) -Delivers BK for Polysemy (Yes/No)[P]		
Practice	-Provides Open-Ended Questions*		
	-Provides Direct Questions*		
	-Provides Immediate Feedback*		
	-Provides practice with both senses of meaning [P]*		
	-Reviews Senses and connects back to core meaning (Yes/No)[P]		
Reflection	-Provides Think Time (Yes/No) -Asks Reflection Question (Yes/No)		

Note. *= In the practice stage, these routines must be checked for each of four practice examples. Therefore, input 1 (or 0) vertically to track routines for each example (this will be modeled shortly) P= These polysemy-related routines are explicitly included in MV, but not in CAP-S lessons.

Procedural Fidelity Checklist for CAP-S

Instructional Stages	**Key Instructional Routines**		**Reviewer Comment**
Introduction	-Provides Lesson Overview (Yes/No) -States Lesson Goal (Yes/No) -Introduces Word in Isolation (Yes/No) -Prompts spelling/sounding out word (Yes/No)		
Modeling	-Delivers BK for Word Meaning (Yes/No) -Provides student-friendly definition (Yes/No) -Models with Image Context (Yes/No)		
Practice	-Provides Open-Ended Questions (Yes/No)*		
	-Provides Direct Questions (Yes/No)*		
	-Provides Immediate Feedback (Yes/No)*		
	-Reviews Target Word Meaning* (Yes/No)		
Reflection	-Provides Think Time (Yes/No) -Asks Reflection Question (Yes/No)		

Note. *= In the practice stage, these routines must be checked for each of five practice examples/nonexamples. Therefore, input 1 (or 0) vertically to track routines for each example (this will be modeled shortly).

Appendix I

Final Pool of Target General Academic Vocabulary: 30 Words Total

Distort	Convene	Orient
Transmit	Diverse	Recover
Exploit	Induce	Interpret
Exclude	Assess	Generate
Integrate	Submit	Coherent
Diminish	Invoke	Simulate
Presume	Refine	Isolate
Suspend	Erode	Trigger
Confine	Intervene	Acknowledge
Consume	Interact	Resolve

Appendix J

Sample Timeline of Experimental Procedures for Jason

Week 1 ***(10/23—10/27)***	**Session 1 (Mon)** CORE Vocab Screener (20 minutes)	**Session 2 (Wed)** Pre-assess 1- TOWRE-2 (5 min for rapport-building); (20 minutes)= 25 min	**Session 3 (Thurs)** Pre-assess 2- VKS (5 min for rapport-building); (20 minutes)= 25 min
Week 2 ***(10/30—11/03)***	**Session 4 (Mon)** Baseline Probe 1 (5 min rapport) (20 minutes)= 25 min	**Session 5 (Wed)** Baseline Probe 2 (5 min rapport) (20 minutes)= 25 min	**Session 6 (Thurs)** Baseline Probe 3 (5 min rapport) (20 minutes)= 25 min
Week 3 ***(11/06—11/10)***	**Session 7 (Mon)** **Induce** (TREAT A-CAP) (30 minutes max)	**Session 8 (Wed)** **Erode** (TREAT B-MV) (30 minutes max)	**Session 9 (Thurs)** **Distort** (TREAT A-CAP) (30 minutes max)
Week 4 ***(11/13—11/17)***	**Session 10 (Mon)** **Coherent** (TREAT B-MV) (30 minutes max)	**Session 11 (Wed)** **Presume** (TREAT A-CAP) (30 minutes max)	**Session 12 (Thurs)** **Intervene** (TREAT B-MV) (30 minutes max)
Week 5 ***THANKSGIVING BREAK*** ***(No Sessions)***			

Week 6 ***(11/27—12/01)***	**Session 13 (Mon)** **Diverse** (TREAT A-CAP) (30 minutes max)	**Session 14 (Wed)** **Invoke** (TREAT B-MV) (30 minutes max)	**Session 15 (Thurs)** **Refine** (TREAT A-CAP) (30 minutes max)
Week 7 ***(12/04—12/08)***	**Session 16 (Mon)** **Confine** (TREAT B-MV) (30 minutes max)	**Session 17 (Wed)** Social Validity Survey (20 minutes max)	
Week 8 ***(12/11—12/15)***		**Session 18 (Wed)** Maintenance Probe 1 (20 minutes max)	
Week 9 ***(12/18—12/22)***		**Session 19 (Wed)** Maintenance Probe 2 (20 minutes max)	
Week 10 ***(12/25—12/29)***		**Session 20 (Wed)** Maintenance Probe 3 (20 minutes max)	