EFFECT OF VOCABULARY INSTRUCTION ON VOCABULARY ACQUISITION, READING COMPREHENSION AND ATTITUDES TOWARDS SCIENCE OF MIDDLE SCHOOL MULTILINGUAL LEARNERS WITH READING DIFFICULTIES

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by

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

EFFECT OF VOCABULARY INSTRUCTION ON VOCABULARY ACQUISITION, READING COMPREHENSION AND ATTITUDES TOWARDS SCIENCE OF MIDDLE SCHOOL MULTILINGUAL LEARNERS WITH READING DIFFICULTIES

presented by Heba Zakaryia Abdelnaby, a candidate for the degree of Doctor of Philosophy, and hereby certify that, in their opinion, it is worthy of acceptance.

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DEDICATION

To my companions on this doctoral and life journey:

Nader, my soulmate and unwavering first supporter, this journey would not have been possible without your constant encouragement and endless support.

To my children — Eslam, my smart, curious and reliable son; Ahmed, whose kindness brightens my world; and Mariam, my lovely source of joy.

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ABSTRACT

Understanding science texts is a daily necessity for individuals in the 21st century. Nevertheless, students in the United States often experience deficiency in this area because the intersection of science and reading instruction represents a critical challenge for teachers and students, especially for students who are emerging multilingual learners (MLLs). Students who are double identified emergent multilingual learners with reading difficulties (MLLs-RD) face compounded challenges reading science texts. The purpose of this study was to examine the effect of a vocabulary intervention on the acquisition of science and general academic words, science comprehension and science attitude for 10 MLLs-RD and students' rating on the effectiveness of the Science Generation intervention incorporated with multimodal direct vocabulary instruction on their learning, engagement, and interest in the topic, and science in general. The study followed an ABAB single case reversal design where participants were divided into 2 groups based on their grade level (i.e., Group 1: 6th grade, and Group 2: 7th and 8th grades). During the intervention students were directly taught new vocabulary, had controlled and open practice and assigned homework. The instructions were culturally responsive and followed the principles of Universal Design Learning. Results reported effectiveness of the intervention on vocabulary acquisition throughout the study phases, while less effects were observed on comprehension.

Key Words: *Multilingual Learners, English Language Learners, reading comprehension, vocabulary, science, students with disabilities, refugees*

CHAPTER 1

Introduction

Multilingual learners (MLLs) are the fastest growing group of learners in US public schools (Oh, 2024). Many MLLs face challenges that hinder improving reading proficiency and comprehension such as limited vocabulary knowledge and phonological processing difficulties (Cummins, 2000). In addition, social and cultural barriers, including parents' limited English proficiency and socioeconomic status, affect reading comprehension among MLLs (Snow et al., 1998).

Background

Reading comprehension holds a central role in the act of reading, representing its fundamental essence (Durkin, 1993) and is crucial for academic success (Cane & Oakhill, 2008) and lifelong learning (National Reading Panel, 2001). Comprehension is a cognitive process wherein a reader focuses on facts, information, or ideas from written materials, interprets the intended meanings of the author, assesses their connection to prior knowledge, and evaluates their relevance and value in achieving the reader's own objectives (Veeravagu, et al., 2010). According to the National Reading Panel (2001), reading comprehension is a process that incorporates complex skills and requires understanding the vocabulary in the text. Reading comprehension and vocabulary instruction begins at the elementary school level and continues to develop to enable students to understand content subject materials such as social studies and science (Cane & Oakhill, 2008).

Scientific literacy is a necessity for citizens to understand science materials and reports on media, develop workforce competency and represent better citizenship (DeBoer, 2000), and it depends on adequate reading comprehension (Norris & Phillips, 2003). Scientific literacy is

defined as the ability of individuals to understand and engage with scientific concepts, processes, and information (Miller, 1983), and incorporates reading, writing and knowledge of science content (Hand et al., 2003), where literacy skills contribute to scientific literacy skills (Shafer et al., 2019). However, recent reports indicate a decline in the reading and science scores for students in multiple grade levels (National Center on Educational Statistics [NCES], 2022).

The National Assessment Progress Reports (NAEP) in 2019 showed lower progress in the science and reading scores for MLLs and SWDs across 4th, 8th and 12th grades in the United States (NCES, 2019). MLLs in fourth grade scored an average of 122, while their peers average score was 155. The gap continues to widen where at 8th grade, MLLs scored 111 compared to 157 for their non-MLL peers, and for 12th grade, MLLs scored 99 compared to 152 for non-MLLs. The reading proficiency gap between MLLs and non-MLLs is especially problematic given that the number of MLLs in schools continues to increase (Wong et al., 2012) with estimates indicating that 40% of students will be from homes in which English is not their first language by 2030 (Solari et al., 2014).

The achievement gaps in science and reading between MLLs and their peers is concerning, as they are compounded for students with reading difficulties. Students with reading difficulties often struggle to navigate the intricate language structures found in discussions related to social studies, science, mathematics, and English language arts (Kennedy & Ihle, 2012). There is limited research regarding the reading needs of students who are both emerging MLLs and with reading difficulties (MLLs–RD; Helman et al., 2022; O'Connor et al., 2022; Van Orman et al., 2021), The overall proportion of MLLs who were classified with reading difficulties was 50.5 % compared with 38.2% for non-MLLs (Office of English

Language Acquisition, 2017). The academic performance of MLLs is usually lower than their peers in content subjects such as science, math, and social studies (NJCD, 2020).

Statement of the Problem

Scientific literacy is a multifaceted skill that is crucial for adapting to a changing world, making informed decisions, identifying real science, understanding media reports, supporting science, navigating political influences, and engaging effectively in democratic processes (Anelli, 2011). Future workers will need to be even more scientifically literate (Post et al., 2011).

While the number of MLLs in the US continues to grow, they remain underrepresented in science, technology, and mathematics (STEM) fields. MLLs are not pursuing STEM careers at the same rate as their non-MLL peers after high school graduation (Zigmont & Wolfe, 2022). They have less presence in STEM school colleges and careers (National Academies of Science, Engineering, and Medicine, 2018). Due to the increasing academic and linguistic demands of STEM, MLLs and MLLs with reading difficulties (MLL-RD) face substantial difficulties in reading comprehension and access to content area instruction (Fang, 2006; Snow, 2010).

Content Area Instruction for Students with Reading Difficulties

Many students with reading difficulties struggle to access and understand the core curriculum and its materials due to problems in comprehension skills (Graves et al., 2011). The features of science texts add an additional layer of complexity to excel the science content for students with reading difficulties. Vocabulary knowledge is necessary for reading comprehension (Bell & McCallum, 2008; National Reading Panel, 2000). Science texts are heavily loaded with novel and technical vocabulary (Fang, 2006; Kennedy & Ihle, 2012) which

students need to understand to be engaged in science reading and discussion (VanUitert et al., 2020). However, students with reading difficulties face challenges in handling genre-specific vocabulary because of "specialized terminology, multiple meaning terms, and gaps in prior knowledge" (Carlisle et al., 2021, p. 49). Such science words and other textual elements are considered as constraints for accessibility to the scientific texts (Hand et al., 2003). Lack of science vocabulary impedes students with disabilities from interacting with the texts and increases reading difficulties (Carlisle et al., 2021; Mason & Hedin, 2011). The academic difficulties that students with reading difficulties face are exacerbated when considering MLLs-RD.

Emergent MLLs-RD

Reading science texts is challenging to MLLs-RD due to the complexity of these reading materials. First, science texts are informational with inconsistent text structure (Botsas, 2019; Mason & Hedin, 2011; Sáenz & Fuchs, 2005). Second, these texts are characterized by heavy conceptual density where multiple scientific terms are introduced. Third, strong background knowledge is a key component in understanding the science content. The lack of these three components makes it difficult for MLLs-RD to comprehend complex scientific reading materials (Mason & Hedin, 2011). Moreover, knowledge of content subject vocabulary is negatively affected by memory and language deficits (Bryant et al., 2011). As a result, the factors of disability, language, and science text features together hinder the access of MLL-RD students to the science reading materials. It indicates an existing gap in reading and science performance between ELL and their peers (Taboada, 2012) that continues to grow over time (Lesaux et al., 2014).

Gaining vocabulary knowledge has always been considered a vital aspect of acquiring a foreign language for language learners (Coady & Huckin, 1997). Academic vocabulary, utilized by teachers and students in content-area subjects like science and social studies, is a crucial tool for acquiring new knowledge, understanding concepts, and expressing ideas (Kim, 2011. However, scholarly research indicates significant delay of oral and academic proficiency for MLLs including vocabulary (Helman et al., 2022; van Orman et al., 2021). On average MLLs spend 3–5 years to improve English language oral proficiency and 4–7 years to acquire English academic proficiency (Hakuta et al., 2000). Scholars attribute these shortcomings to deficits in the students' phonological awareness and working memory and poor word identification skills (Helman et al., 2022). These factors along with poor classroom reading instruction hinder vocabulary acquisition among those learners (Helman et al., 2022).

Science Generation as a Vocabulary Intervention

Science Generation (SciGen) is a science vocabulary intervention designed for middle school students (SERP Institute, n.d.). It enhances students' understanding of academic language with reference to the science context, which is crucial for success in middle school curricula (Jones et al., 2019; Snow et al., 2017). SciGen is an extension of Word Generation (WordGen) which is a cross-disciplinary extended reading program (SERP Institute, n.d.). It aims at improving students' academic vocabulary, perspective-taking abilities, and reading comprehension through weekly units featuring vocabulary instruction, nonfiction texts, and structured discussions at elementary and middle school level (Snow et al., 2009; SERP Institute, n.d.). WordGen and SciGen have been especially effective in high-poverty urban schools and with diverse student populations including those with disabilities (Jones et al., 2019).

Purpose

The challenges in science text comprehension are multifaceted for students who are double identified as MLL-RD, and that the interplay between science text features and language and disability characteristics adds additional layers of complexity for MLL-RD students to get access to the science texts. Therefore, the purpose of this study was to investigate the effect of using SciGen on the acquisition of vocabulary, science comprehension and science attitudes for emergent MLLs-RD.

Key Terms

The study key terms are defined to increase the accessibility for readers.

Blackout Poetry

Blackout Poetry is defined as transforming a written text to a new written product and involves coloring out unnecessary words with a pen, crayon, or marker, leaving behind the selected words to form the poetry (Sulastri & Belkis, 2023). Blackout poetry was used as a final instructional scaffold in this study, where students used the newly learnt vocabulary and writing skills to create a poem of their own.

Emerging Multilingual Learners

Emerging Multilingual Learners (MLLs) is a strength-based term for English Language Learners (ELL) or English Learners (EL), referring to students who are in the process of developing proficiency in multiple languages (WIDA, 2020; Institute of Education Sciences [IES], 2022). This definition emphasizes an assets-based approach, recognizing the linguistic capabilities of these students rather than viewing their language diversity as a deficit. It highlights students' strengths compared with the federal definition that refers to MLLs as ELL students with minority origin and limited English proficiency (US Department of Education,

2020). In this study, students were identified as MLLs according to the family, self-reporting and host refugee organization.

Refugee

Refugees are individuals who were forced to leave their countries because of fears of persecution, war or violence, in which they have a justifiable fear of persecution for reasons related to ethnicity, religion, nationality, political opinion or affiliation to a particular social group (UNHCR, n.d.).

Reading Difficulties

Reading difficulties can be defined in many ways. It could refer to low-level reading skills, less severe levels of low reading achievement such as poor readers, reading problems, and reading struggles, or more severe cases such as dyslexia and reading disabilities (Quinn, 2018). For this study, a reading difficulty was defined as below average in either a student's ability to decode the written words in English, to understand the written text in English, or both. Below average was defined as below the 25th percentile on a standardized test of reading in English in one or more areas.

Reading Comprehension

Reading comprehension cognitive process wherein a reader chooses facts, information, or ideas from written materials, interprets the intended meanings of the author, assesses their connection to prior knowledge, and evaluates their relevance and value in achieving the reader's own objectives (Veeravagu et al., 2010). According to the Simple View of Reading theory, it is the product of decoding and comprehension (Gough & Tunmer, 1986). In this study context, reading comprehension refers to the ability to understand, interpret, and derive meaning from a science informational text.

Science Attitude

Attitude is defined as "the feelings that a person has about an object, based on their beliefs about that object" (Kind et al., 2007, p. 4). In the context of this study, the focus is on students' attitudes toward science. The researcher used Kind et al.'s (2007) science attitude measure to investigate the effects of the Science Generation Intervention on the science attitudes among MLLs-RD at middle school level.

Scientific Literacy

Scientific literacy refers to the ability of individuals to understand and engage with scientific concepts, processes, and information (Miller, 1983).

Vocabulary

Vocabulary is defined as the knowledge of words and their meanings (Honig et al., 2018). In this study, two types of vocabulary were targeted: Tier 2 general academic vocabulary, and Tier 3 content specific vocabulary (Beck et al., 2002).

Vocabulary Knowledge

Vocabulary knowledge is defined as the extent to which an individual comprehends or is familiar with words (Wright & Cervetti, 2016).

Assumptions

This study operates under several assumptions to guide its methodology and interpretation of results. The study views reading comprehension in light of the Lexical Quality Hypothesis, where knowledge and understanding are the core of comprehension (Perfetti & Hart, 2001). The measures of comprehension and vocabulary acquisition are researcher-developed proximal tools that were reviewed and tested before implementation. Guided by

previous studies, I assume that using this measure reflected students' science comprehension performance (Ardasheva et al., 2017; Van Orman et al., 2021).

The study assumed that using SciGen along with scaffolded activities and the blackout poetry, implemented in alignment with constructivism principles of scaffolding and zone of the proximal development (Vygotsky, 1978), would improve the science text comprehension and vocabulary acquisition for MLL-RD including refugees and SWDs and develop positive attitudes towards science.

Finally, the inclusion criteria for this study were students who were double identified as emergent multilinguals and with reading difficulties (performed below the 25th percentile in one area or more areas of reading) at the middle school level by the host organization. The study utilized a single subject design to match the rarity of these target participants in the school population.

These assumptions provided the foundational framework for the study, guiding its approach to measurement, intervention design, and participant selection.

Limitations

This study comes with design limitations related to internal and external validity. Despite being based on previous research, all the vocabulary and comprehension measures used in the study were all developed and many of the instructional materials were researcher developed. In addition, while the science attitude measure was adapted from previous measures, the findings were self-reported by the students who filled out the survey before and after the intervention.

According to Slocum et al. (2022), maturation, testing and session experience, and coincidental events between the baseline and treatment can cause major threats to single case

design where change can be attributed to external factors rather than the intervention. Possible solutions can help in addressing these threats including implementing baseline phases with clearly distinct temporal durations with variation of number of days (for maturation threats). Integrating baseline phases with differing session counts can be used to address testing and session experience threats. The adequate spacing of phase changes on the calendar can help in managing the threats of coincidental events (Slocum et al., 2022).

Possible threats of external validity are the inability to generalize findings to larger populations and visual analysis of data (Cakiroglu, 2012). Nevertheless, positive findings of previous studies such as Kim et al. (2021), Ardasheva and Tretter (2017), and Van Orman et al. (2021) can support the findings of this study. External validity could be enhanced by future systematic replication studies (Horner et al., 2005). Having a well-trained observer, interobserver agreement and randomization in assigning the conditions helped in limiting the threats emerging from visual analysis of data (Cakiroglu, 2012).

Another limitation is the probability of experimenter bias as the researcher would administer the intervention and collect baseline data (Helman et al., 2020). However, having a strong procedural integrity assessment (Helman et al., 2020), such as a second observer. and recording sessions can alleviate this concern. In this study, the researcher recorded intervention sessions that were reviewed by a second researcher and the interobserver agreement was 99.57% across all the study phases and conditions.

Research Questions

The study was guided by the following research questions:

1. What is the effect of teaching vocabulary using multimodal vocabulary instruction with SciGen on science vocabulary acquisition with middle school students who were identified as MLLs- RD?
2. What is the effect of teaching science vocabulary using multimodal vocabulary instruction within SciGen on science comprehension for MLLs-RD at the middle school level?
3. What is the effect of teaching science vocabulary using multimodal vocabulary instruction within SciGen on the science attitudes of the MLLs-RD at the middle school level?
4. How do students rate the effectiveness of the multimodal vocabulary instruction within SciGen on their learning, engagement, and interest in the topic, and science in general?

Organization of the Dissertation

The second chapter delves into existing literature on science interventions for the MLL-RD student population that aims at enhancing comprehension of science texts with emphasis on vocabulary-based methods to offer insights into effective interventions to address the identified challenges in the science subject area. The third chapter describes the study's used methodology. The fourth chapter concludes the results, and the last chapter discusses findings in light of the current literature, and highlights limitations of the study and future directions.

CHAPTER 2

Review of The Literature

The purpose of this chapter is to review vocabulary, tiers and role in comprehension and the existing literature for vocabulary interventions with reference to the science subject context. Then, a review of guiding theories and relevant interventions is introduced to establish the framework for this study.

Vocabulary

Vocabulary can be defined as the knowledge of words and their meanings (Honig et al., 2018). Mastering vocabulary is critical for language development and academic success. According to the National Reading Panel report (2000), effective reading instruction involves key components such as phonemic awareness, phonics, fluency, comprehension, and vocabulary. Vocabulary is also one of the main constructs that contribute to reading comprehension in various theoretical models of reading (Cromley & Azevedo, 2007; Gough & Tunmer,1986; Ahmed et al., 2016). Vocabulary is a strong indicator of appropriate language development and school readiness among young children (Ramey & Ramey, 2004) and is a primary emphasis for reading education in middle and high schools (Kamil et al., 2006).

Vocabulary knowledge is defined as the individual's comprehension or familiarity with words (Wright & Cervetti, 2016) that is an important variable in reading comprehension (McKee, 2012), and early vocabulary knowledge predicts high school reading comprehension (Cunningham & Stanonvich, 1997). Hsueh-Chao and Nation (2000) found that to comprehend text without assistance, individuals needed to know 98% of the text vocabulary.

While word knowledge is important in comprehension, it is important to acknowledge that it does not stand alone. Research suggests that to improve comprehension, children need to

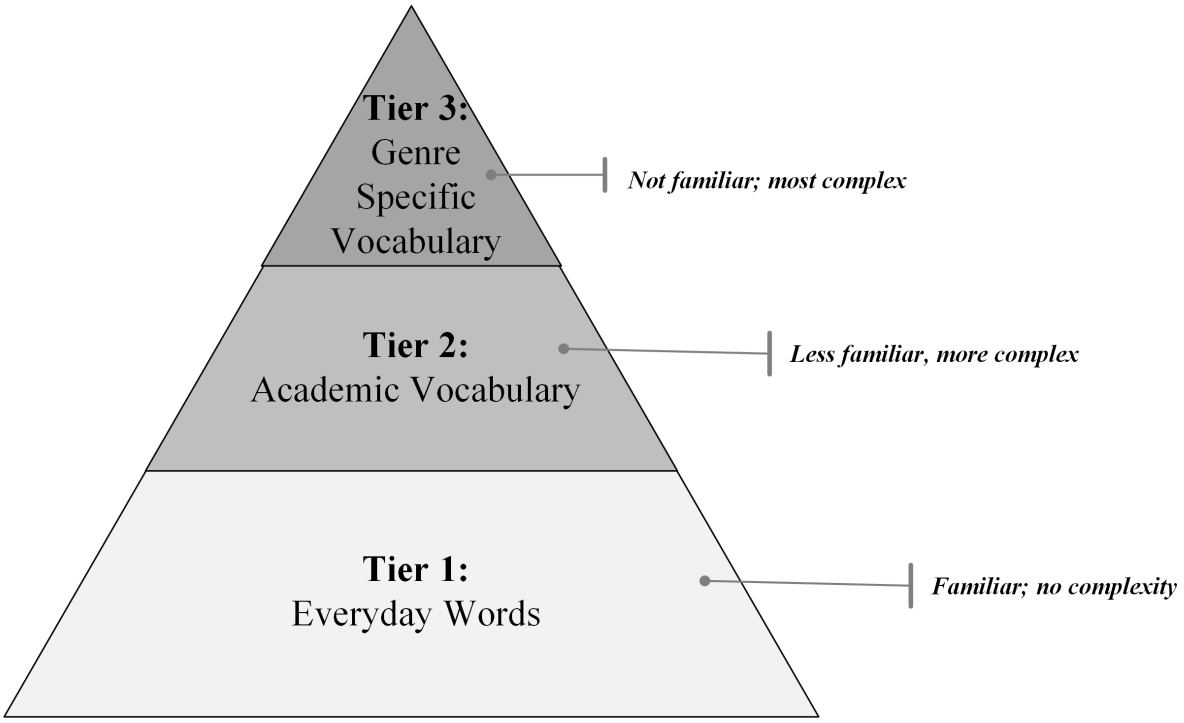
improve two main skills: recognizing and decoding words, and comprehending the text (Cane & Oakhill, 2008). In light of this, it is essential to integrate vocabulary instruction with decoding and comprehension strategies to support students' overall reading success (Duke & Pearson, 2002; Graves, 2006; National Institute of Child Health and Human Development [NICHD], 2000).

Types of Vocabulary

The Common Core State Standards (CCSS) highlight the crucial role of vocabulary, stressing the necessity to acquire and use a diverse range of general academic and domain-specific words and phrases with accuracy (Poch & Lembke, 2018). Vocabulary varies in terms of difficulty and can be classified based on their level of utility or frequency (Honig et al., 2018). According to Beck et al. (2002), and as shown in Figure 1, vocabulary is classified into a three-tier framework. First, *Tier 1 vocabulary* includes all words that are common in oral communication and students are familiar with. Second, words that are wide-ranging and used by literate language users fall under *Tier 2 vocabulary level.* Struggling students are not familiar with these words because they are rarely used in conversations, and they cannot learn them independently. Finally, *Tier 3 vocabulary* is specific domain vocabulary which are related to specific content areas. These words are probably best learned when a specific need arises.

Figure 1

Tiers of Vocabulary based on Beck et al. (2002)



Learning academic vocabulary (Tier 2 and Tier 3) is more difficult compared with Tier 1 vocabulary because it is more specific (Beck et al., 2002; Marzano, 2005). Specific genre vocabulary can be challenging for linguistically vulnerable groups (Helman et al., 2022; O'Connor et al., 2022), who might be unfamiliar with some of the Tier 1 words (Honig et al., 2018). Emergent multilingual learners (MLLs), also known as English language learners (ELL), with learning disabilities or at-risk face difficulties in reading and vocabulary in particular.

Vocabulary Instruction

The relationship between vocabulary and reading comprehension is well established in research (Cromely & Azevedo, 2007) in which vocabulary and comprehension are the main areas of emphasis for reading education in middle and high schools (Kamil et al., 2006) where Common Core State Standards requires students to analyze the meaning of words and phrases as they appear in a text (National Governors Association Center for Best Practices, 2010).

Acquisition of science vocabulary terms is important so students should be able to communicate using scientific concepts as they move through their educational career (Pede, 2017). Researchers used multimedia strategies (Carlisle et al., 2022; Kennedy et al., 2015; VanUitert et al., 2020), mnemonics (Slemrod et al., 2023) and contextual and morphemic analysis (Helman, 2015; Helman et al., 2015; 2020) and multi-component interventions (Seifert & Espin, 2012) for science vocabulary learning.

Vocabulary instruction has been a topic of interest for policy and research since the National Reading Panel (2000) reviewed existing literature from 1979 to 2000 on general vocabulary instruction and summarized the instruction as explicit instruction, implicit instruction, multimedia methods, capacity methods, and association methods. The panel recommended direct instruction, repetition in multiple contexts, active engagement of learners, integration of technology, multiple exposures for words and a variety of vocabulary methods.

Other reviews for vocabulary instruction recommended teaching vocabulary using the student's first language skills, scaffolding, repetition and reinforcement, and differentiation in the classroom (August et al., 2014), and effective instructional approaches include incorporating teaching autonomous word-learning procedures (morphological analysis), emphasizing creating semantic networks, increasing opportunities to use new words in discussion and writing, and providing an engaging and language-rich learning environment (Elleman et al., 2019). Wright and Cervetti (2017) reviewed 36 vocabulary studies and concluded that teaching word meanings through active methods helps with understanding text, but the extent of required instruction remains uncertain. Long-term interventions did not have a strong effect or may not strongly improve overall comprehension but teaching students to

monitor their vocabulary understanding and to use flexible strategies was a promising area for future research.

Multilingual Learners and Vocabulary

There is a critical need for studies about vocabulary instruction for MLLs with reading difficulties (MLLs-RD) because there is a lack of research on this area (Helman et al., 2022). To address this gap, current research with science vocabulary interventions specifically addresses MLLs-RD (Helman, 2015; Helman et al., 2015; 2020), but there are limited studies addressing this area with focus on effects of science vocabulary on comprehension (Carlisle et al., 2022; Van Orman et al., 2021). Moreover, most previous research disregarded cultural consideration in MLLs-RD comprehension interventions (Kelly et al., 2023).

Science Vocabulary and Comprehension Interventions for Multilingual Learners with Reading Difficulties

Multilingual learners (MLLs), particularly those with reading difficulties (MLLs-RD), face multiple barriers in accessing science content, including limited academic vocabulary, language development needs, and reduced exposure to formal science instruction (Van Orman et al., 2021). These students often require instructional approaches that integrate vocabulary, comprehension, and culturally responsive pedagogy to improve science learning outcomes (Kelly et al., 2023). A growing body of research supports several intervention models targeting science vocabulary acquisition (Carlisle et al., 2022; Helman, 2015; Helman et al., 2015; 2020) or both vocabulary and comprehension for MLLs and MLLs-RD (Jones et al., 2019; Tretter et al., 2017; Van Orman et al., 2021). These interventions can be categorized into: (a) direct vocabulary instruction, (b) technology-based interventions, (c) generative and morphology strategies, (d) interdisciplinary science strategies, and (e) cross-content academic

language programs.

Explicit and Direct Vocabulary Instruction

Explicit vocabulary instruction has been one of the most powerful approaches to build science knowledge in MLLs-RD. Science Vocabulary Support program (SVS) is designed for newcomers and mixed-proficiency classes (Van Orman et al., 2021). SVS seems to be a promising intervention for MLL-RD students because it incorporates effective vocabulary instruction elements such as direct instruction, multiple exposure and active engagement reported by previous vocabulary reviews (August et al., 2014; Elleman et al., 2019; Naggy, 1988; National Reading Panel, 2000; Wright & Cervetti, 2017). The use of direct instruction in teaching science vocabulary can enhance science vocabulary knowledge and text reading (Graham, 2010; Seifert & Espin, 2012). SVS uses vocabulary instruction to promote vocabulary learning and reading comprehension which is proven to be effective to comprehension (Bos & Anders, 1990; Xiong, 2020). This intervention was originally designed for MLL learners and used content and instructional scaffoldings that are needed for teaching science to MLLs (Ardasheva et al., 2017). SVS also targets words in Tiers 1, 2 and 3 that are necessary to get access to science texts and is effective in increasing science attitude and achievement among MLL students. The CLUES approach, a generative word-learning approach integrating context clues and morphemic analysis, demonstrated strong effects for English learners with reading disabilities (Tau-U = 1.0) (Helman et al., 2020).

Promoting Adolescents' Comprehension of Text intervention (PACT) also integrates vocabulary instruction with content acquisition through explicit teaching, peer discussion, and comprehension strategies for the social studies content. This leads to improving content knowledge and vocabulary outcomes, especially for students with reading difficulties

(Swanson et al., 2016; Vaughn et al., 2013; Wanzek et al., 2016) and MLLs (Vaughn et al., 2017). The CHAAOS (Creating Habits that Accelerate the Academic Language of Students) program, designed to boost academic vocabulary for English learners with disabilities, demonstrated significant outcomes in a sixth-grade study with effect sizes of $\eta^2 = 0.43$ for vocabulary and $\eta^2 = 0.17$ for comprehension at the social studies content (Sanchez & O'Connor, 2022).

Technology and Multimedia-Based Interventions

Multimedia interventions like the Content Acquisition Podcast for Students (CAP-S), which short multimedia videos on science and social studies content subjects, have demonstrated outstanding success with MLL vocabulary learning (VanUitert et al., 2020a). VanUitert et al. (2020a) measured open-ended vocabulary assessment effect sizes from $d = 1.07$ to 1.57, and multiple-choice outcomes from $d = 0.51$ to 1.13. A comparative study on CAP-S and InferCabulary, a web-based vocabulary intervention, also reported significant gains for both interventions compared to business-as-usual instruction (VanUitert et al., 2020b).

Generative and Morphological Strategies

These types of strategies as CLUES instruct MLLs to obtain word meanings through analyzing roots and affixes of words, and sentence context (Helman et al., 2015). Helman et al. (2015, 2020) emphasized the importance of these generative strategies in building independence in word learning, particularly for ELs with disabilities. In addition to high performance results (Tau-U = 1.0), students reported high engagement and satisfaction with the approach.

Interdisciplinary Science-Literacy Strategies

Systematic interventions incorporating both literacy and content scaffolding also hold promise. Seifert and Espin (2012) corroborated the reality that multielement comprehension interventions targeting vocabulary and fluency also demonstrate effectiveness, ranging from $d = 0.67$ to $d = 1.11$.

Cross-Content Academic Language Programs: Word Generation and Science Generation

Word Generation reading curriculum (WordGen; Snow et al., 2009) is a supplemental vocabulary intervention that aims to enhancing students' vocabulary knowledge, reading comprehension and academic language. WordGen is a cross-content vocabulary intervention that develops Tier 2 and 3 academic vocabulary across subjects for students in Grades 4 through 8. The units within WordGen can be used across ELA, math, science, and social studies, with flexible implementation.

WordGen has two other content specific extensions for middle school level: Science Generation (SciGen) and Social Studies Generation (SoGen) for social studies. WordGen was used with over 3,000 students in randomized controlled trials with students from diverse backgrounds, including monolingual students and MLLs, and reported positive results on improving academic language (Kim et al., 2021). Similarly, the Questioning to Understand and Explain Science Text (QuEST) intervention integrates question generation and discussion strategies to improve science text comprehension. QuEST was found to beneficial to Spanish speaking MLLs by explicitly teaching vocabulary teachers and learners and providing educators professional development training and instructional materials. The intervention reported moderate effects ($g = 0.26$ to 0.37) for MLLs identified as ELL by the school districts in the 6^{th} grade. (August et. al., 2009).

Blackout Poetry

Blackout Poetry is defined as transforming a written text to a new written product and involves coloring out unnecessary words with a pen, crayon, or marker, leaving behind the selected words to form the poetry (Sulastri & Belkis.2023). This process incorporates the skills of reading and writing (Sulastri & Belkis, 2023). This method has been used with reference to the language and art contexts (Jawaheer, 2023) including students (Ladenheim, 2014) and educators of color (Morris, 2019), and has been recommended to integrate science and language with art (Lannin et al., 2024) and for teaching MLLs (Sulastri & Belkis, 2023). Nonetheless, none of the existing studies involved using this strategy with reference to the science-reading context.

Science Attitude

Attitude involves a psychological tendency to evaluate something positively or negatively. It is described as "a complex psychological construct, built up from theoretically subordinate constructs, habit, cognition and emotion" (Greenwald, 1968, p. 386). Attitude involves a psychological inclination or tendency to evaluate something positively or negatively (Gawronski, 2007), it is acquired and not inherited (Shirgley et al., 1988), and significantly influences the learning process (Sulivan, 1927). It is also defined as "the feelings that a person has about an object, based on their beliefs about that object" (Kind et al., 2007, p. 4). Students frequently report negative attitudes towards science (Christidou, 2011), which affects their academic achievement (Siegel & Ranney, 2003) and career interests (Wiebe et al., 2018). However, academic interventions can improve science achievement and accordingly students' attitudes towards areas of science (Aguilera, et al., 2020; Rogayan, 2019). Fouts and Myers (1992) found that students' attitudes towards science significantly increased when they received strong support, engagement, and well-organized learning environments.

Existing literature indicates a gap in the research on the effects of literacy interventions on science attitudes for MLL-RD students. Recent studies investigated the impact of science-based academic interventions on improving science outcomes for students with reading difficulties as well (Gomaa, 2014; Plamsan et al., 2013). Gomaa (2014) investigated the impact of a differentiated instruction using multi-intelligence strategies on science achievement and attitude among middle school students with learning disabilities and reported positive outcomes for achievement $t = 20.54$ ($p = 0.01$) and $t = 16.75$ ($p = 0.01$) for science attitude. Plamsan et al. (2013) investigated the effects of engineering courses on science attitudes of high school students with learning disabilities and reported positive results.

Tretter et al. (2017) studied the effect of science and literacy intervention on the academic performance and attitude among newcomer students who were emerging MLLs. The researchers used an extended science and literacy intervention for middle school attitudes of MLLs students and reported positive impact on attitude ($d = 0.43$). This study may have been among the first to investigate the impact of science reading intervention on middle school MLLs-RD students' attitudes towards science and included refugees, but additional research is needed.

Theoretical Frameworks

The research was guided by four theoretical frameworks. One theory addresses the relationship between vocabulary and comprehension, one focuses on learning theory, one on learning theory applied to language acquisition, and one on culturally responsive instruction.

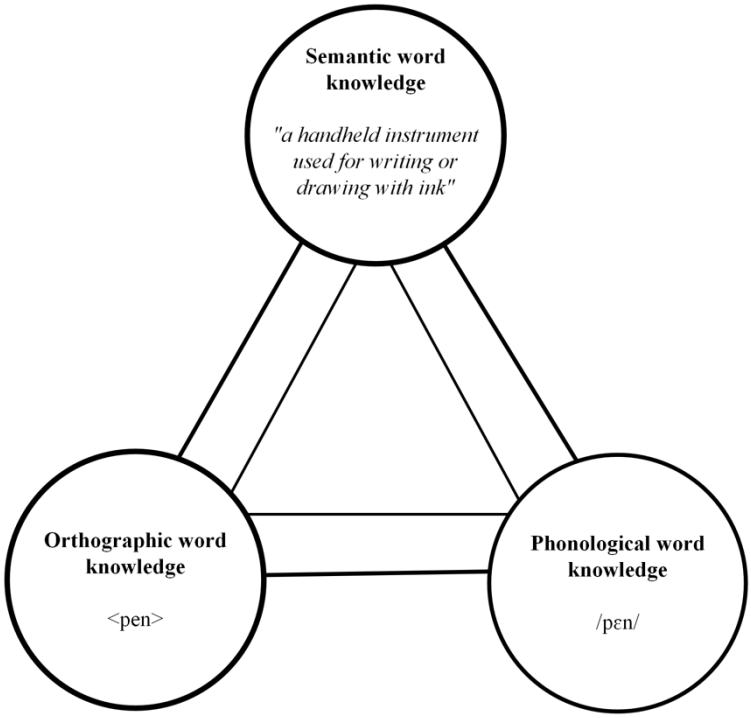
Lexical Quality Hypothesis

The Lexical Quality Hypothesis, proposed by Perfetti and Hart in 2001, suggests that comprehension is all about the knowledge and understanding of words. According to Perfetti

and Hart (2001), the skill in reading comprehension refers to orthographic, phonological and semantic knowledge. As shown in figure 2, skilled readers have a high-quality mental grasp of words, including their meanings, sounds and how they relate to each other. This strong understanding of words and knowledge of how to use them is crucial for reading comprehension. Thus, the focus of the intervention used in the study was on reading words to build understanding, and both understanding of words and text were used as measures.

Figure 2

Lexical Quality Hypothesis based on Perfetti and Hart (2001)



Note. Adapted from Seidenberg and McClelland (1989). This figure shows how word recognition involves spelling (orthography), sound (phonology), and meaning (semantics) working together.

Zone of Proximal Development, Gradual Release of Responsibility and Scaffolding

Vygotsky (1986) described the process of science learning through comparing it with new language learning:

> The process of acquiring scientific concepts reaches far beyond the immediate experience of the child, using this experience in the same way as the semantics of the native language is used in learning a foreign language. In learning a new language. one does not return to the immediate world of objects and does not repeat past linguistic developments, but instead uses the native language as a mediator between the world of objects and the new language. Similarly, the acquisition of scientific concepts is carried out with the mediation provided by already acquired concepts. (p. 161).

According to Vygotsky (1986), learning science would be a process of building connections between old and new experiences where individuals connect their prior knowledge to their new experiences when learning science. It is similar to learning a new language where learners use their native language to learn a new one. So, acquiring scientific knowledge happens with the help of the learners' prior knowledge. In this study learners used both experiences and native language along with the intervention instructional supports to get access to the new science content.

Instruction for the current study was informed by Vygotsky's (1986) principles of learning, and the concepts of the zone of proximal development (ZPD) and gradual release of responsibility in particular. According to Vygotsky (1978), the ZPD refers to the range of tasks or activities that a child can perform with the assistance of a more knowledgeable individual, such as the teacher in this study, but cannot yet do independently. It represents the gap between

a child's actual developmental level and their potential developmental level. The gradual release of responsibility was inspired by ZPD and developed by Pearson and Gallagher (1983) where it assumes that learners take control of their learning over time (Riviera, 2015). This study addressed these concepts with reference to science vocabulary acquisition.

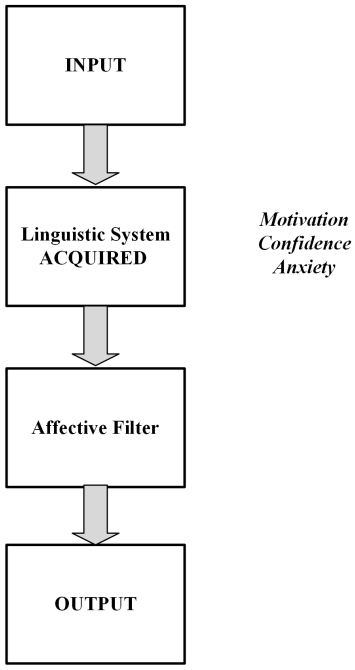
Scaffolding is another important component of this instruction process. It is strongly recommended for literacy development of MLLs (August et al., 2014) and increase of science vocabulary (Medina & Sohn, 2013). Through the instructional and content scaffolds, the students moved to be more independent learners. Instructional scaffolds refer to activities that provide learning opportunities and c*ontent scaffolds* which are support materials for instruction (van Garderen et al., 2021), were both selected and used to meet the students' needs and enhance science vocabulary learning. Multidisciplinary scaffolds, such as found poems, blackout poetry, word tournaments and slow reveal graphs, that incorporate science, math, language and art were used in this intervention to enhance learners' independence.

Affective Filter Hypothesis and Multimodal Vocabulary Instruction

The affective filter theory was first proposed by Dulay and Burt (1977) and later studied by Krashen (1982) who formalized the idea into a working hypothesis. According to Krashen's (1982) Affective Filter Hypothesis, and as shown in Figure 3, a high affective filter caused by fear of failure, lack of engagement or self-confidence can block the full processing of language acquisition. In contrast, second language acquisition is most effective when learners are emotionally receptive, when being confident, motivated, and low in anxiety (Krashen, 1982).

Figure 3

Affective Filter Hypothesis based on Krashen (1982)



Vocabulary interventions such as Science Generation (SciGen) aim to reduce the affective filter by using multiple engaging modalities such as peer and group discussion, visuals, writing, and academic language in context. These modalities are used as scaffolds to promote comprehension and confidence in content-rich settings in order to support cognitive processing of new vocabulary and create a safe and interactive learning environment for MLLs. When students can talk through ideas with peers, visualize concepts through diagrams and videos, and engage in purposeful writing, they are more likely to feel supported and experience success, which accordingly would lower their affective filter.

Research Gap

Existing interventions with a focus on science vocabulary and comprehension, such as SVS and SciGen are promising; however, they are limited and have shortcomings. Existing literature reports lack of academic interventions addressing science vocabulary for MLLs with reading difficulties/disabilities (Helman, 2015). Even existing interventions such as CAP-S (VanUitert et al., 2020b) and CLUES (Helman, 2015) has more focus on science knowledge

and vocabulary acquisition than science reading comprehension, which are both important and required. Other interventions that address both vocabulary and comprehension, such as Word Generation intervention, which provides multimodal and multidisciplinary intervention material, has limited number of studies that meet the What Works Clearinghouse (WWC) criteria. According to WWC, WordGen intervention has met evidence standards with reservations, with only one study matching its criteria, showing improvement in vocabulary, and reading comprehension (What Works Clearinghouse, 2020). The WordGen instructional materials do not incorporate direct vocabulary instruction. On the other hand, SVS which was reported to improve vocabulary acquisition, science reading comprehension and attitudes towards science has not been validated by WWC as an effective intervention. Also, SVS is a supplementary vocabulary intervention that supports school curriculum (Van Orman et al., 2021). Other interventions such as PACT and CHAAOS have not been applied in the science content area, while QuEST is only available in Spanish and targets Spanish- speaking MLLs. Also, research indicates a lack of culturally responsive intervention to improve MLLs science learning outcomes (Kelly et al., 2023). In light of these findings, there is a need to develop science reading intervention that explicitly teach vocabulary while incorporating cultural needs of learners in order to evaluate its impact on words, comprehension and interest in science.

Purpose

Research on vocabulary instruction has emphasized various methods and recommendations for effective teaching including explicit instruction, active engagement, technology integration, and multiple exposures as key elements (August et al., 2014; Elleman et al., 2019; Wright & Cervetti, 2017). The relationship between vocabulary and reading comprehension is well established in research (Cromely & Azevedo, 2007) and vocabulary and

comprehension are the main areas of emphasis for reading education in middle and high schools (Kamil et al. 2006). Thus, acquisition of science vocabulary terms is important so students should be able to communicate using scientific concepts as they move through their educational career (Pede, 2017).

Students who are MLLs, and those who are MLL-RDs experience significant difficulty with vocabulary and accessing science instruction (Helman et al., 2022; O'Connor et al., 2022). The main purpose of this study was to examine the effect of using multimodal vocabulary instruction following SVS and PACT models for teaching Tier 3 vocabulary (i.e., scientific technical terms) and Tier 2 vocabulary (functional and general vocabulary) using the SciGen curriculum on the science content vocabulary acquisition and reading comprehension and science interest for MLL-RD students in middle school grades 6-8. Previous literature focused on science reading interventions with reference on the populations of students with disabilities (e.g., Kennedy et al., 2015; 2020; 2022) or MLL (e.g., Lara-Alecio et al., 2012). This research addresses the gap in current literature.

Research Questions

The following research questions guided the study:

1. What is the effect of teaching vocabulary using multimodal vocabulary instruction with SciGen on science vocabulary acquisition with middle school students who were identified as MLLs- RD?
2. What is the effect of teaching science vocabulary using multimodal vocabulary instruction within SciGen on science comprehension for MLLs-RD at the middle school level?

3. What is the effect of teaching science vocabulary using multimodal vocabulary instruction within SciGen on the science attitudes of the MLLs-RD at the middle school level?
4. How do students rate the effectiveness of the multimodal vocabulary instruction within SciGen on their learning, engagement, and interest in the topic, and science in general?

CHAPTER 3

Method

The research questions will be addressed with a repeated treatment single-subject experimental design with 10 participants. Next, I will describe the participants, measures, intervention, and procedure.

Setting

The study took place in a local refugee community organization in the U.S. Midwest. The refugee organization supports refugee and immigrant families from the Middle East, Africa, Afghanistan, Vietnam, Myanmar, and Ukraine by providing families with the services to address basic needs, education, and professional development (City of Refuge, n.d.). The organization provides immigrant and refugee school students with academic and social services support through twice a week after school programs: the Homework Helpers and Youth Impact Group. Both programs match volunteers with students to help with schoolwork, connect students with local resources, and provide a space for recreational activities (City of Refuge, 2024, September 26).

The Homework Helpers program supports elementary and middle school students' academic skills by giving them a quiet space and time to focus on schoolwork, reading or math activities. Each student is paired with a volunteer tutor and they both work on assigned tasks. In general, the program session begins with a trip to the playground, depending on the weather, followed by doing homework and academics at the organization space or the public library, and ending with time for board games. On some days, students have guest visitors, field trips or other educational, cultural, or recreational activities. The purpose of this group is to improve

students' academic, social, and emotional skills and lessen the learning gap between immigrants/ refugees and their peers.

The Youth Impact Group is another program that targets middle and high school students with special focus on academic tutoring, American College Testing (ACT) preparation, financial literacy, social emotional learning, and careers, and college preparation. Students are paired with volunteer tutors for academic support, and after finishing schoolwork students can engage in recreational activities. This group improves students' skills to be ready for high school and life after graduation.

A non-exempt Institutional Review Board approval #2100241 was granted for the study on October 9th, 2024. Additional security background checks and volunteer training were conducted by the host organization to ensure the safety of participants. Upon completing the required approvals and training, the research team were permitted to work with the children.

Participants

The sample of the study was recruited in collaboration with the local refugee host organization from both the Homework Helpers and Youth Impact Group programs. Participants were recruited based on the selection criteria, (a) enrolled in the middle school level in grades 6 through 8, (b) identified by the school district as emerging multilinguals, and (c) identified by the organization/parents as students having reading difficulties in English language (at least in one area of reading).

Parents of the 15 middle school students from a multilingual background who attended one of the two programs were contacted through phone calls and in person meetings to inform them about the study. Translated copies of consent and assent forms of the research study were provided to families where the researcher and interpreters contacted each family, provided

detailed information on the study for students and parents, and responded to inquiries about the study. Upon approval, signed consent and assent forms were collected from families.

The parents of the 10 students provided consent for their students to participate. Thus, the study sample included 10 students of diverse countries of origin with different native languages, legal status, years in the United States, grade levels and disability status. Prior to the study, the researcher had a short informal interview with the family of each participant to inquire about the student background such as parents' education, number of family members of the household and student order, students' legal status in the US and parents' involvement in the student education, and to build rapport with the families and participants.

Most of the participants (n = 6) were originally from Afghanistan, the Pashtun ethnicity. Four of the Afghan participants were refugees who entered the United States in the past 3 years following the withdrawal of the U.S. troops from Afghanistan in 2021. Of the four remaining participants two were from Egypt, one from Libya, and one from Tanzania. The six Afghan participants spoke the Pashto language which was the first language in Afghanistan and spoken across parts of Pakistan and Iran (UNESCO, n.d.). Three of the four non-Afghan students spoke Arabic and the student from Tanzania spoke Swahili.

Most of the students were in the United States for 4 years or less (n = 9) while only one student spent less than 1 year. The sample included students at middle school from Grades 8 (n = 2), 7 (n = 4) and 6 (n = 4). Only one student was identified with a disability and had an individualized educational plan (IEP) under the language impairment category. Many of the participants were enrolled in an English learner-clustered school (n = 6), which was one of the school locations designated by the district for the English language learners and newcomer students. All participants received a free or reduced-priced lunch from their schools. View

table 1 for student participant information. After the table, an overview of each participant is provided using a pseudonym for each student.

Table 1

Student Participant Demographic Characteristics (n = 10)

Variable	*n*	%	Variable	*n*	%
Sex			Number of Spoken Languages		
Male	5	50	2	6	60
Female	5	50	3	3	30
			4	1	10
Grade Level			Country of Origin		
6^{th} grade	4	40	Afghanistan	6	60
7^{th} grade	4	40	Egypt	2	20
8^{th} grade	2	20	Tanzania	1	10
Free or Reduced-Priced Lunch	10	100	Libya	1	10
Legal Status			Years in the United States		
Refugee	5	50	1 or less	1	10
Immigrant	4	40	2	3	30
Citizen	1	10	3	5	50
Special Education Disability	1	10	4	1	10

Nada

Nada was a sixth-grade female student who was originally from Egypt and arrived in the United States 2 years ago. Nada was a multilingual learner who spoke Arabic as a native

language, English as a second language, and Japanese as a third language. Both of Nada's parents had a university degree, and both were biliterate in English and Arabic. The family was legally staying in the United States as immigrants.

Sahar

Sahar was a female student in sixth grade who arrived in the United States 3 years ago as an immigrant with her family. Sahar was a MLL who spoke Pashto as her first language, Farsi as her second language, and English as her third language. She also knew how to read and write in Arabic. Sahar's father completed high school in Afghanistan and was proficient in English and Pashto. Her mother completed third grade and was only proficient in Pashto. The family was legally staying in the United States with immigrant status.

Huzaifa

Huzaifa was a sixth-grade male from Afghanistan who arrived in the United States 4 years ago. Huzaifa was a MLL who spoke Pashto as his first language, Farsi as his second language, Urdu as his third language, and English as his fourth language. He had some basic knowledge of reading in Arabic. Huzaifa's father had a graduate degree from a college in the United States and spoke proficient English, while his mother finished high school in Afghanistan and spoke only some English. The family was legally staying in the United States as refugees.

Zia

Zia was a sixth-grade male who was originally from Afghanistan and who moved to the United States 3 years ago with his family as refugees. Zia was a bilingual learner who spoke Pashto as his first language and English as his second language. Zia spoke and wrote in English, but both of his parents were reportedly illiterate in their native language.

Ali

Ali was a seventh-grade male student who is originally from Afghanistan who moved to the United States 3 years ago with his family as refugees. Ali was also a MLL who spoke Pashto as his first language and English as his second language. Ali spoke and wrote in English only and both of his parents were reportedly illiterate in their native language.

Reza

Reza was a seventh-grade male originally from Afghanistan who moved to the United States 3 years ago with his family as refugees. Reza was a MLL who spoke Pashto as his first language and English as his second language. His father completed high school in Afghanistan and was proficient in both English and Pashto, while his mother completed middle school and was only proficient in Pashto.

Anaya

Anaya was a seventh-grade female student from Afghanistan who moved to the United States 3 years ago as a refugee. Anaya spoke Pashto as her native language and English as her second language. Anaya's father completed high school in Afghanistan and was proficient in English and Pashto. Her mother completed elementary education in Afghanistan and was only proficient in Pashto.

Arwa

Arwa was a seventh-grade female student who was born in the United States and raised in Libya. She returned to the United States 2 years ago and was currently enrolled in the EL and special education school services under the language impairment category. Arwa's parents were both biliterate in English and Arabic. Her mother had a graduate education from Libya, and her father completed high school education in Libya.

Yasin

Yasin was an eighth-grade male student who was originally from Egypt and who was Nada's older brother. He arrived with his family in the United States 2 years ago. Yasin was a MLL who spoke Arabic as a native language, English as a second language, and Japanese as a third language. Both of Yasin's parents had a university degree, and both were biliterate in English and Arabic. The family was legally staying in the United States as immigrants.

Tumo

Tumo was an eighth-grade female student from Tanzania who arrived in the United States 9 months ago as an immigrant with her family. Tumo's native language was Swahili, and she spoke English as her second language. Tumo's father completed college and spoke Swahili, French, and English proficiently. Her mother finished high school from Tanzania and was also multilingual with a developing level of English proficiency.

Measures

Different measures were used throughout the study to evaluate student performance during screening, pre, during and post stages of the study. For the screening stage, the researcher used academic measures (including language, science knowledge and vocabulary) and non-academic measures (such as acculturation and English language use) for eligibility determination. Pre and post study measures of science vocabulary and science attitude survey were used to evaluate the levels of vocabulary and attitude on science before and after the study. During the study, science vocabulary and comprehension measures were used to assess the level of mastery of academic content. Also, a Likert scale exit slip was used to investigate the social validity of the intervention. This section provides a detailed description of each measure.

Screening Measures

Screening assessments were implemented to ensure that participants meet the inclusion criteria because the study was conducted in a non-school setting and there was no access to most of the students' academic records, English Language Learner status (EL status), and demographic information. The assessments incorporated standardized academic assessments, and non-academic assessments such as the short acculturation survey and language acculturation survey.

Vocabulary and Reading Skills

The Peabody Picture Vocabulary Test, Fifth Edition (PPVT 5) was used to assess students' knowledge of vocabulary (Dunn, 2019). In order to evaluate students' academic performance, Woodcock-Johnson IV (WJ IV) subtests of reading Word– Letter Identification (W-L ID) and Passage Comprehension (Comprehension), were selected and the Science subtest from the Cross-Domain Clusters was administered to assess science knowledge (Mather & Wendling, 2014). WJ IV subtests have a high reliability in individuals aged 5 to 19, with median reliability of 0.92 for W-L ID, 0.89 for Comprehension and 0.76 for Science (Mather & Wendling, 2014). PPVT 5 demonstrates high reliability across different age groups with an overall reliability of 0.97 (Dunn, 2019). The half-split reliability of 0.97 for individuals aged between 11 years 0–11 months, 13 years 0-11 months, and 14 years and 0-11 months, and 0.98 for individuals aged 12 years 0:11 months (Dunn, 2019).

The researcher and one graduate student in special education, with 10 years of experience as a special education teacher, were trained on how to administer the measures during a 2-hour in-person training that was facilitated by a nationally certified school psychologist. The screening measures were conducted in person in a one-to-one setting by the

researcher, but each administration was also recorded via Zoom. The recordings were reviewed by the trained graduate student to ensure fidelity of implementation and scoring. The student responses were coded as correct or incorrect by the observer to compute interobserver agreement. The average time of test assessment administration across participants was 30 minutes and 14 seconds.

Interobserver agreement. Interobserver agreement (IOA) was computed for the two measures by having both assessors score each student response, one in person and one with the recorded Zoom session. The number of agreements was divided by the total number of items administered and multiplied by 100 to obtain a percentage of agreement, which equaled 100%.

Results of screening. As shown in Table 2, Nada and Anaya scored the highest among participants, with standard scores of 71 which equaled the third percentile. The remaining eight students all had standard scores that fell at or below the first percentile and suggested significant difficulty with receptive vocabulary in English.

Results of WJ IV indicated that all participants met the inclusion criteria exhibiting a deficit in one or more areas of reading. However, variability in performance was identified across participants. Nada scored the highest in the WJ subtests of ID (SS: 99, PR: 47), Comprehension (SS:88, PR: 21) and Science (SS: 83, PR:13). Huzaifa also scored relatively high in ID (SS: 97, PR: 42), but lower on Comprehension (SS: 82, PR: 12) and Science (SS: 60, PR:0.4). Zia, Reza and Tumo scored the lowest, having a standard score of 40 for ID (PR: <0.1), and scores below 40 for Comprehension (PR: <0.1) and Science (PR: <0.1). Anaya, Arwa and Yasin showed variability in scores where Anaya scored higher in ID but lower in comprehension compared to Arwa and Yasin.

Instructional groups. Students were paired in groups based on grade and performance where each group consisted of a minimum of two students with higher achievement paired with students with lower achievement. For Group 1, Nada and Sahar were paired, as well as Huzaifa and Zia. In Group 2, Yasin was paired with Ali, Reza with Anaya, and Arwa with Tumo. Later, the three boys Yasin, Ali and Reza were paired together, and the three girls Anaya, Arwa and Tumo worked together as a team.

Table 2

Students' Academic Screening Scores

	PPVT 5		WJ ID		WJ Comprehension		WJ Science	
Student	SS	PR	SS	PR	SS	PR	SS	PR
Nada	71	3	99	47	88	21	83	13
Sahar	54	0.1	41	<0.1	<40	<0.1	45	<0.1
Huzaifa	61	0.5	97	42	82	12	60	0.4
Zia	40	<0.1	40	<0.1	<40	<0.1	40	<0.1
Ali	58	0.3	<40	<0.1	<40	<0.1	40	<0.1
Reza	40	<0.1	40	<0.1	40	<0.1	<40	<0.1
Anaya	71	3	<40	<0.1	<40	<0.1	48	<0.1
Arwa	59	0.3	75	5	50	<0.1	<40	<0.1
Yasin	65	1	73	4	42	<0.1	55	0.1
Tumo	40	<0.1	<40	<0.1	<40	<0.1	<40	<0.1

Note. *Age Based Standard Scores (SS) and Percentile Ranks (PR) on the Peabody Picture Vocabulary Test - 5th Edition (PPVT-5), and the Woodcock-Johnson 4th Edition (WJ IV) Letter Word Identification (ID), Comprehension, and Science Subtest for the Participants*

Acculturation and Language Use Measures

Two self-reporting short surveys were used to evaluate students' immersion in the U.S. culture and English language. The acculturation measure assessed social circles, relationships, food preferences, holidays observance, and thinking processes. Meanwhile, the language acculturation survey or English language use survey evaluated the English language use in reading and thinking, personal communication with others, friends, and family members. Below is an overview of each measure. In this study, the acculturation measures were used for two main purposes: 1) evaluating students' linguistic and cultural integration in the American society, and 2) according adjust the academic intervention to address students' academic and socio-emotional needs.

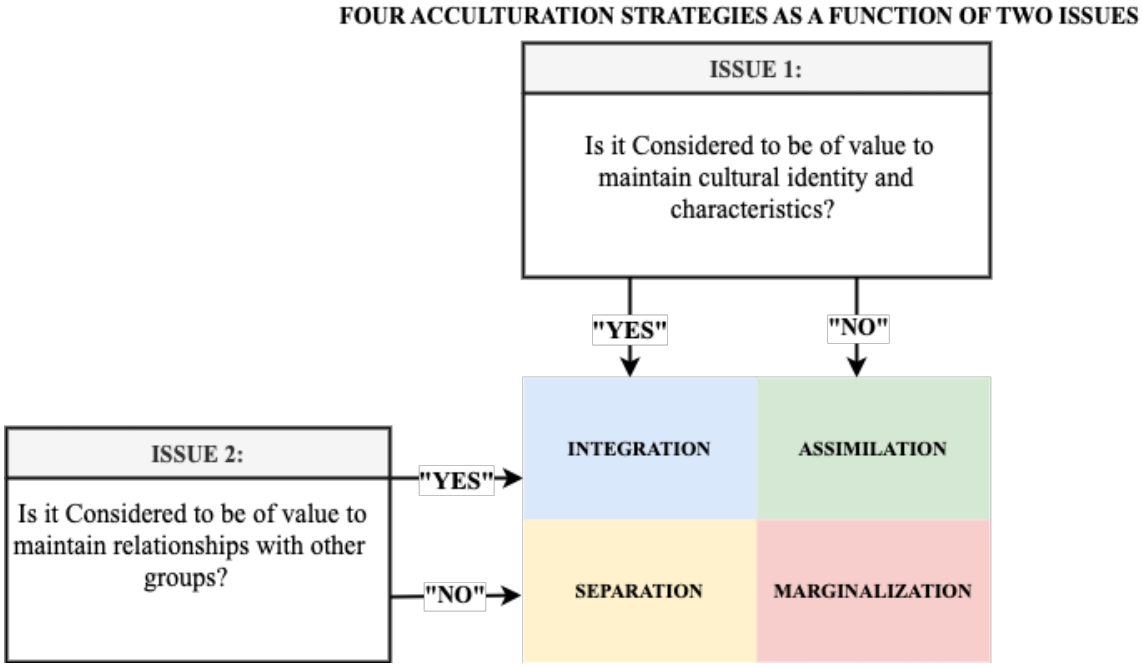
Acculturation Short Survey

Acculturation refers to the process of cultural and psychological change that occurs when different cultures interact (Sam & Berry, 2010). Acculturation was selected as a diagnostic measure because the degree of language acquisition among second language learners depends on their level of acculturation (Schumann, 1986). Acculturation measures were adapted from the Acculturation, Habits, and Interests Multicultural Scale for Adolescents Acculturation Short Survey (AHIMSA) created by Unger et al. (2002). This measure was developed based on Berry's (1992) acculturation model. According to this framework, when responding to a cultural shock, individuals follow different adaptation strategies in response to two main issues: (a) acceptance or rejection of one's native culture: whether it would be valuable to maintain one's native identity and characteristics (Berry, 1992); and (b) assimilation or rejection of the new culture and whether it would be valuable to maintain relationships with other groups (Berry, 1992).

The responses for these two questions are categorized into four types ordered as follows: (a) Integration, the highest level of acculturation, is when individuals adopt elements from both native culture and new culture; (b) Assimilation, when individuals adapt elements from the new culture only; (c) Separation, happens when individuals neglect the new culture in favor of the native culture; and (d) Marginalization, the lowest level of acculturation, occurs when individuals reject both native and new cultures (Berry, 1992). Figure 4 shows Berry's model of acculturation strategies of adaptation (Berry, 1992).

Figure 4

Berry's (1992) Acculturation Framework: Acculturation Four Strategies



The assessment was administered individually where the survey began with requesting students to fill out demographic information on grade, number of years in the United States, citizenship status, country of origin, and languages spoken at home. Then, an example question was used to practice using the measure where the student read a statement on sport preference

(i.e., The sports or physical activities I enjoy are influenced by…) and chose the option that represents them the most. The researcher read aloud each statement and clarified any question and choice, if necessary. To increase accessibility, the survey provided a read-aloud option and translation services to assist students with unknown words.

Students were asked to respond to statements about their personal preferences by selecting one of the four options: a) The United States, b) The country my family is from, c) Both, d) Neither. Each response represents a different acculturation strategy, and the responses were scored based on the acculturation level they represent. For example, when responding to a prompt, selecting "The United States" indicates Assimilation (ranked as 3), and selecting "The country my family is from" indicates Separation (ranked as 2). On the other hand, selecting "Both" indicates Integration (ranked as 4, the highest level), and selecting "Neither" indicates Marginalization (ranked as 1, the lowest level). On average, students spent 20 minutes and 27 seconds responding to the survey. The Cronbach's alpha coefficients of the measure subscales indicated acceptable internal consistency for the Assimilation ($\alpha = 0.79$) and Integration subscales ($\alpha = 0.79$), moderate reliability for the Separation subscale ($\alpha = 0.68$), and low reliability for the Marginalization subscale ($\alpha = 0.50$) () (Unger et al., 2002).

As shown in Table 3, the survey results showed different levels of acculturation across the survey items with a higher level of integration for Items 1, 2 (60%), and 8 (50%) compared to higher levels of separation for Items 7 (70%) and 6 (60%) respectively. According to the results, 60% of students reported integration, the highest level of acculturation, in terms of Item 1 on being comfortable with people from both native and new cultures and Item 2 on having best friends from both cultures. For Item 8, on the way they think and do things, 50% of students reported assimilation, rank 3 of acculturation.

The separation strategy was prominent in some areas, particularly for Item7 where 80% of students reported food from their native culture, followed by Item 6, in which 70% of students indicated celebrating native holidays. This indicates that while students may integrate some elements from the new culture, their ties with the native culture continue to be strong.

Table 3

Frequency of Responses on Acculturation Level Scale

	The United States (Assimilation)		The Country My Family Is From (Separation)		Both (Integration)		Neither Marginalization)	
Item	*n*	%	*n*	%	*n*	%	*n*	%
1. I am most comfortable being with people from	0	0	4	40	6	60	0	0
2. My best friends are from	2	20	2	20	6	60	0	0
3. The people I fit in with best are from	6	60	3	30	0	0	1	10
4. My favorite music is from	1	10	4	40	4	40	1	10
5. My favorite TV shows are from	1	10	4	40	4	40	1	10
6. The holidays I celebrate are from	3	30	7	70	0	0	0	0
7. The food I eat at home is from	0	0	8	80	2	20	0	0
8. The way I do things and think are from	1	10	4	40	5	50	0	0

Language Acculturation.

English language usage was evaluated using a four-item survey adapted from Unger et al. (2002). Unger's work was created based on the Brief Acculturation Scale for Hispanics (BASH) developed by Norris et al. (1996). The original measure reported strong internal reliability of Cronbach alpha coefficients for total Sample (α = .90), Puerto Rican Respondent subgroup (α = .92) and Mexican American Respondent subgroup (α = .92) (Norris et al., 1996).

The survey included the following questions: “In general, what language do you read?”, “In general, what language do you speak?”, “What language do you usually speak at home?”, “What language do you usually think in?”, “What language do you usually speak with friends?” The responses include Only English, Mostly English, English and Another Language, Mostly Another Language, and Another Language Only. For this study, Items 1 and 2 from the original survey were combined into one item, “In general, what language do you read and speak?”. Responses were scored as in Table 4, where Only English was scored as 5 (the highest English language usage level), and Another Language Only was scored as 1 (the lowest English language usage level).

Table 4

Frequency of Responses on English Language Use Scale

	Only English (5)		Mostly English (4)		English and Another Language (3)		Mostly Another Language (2)		Only Another Language (1)	
Item	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
1. In general, in what language do you read and speak?	2	20	0	0	5	50	3	30	0	0
2. What languages do you usually speak at home?	4	40	0	0	3	30	2	20	1	10
3. In what language do you usually think in?	0	0	0	0	1	10	1	10	8	80
4. What language do you usually speak with friends?	1	10	2	20	6	60	0	0	1	10

As shown in Table 4, participants reported lower levels of using English language in most of the survey items (i.e., Items 1, 3 and 4) compared with a higher level of English usage for Item 2. For Item 3 on the language of thinking, 80% of students reported thinking in their native language, compared to 0% of students thinking in English or Mostly English. On Item 4 about language use with peers, 60% of participants indicated using English and another

language when speaking with friends, while only 10% percent reported using English only while communicating with peers. Responses on Item 1 on reading and speaking language revealed that 50% of participants read and speak in both English and their native language, while 10% responded by reading and speaking mostly in their native language. Interestingly, only students with illiterate parents (i.e., who do not read and write in their native language) reported reading and speaking only in English.

Using English only was the most rated in use for home oral communication. 40% of participants reported speaking only English, compared with 30% reported using English and another language, 20% for using mostly native language and 10% for using only their native language. Based on these results, while many students reported using English only in home communication, or both languages in reading and speaking with peers, the usage of their native language was prominent in thinking.

Per the results of academic assessments and acculturation and language surveys, all students were confirmed to be emerging multilingual learners (MLL) under the ELL status in which they reported lower levels of acculturation and English language use. Similarly, the results of PPVT 5 and WJ IV confirmed that participants met the academic inclusion criteria of the study.

Science Vocabulary and Science Comprehension

After meeting the eligibility criteria, the researcher conducted pretests of academic knowledge (science vocabulary and reading comprehension) and on science perception (attitude). The science vocabulary and comprehension measures used in this study were researcher-generated. Given these measures are often more proximal and sensitive to growth, they should result in data that can show a positive effect. Both performance measures of

science vocabulary and comprehension are researcher-generated using Artificial intelligence tools (AI). The study measures were created using Diffit AI and ChatGPT tools. Then, measures were tested and reviewed by the researcher to match grade lexile level and research guidelines and peer-reviewed by three senior researchers in the fields of English language arts, special education and evaluation and a state certified experienced teacher in the science, technology, and mathematics field. Microsoft Forms were used for data collection due to their accessibility with read aloud, and translation services.

Research Question 1: Science Vocabulary Acquisition

Science vocabulary acquisition was assessed using a researcher-developed science vocabulary acquisition performance measure guided by previous measures developed by Espin et al. (2013) and Conyer et al. (2023). Vocabulary knowledge measures were timed, had two distracting definitions and each definition did not exceed 16-word limit (Conyer et al., 2023). The measure included 5 item vocabulary-matching measures where students matched the definition with the correct term and *additional* two definitions for distraction (i.e., 7 total definitions). The score for each measure was the number of items correctly matched and ranged from 0 to 5.

Four academic progress monitoring measures were created by combining weekly vocabulary acquisition and reading comprehension measures into a single assessment to facilitate implementation. However, students reported the start and finish times separately for each measure. Four research experts and a science teacher reviewed the measures, and finally four middle school MLLs were asked to pilot test them before using them for this study. View Appendix B for the progress monitoring measures. Before using the measure, I trained the

participating students on using the measure through a practice activity where they match capitals with countries and answer multiple choice questions on a text about a country.

Research Question 2: Science Comprehension

Existing comprehension measures do not provide content area specific comprehension assessment (Morsy et al., 2010). Thus, previous researchers often used researcher-developed measures for science comprehension studies (Kaldenberg et al., 2015). Therefore, for this study I created science comprehension measures using AI tools that were based on Ardasheva et al. (2021). First, I created science passages and corresponding questions with *Diffit* (https://beta.diffit.me/#topic). Diffit is an educational AI tool that can alter texts across various levels and languages. Moreover, it generates summaries, identifies key vocabulary words, and creates comprehension and open-ended questions suitable for class discussions that teachers can review and modify (Ferlazzo, 2023). I used this tool to create a passage that incorporated the newly taught words at the student grade level. The following prompt was used on Diffit main interface page "*Create a comprehension paragraph (1030L–1340L) in 300 words discussing multicellularity and how a system is greater than the sum of the parts using words organism, tissue, organ, system, strategy, specialize, cooperate & hierarchy.*" In response to the order, the tool created a passage with multiple choice and open-ended questions. The researcher adapted/changed the multiple choice and removed the open-ended questions.

The Lexile level of the passage was checked using Lexile Text Analyzer (https://hub.lexile.com/analyzer) and Hemmingway Editor (https://hemingwayapp.com/).Flesch-Kincaid Grade Level was analyzed using Microsoft Word Lexile analyzing tools. The Lexile analysis resulting data are presented in Table 5. The sequence of questions was: 1. Vocabulary knowledge, 2. Scanning comprehension, 3.

Skimming (main idea), 4. Lexicon (relationship between words and sentences for text comprehension, and 5. Comprehension inference skill.

Then, the researcher asked a senior research expert, an English language arts college professor, an assessment expert, and a science teacher to review the measures before asking volunteer middle school MLLs to pilot test it. Four comprehension tests were created (i.e., one per each unit) and comprehension data were collected resulting in five comprehension data points for each unit. Each comprehension measure consisted of 5 items. The scores range was between 0 for the lowest and 5 for the highest.

Table 5

Difficulty Level Data for Comprehension Measure Passages

Measure	Word Count	Lexile Text Analyzer Lexile Range	Hemingway Editor Readability	Flesch-Kincaid Grade Level
Week1	272	810L - 1000L	Grade 8	7.7
Week 2	248	810L - 1000L	Grade 8	7.5
Week 3	300	810L - 1000L	Grade 7	7.7
Week 4	243	810L - 1000L	Grade 7	7.9

Research Questions 3 and 4: Science Attitude and Social Validity

I used the following two non-performance measures in this study to address Research Questions 3 and 4 science attitude scale for science attitude and exit slip for social validity. A science attitude scale was adapted from Kind et al. (2007) and Tretter et al. (2017) to measure the students' science attitude before and after the intervention. The measure addresses the constructs of (a) learning science in school, (b) practical work in science, (c) science outside of school, the importance of science, self-concept in science, and (d) future participation in science (Kind et al., 2007). Students rated five statements about science before and after the intervention using a 5-point Likert-type scale with the following options: 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, and 5 for strongly agree. The data were examined by item, which ranged from 1 to 5.

Social validity is the evaluation of the effectiveness, suitability, and satisfaction of participants on the intervention (Kennedy, 2005). While developing research-based interventions is important, there is less focus on the perspectives of students regarding these interventions at the school level. Exit slip is a highly recommended and uncomplicated way to gather knowledge about students' engagement in and understanding of a lesson and use this information to adjust instruction so learners can achieve greater success (Windschit et al., 2013). A researcher-developed exit slip survey was used by students to rate their learning experiences after the treatment conditions. The exit slip consisted of 5-point Likert scale items (i.e., rate lesson, engagement, science learning, vocabulary learning and interest in the topic) adapted from Abdelnaby et al. (2023) for rating science instruction. At the end of each treatment session, students individually rated the quality of the lesson in the aforementioned areas from 1 to 5, in which 5 is the highest and 1 is the lowest. The scale five ranks were: 1 Not good at all 😠, 2 Not good 🙁, 3 Okay 😐, 4 Good 🙂, and 5 Very good😁. The scale included emojis and a student friendly interpretation of each scale level in order to enhance respondents' understanding and engagement. The score was the mean rating for each unit by group and ranged from 1 to 5.

Intervention

Science Generation (SciGen), developed by The Strategic Education Research Partnership at Harvard University, was a part of the Word Generation (WG) program curriculum focusing on Tier 2 and Tier 3 academic vocabulary with a focus on science. It was an extended vocabulary intervention in which 18 week-long units offered opportunities to read, write, discuss, and develop arguments about topics in science by building relevant knowledge and offering opportunities to use academic vocabulary in different contexts (SERP Institute,

n.d.). Each intervention week-unit included daily 40–50-minute science lessons that introduce 5–10 academic words, supplemented by cross-disciplinary activities to enhance engagement and support scientific argumentation (SERP Institute, n.d.). The units cover the areas of Life Sciences, Physical Sciences, Earth and Environmental Sciences, Chemistry, Physics, and Scientific Inquiry and Methods. (SERP Institute, n.d.). Access to all instructional materials, including PDF documents, lesson plans and dashboard is provided free of charge for teachers upon signing up on the program website (https://access.serpinstitute.org/register/?page=112).

The curriculum was selected for its effectiveness, affordability, and alignment with both state and national standards. First, the WordGen and SciGen curricula were implemented in randomized control trials and demonstrated effectiveness among fourth through seventh graders including multilingual learners, with an effect size *of d* = 0.19 in perspective-taking skills and *d* = 0.10 reading comprehension for sixth and seventh graders (Jones et al., 2019). Second, all instructional materials specifically designed for the program for educational purposes including activities, illustrations, lesson plans, videos and animations are available free of charge on the website upon signing up. Third, the curriculum is aligned with national standards. Fourth, compared with Science Vocabulary Support and other interventions, the intervention is independent academic units that are designed to be taught independently from school curriculum. The researcher along with a state certified science teacher reviewed content and selected two units that met the state learning standards and Next Generation Science Standard (NGSS), as shown in Table 6. Unit summary and standards are in Appendix 1.

Table 6

Units Taught in the Intervention with Corresponding Target Words and Standards

Unit	Description	Target Words	State Standards	NGSS
Unit L6: Cells Teaming Up	The unit examines multicellularity and its hierarchy by using a sports team metaphor.	Tier 2 Words: Strategy, Specialize, Cooperate, Hierarchy Tier 3 Words: Organism, Tissue, Organ, System	6-8.LS1.A.1 6-8.LS1.A.2 6-8.LS1.A.3 6-8.LS1. A.4	MS-LS1-1 MS-LS1-2 MS-LS1-3 MS-LS1-4
Unit M1: Small, Smaller, Smallest	The unit explains the structure and properties of matter for students.	Tier 2 Words: *Conservation, Reaction* Tier 3 Words: *Particle, Element, Atom, Molecule, Compound, Particulate*	6-8.PS1.A.1 6-8.PS1.A.2 6-8.PS1. B.1	MS-PS1-1 MS-PS1-2 MS-PS1-3

Note. NGSS refers to the U.S. Next Generation Science Standard.

While the curriculum demonstrated positive effects in previous research, I made additional adjustments to solidify instruction and increase accessibility of content. Effective content area vocabulary instruction for MLLs at elementary and middle school students should be provided intensively over multiple days, integrated with English language instruction in content areas, offer opportunities of structured writing practice, and be delivered in a small-group model for student needing literacy and language support (Baker et al., 2014). Thus, each lesson had a vocabulary review and writing activity in which students interacted with the words and texts in class or after class (i.e., using words in sentences, found poems and blackout poetry) as homework. All instructional materials were included in a colored student activity book for each unit that included a glossary of target words and in class and homework sheets. Multiple scaffolds were added to the small group lessons including higher achieving multilingual peers to provide academic support, translation of materials in the native language, vocabulary review using multimedia flashcards, Quizlet wordlist, so students can review and practice words at their own pace during and outside the class.

The original lesson plans were adjusted to meet state standards. For example, one section of Unit 2 on organ transplants was removed because its focus was not included in the standard. Unlike the original curriculum lesson plans, the focus on explicit direct vocabulary instruction was strongly demonstrated throughout the lessons. At the beginning of each unit, students were directly instructed on the new vocabulary following the Promoting Adolescents' Comprehension of Text (PACT) model in which students learned the new words, pronunciation, syllables, definitions, examples and non-examples on each and how to use it in a sentence. Students were provided with a glossary for each term with a visual presentation and a translation of the terms in their native language. In their activity book, students fill in graphic

organizer with definition, visual presentation, example and non-example for each word. Then, there was a controlled practice on matching words with definitions while having two extra definitions as distractors and students completed the rest of the activity as a homework. On Day 2, the lesson opener was a vocabulary review activity, followed by a written vocabulary practice activity, and then the lesson followed the original format lesson.

On Day 3, the lesson also began with a vocabulary review activity, then I followed the original lesson plan while adding an additional vocabulary usage activity where students used the words in context through a short STEM slow reveal graph activity. In this activity, the teacher presented graph components in stages to engage students and avoid information overload. Students looked at the graph and used new words to answer questions on the graph in writing, students used different familiar words including the new words to create found poems as a practice. On Day 4, the lesson began with another short practice activity and followed the original format but concluded by an additional activity in which students created blackout poetry texts through highlighting words of interest and crossing out unnecessary extracts. On Day 5, after reviewing the words, the lesson followed the original plan but was wrapped up with a word tournament game in which students selected their favorite words and competed in teams to pick their favorite. Detailed lesson plans for each day can be found in Appendix C.

The curriculum units' content and activities were reviewed and adjusted to meet students' interests and needs. First, curriculum was scanned to navigate how well the instructional units would support MLLs from Afghanistan, Egypt, Libya and Tanzania. using the Culturally Responsive Curriculum Scorecard developed by the NYU Metro Center (Bryan-Gooden et al., 2019). The five key areas of the rubric were: Representation, Social Justice,

Student-Centered Instruction, Linguistically Responsive Practices, and Teachers' Materials & Supports. The content was evaluated manually through the researcher and electronically using the artificial intelligence tool ChatGPT. The results indicated a lack of cultural responsiveness in the instruction in the rubric areas. In order to bridge this gap, the researcher incorporated instructional and content and linguistic scaffolds to enhance the learning experience such as using multimedia, ELA activities (word tournament, blackout poetry and found poems) and STEM activities (i.e., slow reveal graph and PhET Interactive Simulations for atoms: (https://phet.colorado.edu/en/simulations/build-an-atom).

After each session, students were assigned a short homework task. Homework components was added to provide students opportunities to practice language and it was incorporated in previous research on MLLs in the STEM field (Lara-Alecio et al., 2012; Van Orman et al., 2021). Selected homework assignments were mostly adapted from the Science Vocabulary Support Intervention (Ardasheva 2013; Ardasheva & Tretters, 2017) except for homework day 1. For day 1, students were assigned to match word with definitions, as a practice for the assessment. For Days 2 and 4, students were asked to copy words using the spelling pyramid, in which students build the word step by step by adding one letter at a time. The purpose of this activity is to support knowledge of word spelling and pattern recognition. For days 4 and 5, students were asked to use words in meaningful sentences to build their knowledge of the use of words in contexts. The completion of homework was recommended but not mandated.

Additionally, cultural, and linguistic adjustments were made to increase engagement with the content. For example, the dialogue on the first unit on basketball was changed to soccer 'football' as it was the favorite sport among the participants and the most popular in

their native countries. Additionally, some unfamiliar proper names in the dialogues were replaced with more common ones. Elements from students' native culture such as pictures of famous soccer 'football' players, food items and translations of texts in their native language were included in the lessons. During the lesson students were encouraged to use their native language with peers if they could not express themselves enough in English in order to clarify meanings or express their ideas. Students had the space to share their personal experiences and native culture. The dynamic nature of activities provided students with a safe space to learn and interact with peers without feeling pressured. View Table 7 for an overview of the intervention.

Table 7

Overview of Treatment Procedure

Session	Activity
One: **Introduction** 60 minutes	-Introduce intervention format and materials (PACT): Word, syllables, definition, visual representation, word in a sentence, example and non-example for each word. -Teach new words using visual and instructional scaffolds and direct instruction (PACT). -Controlled Word Practice: Match word with pictures. - Science Generation activities. - Closing activity: Students share something they learned in the class. - Progress monitoring 1 -Exit slip 1 -Homework 1: Complete the matching word with definition activity.

Two: -Opener

Practice 1 -Review week 1 words (PACT)

60 minutes -Work in words in context and connect words across authentic science contexts and modalities (such as science investigations, journaling, videos, chapter activities, and further readings)

- Science Generation activities

- Closing activity

- Progress monitoring 2

-Exit slip 2

-Homework 2: Copy 5 words as a word pyramid.

See the example blow for the word *hierarchy.*

h

hi

hie

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hiera

hierar

hierarc

hierarch

hierarchy

- Students repeat this for five different words from the vocabulary list.

Three:	- Opener
Practice 2	- Review week words (PACT).
60 minutes	- Connect words across authentic science contexts and modalities.
	Math and science slow- reveal-graph: Teacher presents a normal bar chart. in stages, instead of all at once. For example, the teacher presents the graph. bars, then x axis, followed by y axis and then the graph label. Students practice reading and interpreting the graphs in an interactive way through analysis and discussion without being overloaded with information through AI generated slow reveal graphs. (https://slowrevealgraphs.com/)
	- Reading and writing practice
	- Found poem activity: Students build a poem using paper excerpts with words.
	- Closing activity.
	- Progress monitoring 3.
	- Exit slip 3.
	- Homework 3: Copy the rest of the words as word hierarchy.

Four:	-Opener
Open Practice	-Review week words
60 minutes	-Blackout poetry: Students receive a text, watch a video and highlight words on interest to create a message.
	- Closing activity
	- Progress monitoring 4
	-Exit slip 4
	-Homework 4: Choose 5 words and use them in complete sentences. Directions: Write one complete sentence using the word in a science context. Example: *Photosynthesis* is the process green plants use sunlight to make their own food.
Five:	-Opener
Open Practice	-Review week words
90 minutes	-Science Generation Curriculum
	-Word Tournament Activity: Students race in teams to select their favorite word. Teacher uses Flippity website to show word brackets (https://www.flippity.net/TournamentBracket.htm).
	- Closing activity
	- Progress monitoring 5
	-Exit slip 5
	- Homework 5: Use the rest of the words in complete sentences.

Procedure

The intervention was delivered in two small groups. Participants were divided into groups based on their grade level. Group1 included the sixth-grade students, Nada, Sahar, Huzaifa and Zia, while Group 2 consisted of Ali, Reza, Anaya and Arwa, who were in seventh grade, and Yasin and Tumo from eighth grade. While all students have reading difficulties, each group included at least one student with a relatively higher academic reading skills was paired with peers with lower reading skills.

Baseline data was collected individually five times per week for the two-week condition span. Next, the intervention condition was conducted in 2 weeks with 5 sessions per week, and an average implementation of 1 hour per session. Following each intervention session students worked on homework using the activity book to practice the new words. Because most of the students needed additional support with the reading assignments and lacked those supports at home, students completed the homework before or after the intervention session with help of their higher achieving peers or the researcher. A summary of time per session in minutes (Duration) and homework completion percentage (HW%) is provided in table 8 below. Finally, generalization and maintenance data were collected individually after the end of the intervention. Maintenance measure was implemented once a week for 3 weeks after the end of the intervention in which students were asked to match 20 words randomly selected from the 4 units with 28 definitions. The words were not thematically organized in groups as in the pre-post assessment. The same measure was used in the maintenance phase a month later after the end of the intervention to evaluate students' mastery of word knowledge.

Table 8

Duration of Sessions in Minutes and Homework Completion Percentage (HW%) Across Study Units Per Each Session

	Unit 1				Unit 2			
	Group 1		Group 2		Group 1		Group 2	
Session	Duration	HW%	Duration	HW%	Duration	HW%	Duration	HW%
One	55	100%	60	60 %	60	100%	65	100%
Two	60	75%	63	80 %	55	75%	64	80%
Three	58	75%	60	80 %	57	75%	60	80%
Four	60	75%	65	80%	55	75%	55	80%
Five	83	75%	85	60 %	60	50%	65	60%

Note. Duration is measured in minutes. HW% = Homework completion percentage.

Research Experimental Design Overview

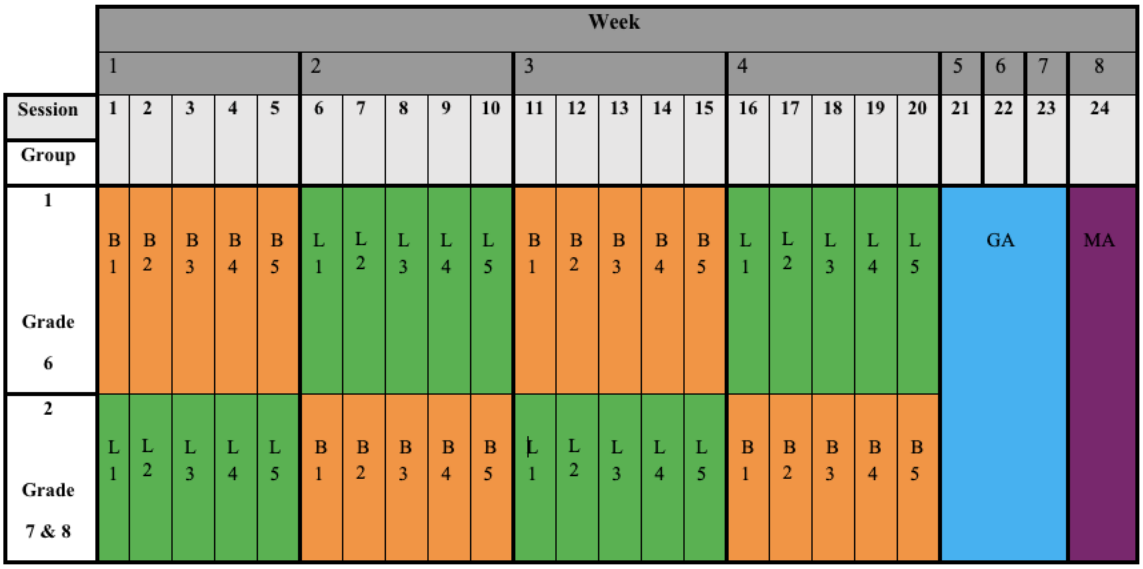
This study used an ABAB reversal single-subject design to investigate the impact of the Science Generation intervention on the science vocabulary knowledge and reading comprehension of ten middle school multilingual students. The reversal single-case design offers two opportunities to validate that the intervention is effective as it is initially observed (McCormick,1992). This comparison enhances the reliability of the findings (Riley-Tillman et al., 2020). It is a stronger version of the ABA design (Byiers et al., 2012) with a higher internal validity. Logistically, this design provides flexibility to conduct research on a low-incident student population (Cakiroglu, 2012; Kazdin, 1982), such as students identified as MLL with reading difficulties including those identified as refugees or with disabilities.

The reversal case design was selected because of its enhanced control with increased confidence that any observed treatment effects can be attributed to the treatment itself rather than other external factors (Kazdin, 2011). In this study, the *reversal* single-subject design was used to evaluate the change of the effect of the independent variable, SciGen intervention, on the dependent variables of reading comprehension, word acquisition and science attitude for middle school students in the Midwest area who are identified as both MLLs and with reading difficulties (MLLs-RD). The unit of analysis was the group, and all scores were averaged across the participants in the group to plot and visually analyze the data.

The study followed Council of Exceptional Children (CEC) guidelines for single subject design (CEC, 2014). The start of the sequence of conditions across participants was randomly assigned using Coin Flip (https://randomwordgenerator.com/coin-flip.php). The intervention was administered to students in two small groups. Small group design was selected based on evidence that preteaching vocabulary in such settings can improve reading comprehension (BlackBurns et al., 2011; Burns et al., 2011; Drevno et al.,1994). In the small group format, the researcher worked with a minimum of four students in each group to maintain the peer-based collaborative nature of the intervention. The conditions incorporate *baseline, intervention, baseline, intervention, generalization and maintenance* phases (CEC, 2014) as shown in Figure 5.

Figure 5

Study Design: Data Collection Schedule



Note. Numbers 6, 7 & 8 refer to grade level and Session to the number of sessions in each week. Orange B = Session number of baseline phase, where data collection of performance assessment and pre-science attitude survey. Green L = Lesson number in intervention phase in which lessons were implemented and vocabulary and comprehension performance assessment were used. Blue GA = generalization phase, and assessments used were generalization performance assessment and post-science attitude survey. Purple MA= maintenance phase, and assessment used was the generalization assessment vocabulary measurement.

Fidelity and Interobserver Agreement

Treatment fidelity was evaluated using an intervention checklist, developed by the researcher, which was used by independent observers. The intervention checklist was created to align with procedures with the components of the intervention (i.e., lesson plan components) and overall quality of instruction (e.g., model, lead, test and culturally responsive instruction). The intervention sessions were recorded and timed for implementation fidelity. The second observer was trained by the researcher on using the checklist. The researchers reviewed 4 practice videos in which the interobserver agreement of the fidelity training was 95%. Then, a

total of 30% of the intervention conditions were observed by the second independent observer using an intervention checklist. The number of items observed was divided by the total number of items and multiplied by 100 to compute a percentage for treatment fidelity. The fidelity total percentile was 95.7%.

Interobserver agreement was calculated for the interventionist's scoring of the outcome data in the same manner as intervention fidelity. The recorded video of the assessment session was viewed by a second observer. The total number of agreed upon items was divided by the total number of items and multiplied by 100. As shown in Table 7, IOA was high across all phases and equaled a total of 100%. View table 9 for Fidelity summary.

Table 9

Fidelity of Implementation Throughout the Study Phases

Phase	Observation %	Fidelity %
Diagnostic assessment	30%	100%
Pre assessment	25%	100%
During assessment	25%	100%
During intervention	30%	100%
Post assessment	25%	100%
Generalization	25%	100%
Maintenance	25%	100%
Total	27%	100%

Analyses

The participants' performance was graphed over time, and the intervention's effectiveness was examined with visual analyses of trend, level, and immediacy of level change. The Tau-U effect size was calculated using Tau-U calculator (https://singlecaseresearch.org/calculators/tau-u/). Pre- and post-test data were reported as means and standard deviations.

CHAPTER 4

Results

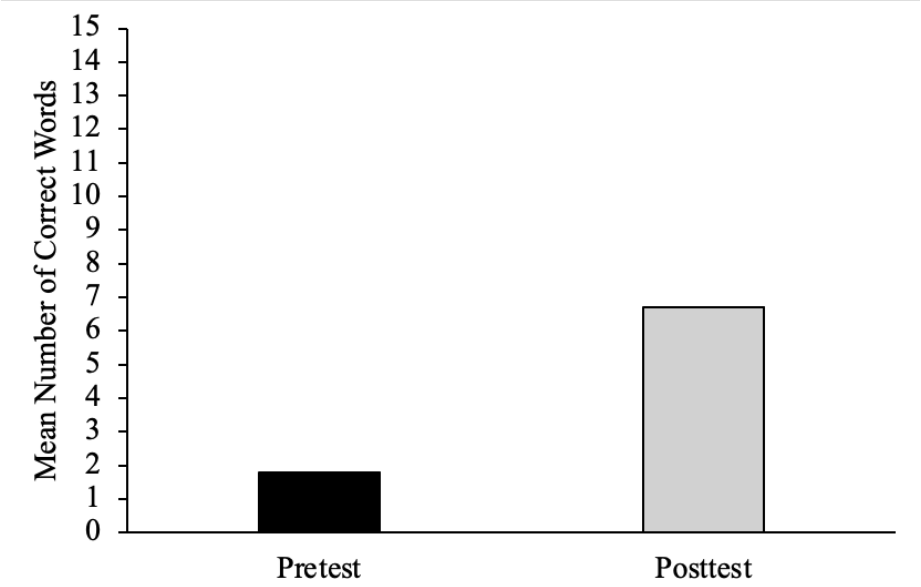
The study investigated the effect of multimodal vocabulary instruction on science vocabulary acquisition, comprehension, and attitude among multilingual learners (MLL) with reading difficulties at the middle school level. The study followed a single subject reversal ABAB design and intervention was implemented in a small group format. Likert scale social validity survey was used to evaluate the participants' perspectives on the intervention. Descriptive statistics of the social validity survey are provided. This chapter presents the results for each research question.

Research Question 1: The impact of SciGen on Vocabulary Acquisition

Research Question 1 examined the effect of the multimodal vocabulary instruction using Science Generation curriculum on tier 2 and tier 3 vocabulary acquisition. On average, students spent 4 minutes and 18 seconds completing each assessment. As shown in Figure 6, students demonstrated a pretest mean of 1.8 (*SD* = 1.03) items correct across all of the participants, which increased to a mean posttest score of 6.7 (*SD* = 3.65). The mean vocabulary score increased by nearly 25%, which was around 5 words.

Figure 6

Descriptive Statistics for Pre- and Post-Vocabulary Scores

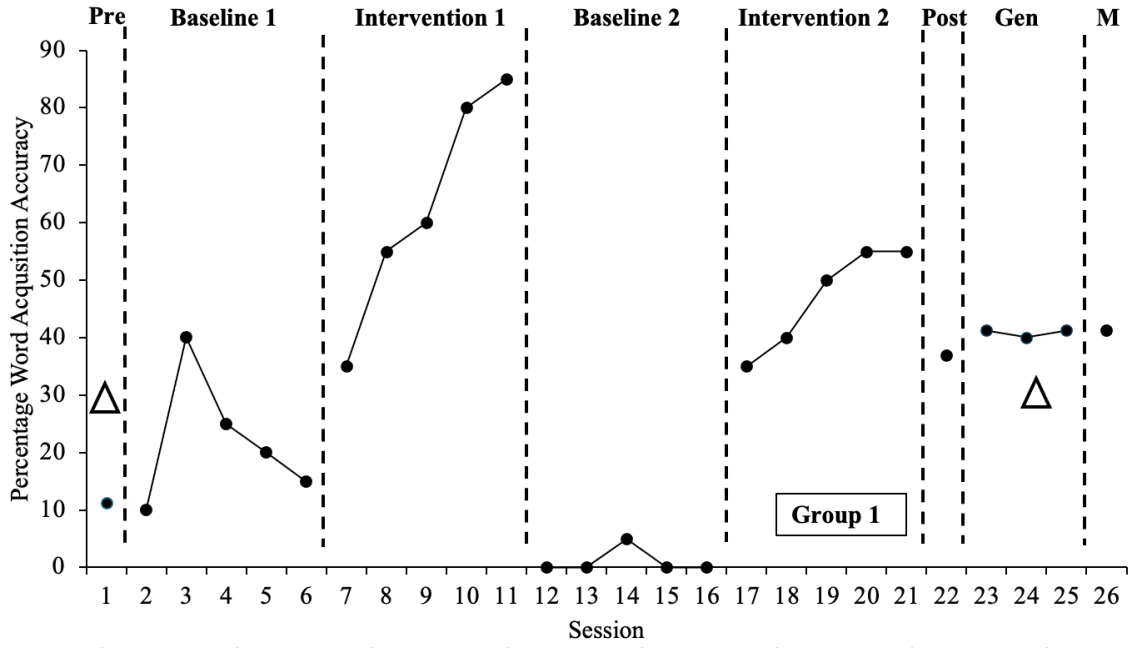


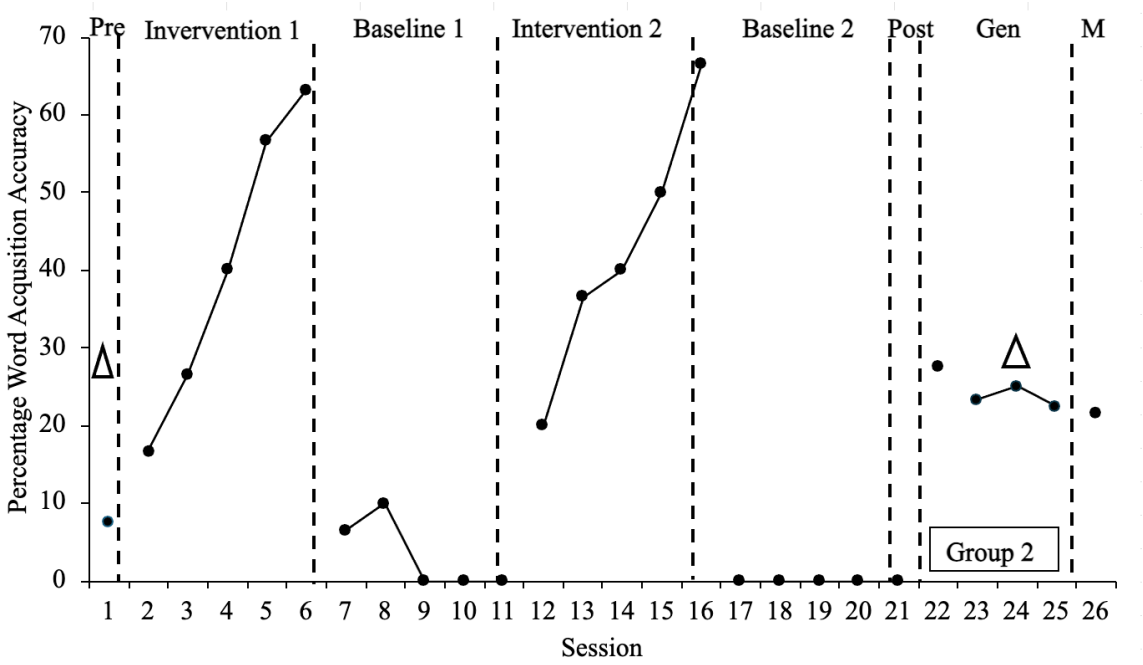
Note. SD Pre = 1.03 SD Post = 3.65

For vocabulary acquisition through the study phases, data were analyzed through visual analysis and effect sizes were calculated for students' scores. As shown in Figure 7, there was a positive effect of the intervention on vocabulary acquisition. The descriptive data for each phase are presented in Table 8.

Figure 7

Vocabulary Average Scores during the Pretest (Pre), Baseline, Intervention, Posttest (Post) Generalization (Gen), and Maintenance (M) Phases





Group 1: Sixth Graders Nada, Huzaifa, Sahar and Zia

The first phase was baseline for Group 1. The trend for the data within the first baseline phase decreased, and the direction of change was mostly negative. After introducing the intervention, there was an immediate increase in vocabulary mean scores for the group. The

trend within this phase was rising, with a continual increase in performance through time. The overall level of vocabulary acquisition improved, with average scores increasing from the baseline range (1-1.5) to around 3-4 points. The direction of change during this intervention phase was positive. When withdrawing the intervention in the second baseline phase, the group average vocabulary acquisition scores dropped to 0 and continued flat, with a slight shift at day 13. The overall level percentage of 10%. The trend was mostly flat.

After resuming the intervention, the level of vocabulary scores began to rise again at a lower level compared with the first intervention phase. The immediacy of effect was observed but at a lower phase compared with the first intervention phase. The trend continued to increase at a lower level compared with the previous intervention phase. The direction of change remained positive. The intervention has a statistically significant improvement in vocabulary average scores with Tau-U effect size of 1.00, z= 3.69, p <.0002 and a 95% confidence interval between 0.47 and 1.00.

The generalization phase took place a week after the end of the intervention and data collection continued for three weeks by conducting the assessment once a week. The administration of the measure was in a one-to-one setting. During the generalization phase, students continue to demonstrate knowledge of words; however, the vocabulary mastery percentile dropped to be around 40%.

The maintenance phase was a month after the end of the study, and students continued to show knowledge of vocabulary at the same rate, 40%.

Group 2: Seventh and Eighth Graders Ali, Reza, Anaya, Arwa, Yasin and Tumo

As shown in Figure 2, the intervention has positive effects on Group 2 during the intervention phases. The first phase was intervention for Group 2. The trend for the data within

the first intervention phase noticeably increased, and the direction of change was positive. When withdrawing the intervention in the first baseline phase, the group percentage of vocabulary acquisition accuracy dropped to around 8% and continued flat, with a slight shift on Day 8. The overall level percentage of 10%. The trend was mostly flat.

When the intervention was resumed, the level of vocabulary scores began to rise again at a higher level compared with the first intervention phase. The immediacy of effect was observed but at a higher phase compared with the first intervention phase. The trend continued to increase at a higher level compared with the previous intervention phase. The direction of change remained positive. After withdrawing the intervention in the second baseline phase, the group average vocabulary acquisition scores dropped to 0 and continued flat throughout the phase. The overall level percentage was 0% and the trend was flat. Similar to Group 1, the intervention has shown statistically significant improvement in vocabulary acquisition, with Tau-U effect size of 1.00, $z = 4.06$, $p < .001$ and a 95% confidence interval between 0.57 and 1.00.

During the generalization phase, students continued to demonstrate knowledge of word but at a lower level as the vocabulary mastery percentile dropped to be around 20%. Similarly, during the maintenance phase students showed knowledge of vocabulary with a 20% mastery percentile. Students continue knowledge of vocabulary with nearly 20% of mastery.

Table 10

Descriptive Statistics of the Overall Vocabulary and Comprehension Scores for Groups 1 and 2

	Vocabulary		Comprehension	
	Baseline	Intervention	Baseline	Intervention

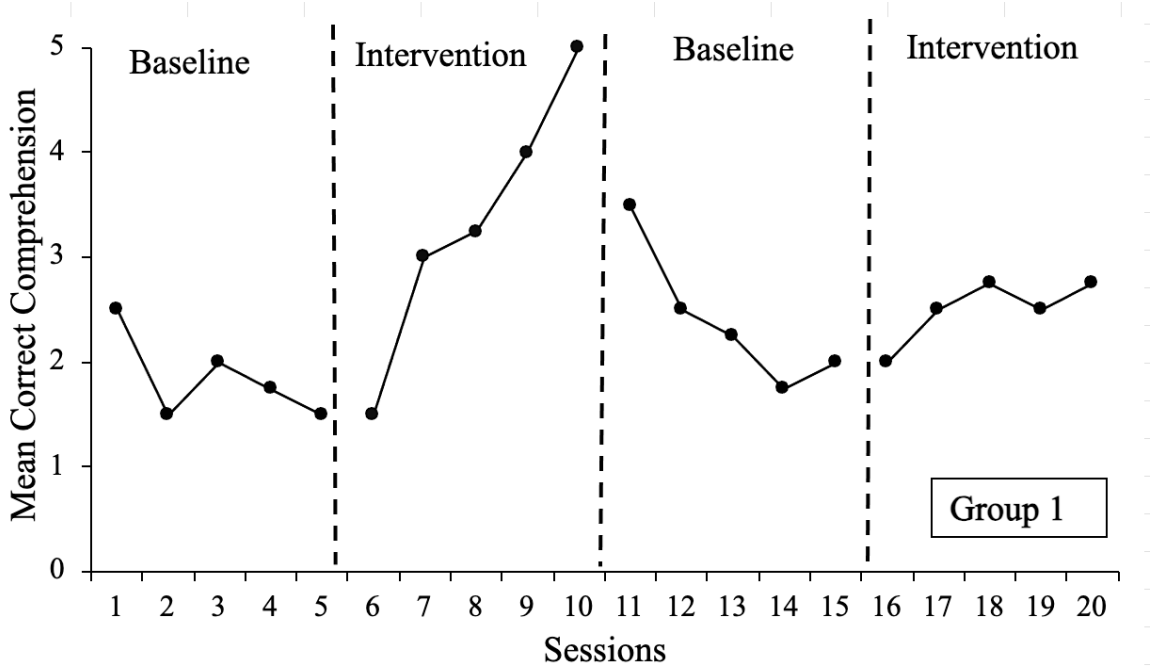
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	1.43	1.47	1.85	1.48	2.53	1.03	2.75	0.91
2	0.77	1.11	1.44	1.17	1.52	0.47	1.63	0.48
Total	2.20	2.58	3.29	2.65	4.05	1.50	4.38	1.39

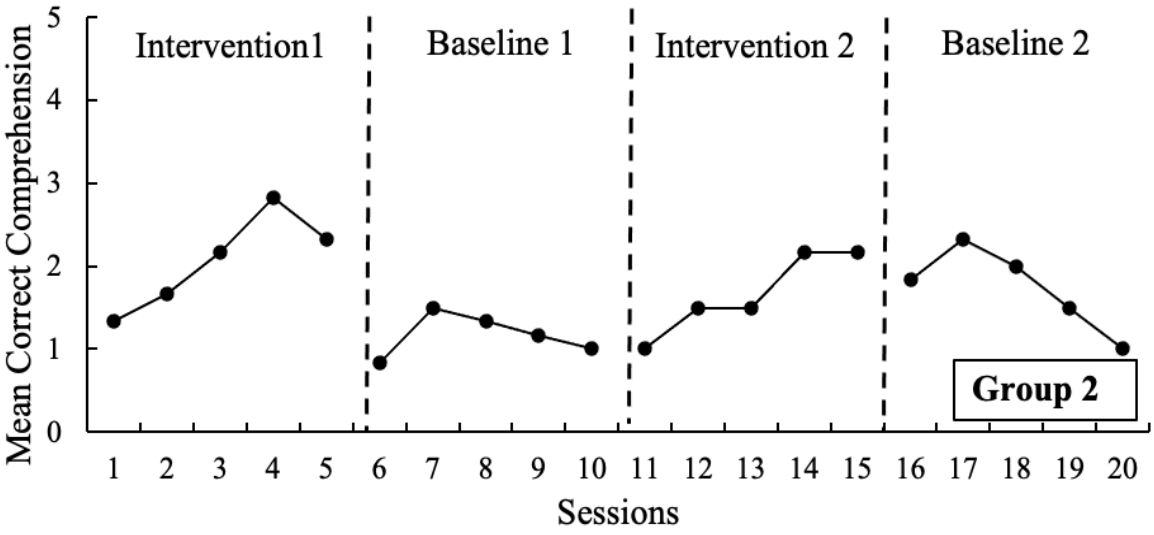
Research Question 2: The impact of SciGen on Science Reading Comprehension

Research Question 2 examined the effect of the multimodal vocabulary instruction using Science Generation curriculum on science reading comprehension. Data were analyzed through visual analysis, and effect sizes were calculated for students' scores. The data are displayed in Figure 8 and Table 9.

Figure 8

Group 1 and 2 Comprehension Average Scores during the Baseline and Intervention Phases





Group 1: Sixth Graders Nada, Huzaifa, Sahar and Zia

In the first baseline phase, the group average comprehension scores started at 2.5 and remained low and stable. The trend was decreasing, indicating that without intervention, students were not making significant progress in their science reading comprehension. The level of performance for group average scores during this phase was approximately 1 to 2 points.

After introducing the intervention in the first phase, there was an immediate and noticeable increase in comprehension scores. The trend within this phase was rising, with a steady increase in performance over time. The overall level of comprehension improved significantly, with average scores increasing from the baseline range (1-2) to around 4-5 points. When withdrawing the intervention in the second baseline phase, the group average comprehension scores dropped to 3.5 and continued to decrease, with slight shifts over time and an overall level percentage of 25%. The trend was decreasing, indicating that students would not maintain progress in reading comprehension without intervention. The level of performance for group average scores during this phase was around 2 to 3 points. The direction

of change was negative. The immediacy of effect was negative, as the scores decreased after withdrawing the intervention.

After continuing the intervention, the level of comprehension scores began to rise again at a lower level compared with the first intervention phase. The immediacy of effect was observed but at a lower phase compared with the first intervention phase. The trend remained moderately increasing. The direction of change was still positive. The effect size of the intervention was strong but not statistically significant with a Tau-U effect size of 1.00, z = 1.58, p = .1138, 95% CI [–0.24, 2.24].

Group 2: Seventh and Eighth Graders Ali, Reza, Anaya, Arwa, Yasin and Tumo

During the first intervention phase, comprehension scores started low, around 1, and then increased gradually, to 3 before slightly declining. The trend was rising at the beginning but decreased towards the end of the phase. The direction of change was positive at first but then changed.

After removing the intervention, comprehension scores showed an immediate decrease around 1 to 2 and then stabilized. The trend in this phase was downward and the overall level remained low compared to the phase. The trend was decreasing, indicating that students would not maintain progress in reading comprehension without intervention. The immediacy of the effect was negative, indicating the decrease of the scores after withdrawing the intervention.

After reintroducing the intervention, comprehension mean scores showed immediate improvement, rising from 1 to 2 and stabilizing. The trend was moderately rising. The overall level was increasing, and direction of change was positive.

When withdrawing the intervention in the second baseline phase, the group average comprehension scores dropped to 1.5, rose to 2.5, and then continued to decrease, and an

overall level percentage of 20%. The trend was decreasing, indicating that students would not maintain progress in reading comprehension without the intervention. The level of performance for group average scores during this phase was around 1 to 2 points. The direction of change was negative. The immediacy of effect was negative, as the scores decreased after withdrawing the intervention. The effect sizes were lower than Group1 and statically non-significant, with a Tau-U effect size of 0.70, $z = 1.57$, $p = .1175$, 95% CI [–0.18, 1.58].

Research Question 3 Results: The impact of the Intervention on Science Attitude

Research question 3 investigated the impact of the multimodal vocabulary instruction using the Science Generation curriculum on the science attitude of students. As shown in Figure 9 and table 11, there was a clear increase in score for each item. For the item "I would like to do more science at school," the mean score increased from 2.90 (*SD* = 1.37) compared to post-survey mean score of 4.40 (*SD* = 0.97). Similarly, item 4 "In my science class, I understand everything", students' post survey responses showed improvement on science attitude (*M* = 4.20, *SD* = 0.92).

Figure 9

Comparison of Pre- and Post- Scale Responses for Science Attitude Items

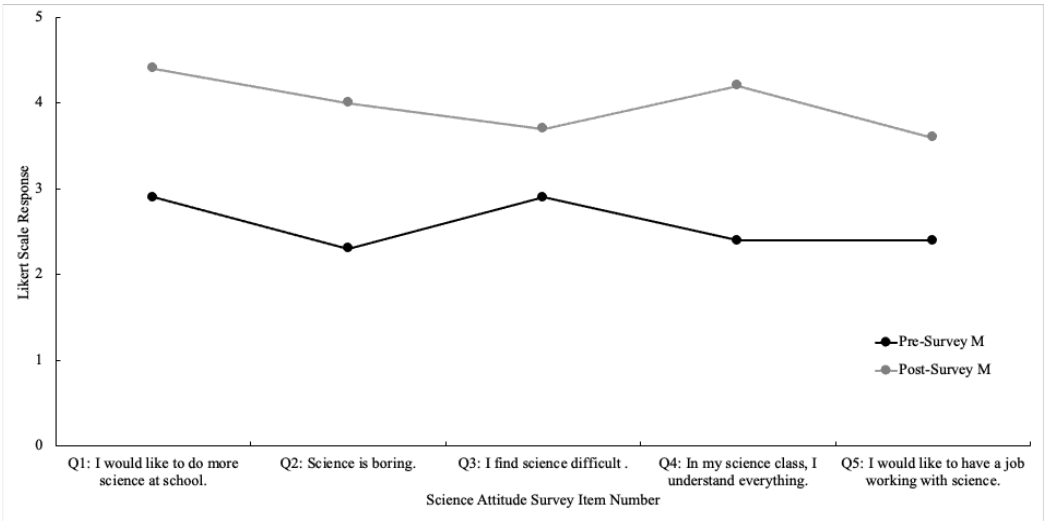


Table 11

Summary of Pre- and Post-Survey Mean Scores and Standard Deviations for Science Attitude Items

Item	Pre-Survey M (*SD*)	Post-Survey M (*SD*)
Q1: I would like to do more science at school.	2.9 (1.37)	4.4 (0.97)
Q2: Science is boring (Reverse).	2.3 (1.49)	4.0 (1.15)
Q3: I find science difficult (Reverse).	2.9 (1.37)	3.7 (1.34)
Q4: In my science class, I understand everything.	2.4 (1.17)	4.2 (0.92)
	13.9 (6.91)	19.9 (4.54)
Q5: I would like to have a job working with science.		
Total Score	13.9 (6.91)	19.9 (4.54)

Research Question 4 Results: Students' Rate of the Effectiveness of The Intervention

The fourth question examined the social validity of the intervention through students' rating of their learning, engagement and interest in the unit topic and science in general. On average, students spent 3 minutes and 2 seconds filling out the survey. As shown in Figure 10 and Table 12, the mean social validity rating scores for group 1 were higher and ranged between 4.1 and 4.5 for both units indicating satisfaction of lesson, engagement, science learning, vocabulary learning and interest in the science topic. On the other hand, the mean social validity scores of Group 2 were lower ranging between 3.43 and 3.6 for unit 1 and 3.35 and 3.72 for Unit 2 indicating less ratings for science lessons in unit 2 ($X = 3.35$) compared with Unit 1 ($X = 3.6$). It is worth mentioning that both groups had lower means of social validity ratings for Unit 2 lessons (i.e., group 1 $X = 4.35$, group 2 $X = 3.35$), compared with Unit 1(i.e., group 1 $X = 4.45$, group 2 $X = 3.6$). However, both groups have higher mean vocabulary learning and interest in the topic ratings for Unit 2 compared to Unit 1. Table 12 shows mean social validity ratings for both groups across the two units.

Figure 10

Comparison of Social Validity Scale Responses for Units 1 and 2 Across Group 1 and 2

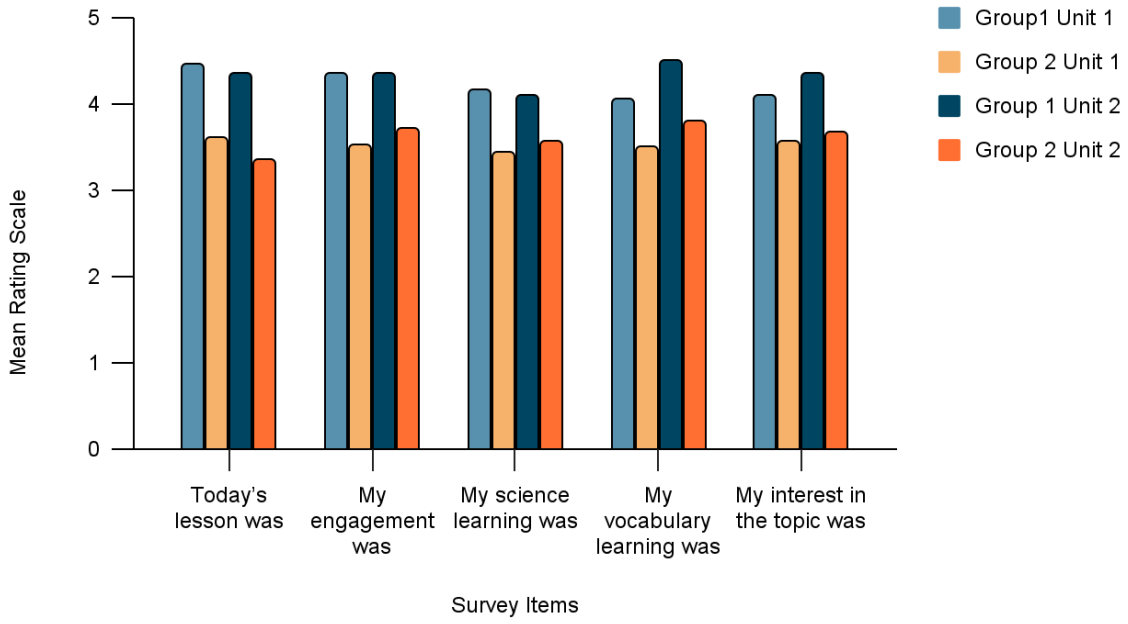


Table 12

Mean Scores for Each Likert Scale Item Responses Across Participant Groups Per Each Unit

		Group 1		Group 2	
	Survey Item	Unit 1 *X*	Unit 2 *X*	Unit 1 *X*	Unit 2 *X*
1.	Today's lesson was	4.45	4.35	3.6	3.35
2.	My engagement was	4.35	4.35	3.53	3.72
3.	My science learning was	4.15	4.1	3.43	3.56
4.	My vocabulary learning was	4.05	4.5	3.5	3.8
5.	My interest in the topic was	4.1	4.35	3.57	3.67

Note. Students rated each lesson on a 1–5 scale, in which1 indicates frustration and 5 indicates full understanding and enjoyment. Ratings were collected via Microsoft Forms using emojis and brief descriptions to support clarity.

CHAPTER 5

Discussion

The aim of this chapter is to discuss the findings of the research that examined the impact of multimodal vocabulary instruction using the Science Generation curriculum (SciGen) on science vocabulary acquisition, science reading comprehension, attitudes towards science and student engagement among multilingual learners (MLLs) with reading difficulties at the middle school level. The results were analyzed across the aforementioned areas with reference to existing literature. Limitations and implications for research and practice were identified.

Vocabulary Acquisition

The intervention showed a significant positive effect on students' science vocabulary acquisition. Results indicated a large effect size (r = .89) from pre- to post-assessment using a Wilcoxon signed-rank test. Tau-U analysis across both groups also had strong effect sizes (Tau-U = 1.00), indicating robust gains in vocabulary acquisition. The results of Wilcoxon's signed rank test were in favor of the post test scores (z = -2.80, p = .005).

Results of visual analysis also indicated the effectiveness of the intervention, where students showed a consistent improvement of vocabulary acquisition during the intervention phases compared with a drop in performance when the intervention was removed. These findings are consistent with existing literature on the effectiveness of structured vocabulary intervention that used direct and multimodal vocabulary instruction for students with language learning needs (Helman et al., 2020; Kennedy et al., 2015; Sanchez & O'Connor, 2022).

The improvement observed during intervention phases, and the decline during withdrawal, supports the need for continuous, structured vocabulary learning. While

generalization and maintenance phases showed reduced retention, the fact that students retained 20–40% of the vocabulary weeks after the intervention ended suggests that multimodal instruction has longer-term effects, even in the absence of continued support.

Science Reading Comprehension

The gains in science reading comprehension were less significant compared to vocabulary. Although both groups showed improvements during intervention phases, the results indicated less consistency, with occasional regression during baseline and intervention phases. This finding is supported by existing literature, where vocabulary instruction alone is often insufficient for improving complex reading comprehension tasks unless it was paired with explicit strategy instruction (Kaldenberg et al., 2015).

The comprehension improvements may also have been constrained by the study's short duration and students' baseline literacy levels. Nevertheless, the upward trends during intervention suggest that vocabulary knowledge facilitated comprehension to some extent. This supports integrated vocabulary-comprehension models, as seen in interventions like PACT (Swanson et al., 2017) and SVS (Ardasheva et al., 2017), which emphasize the interdependence of vocabulary access and text understanding.

Attitudes Toward Science

Attitudes towards science responses revealed statistically significant improvements in students' interest and self- competence in science. For example, students expressed greater desire to engage in science activities at school and reported improved understanding in class ($r = 0.80$ and $r = 0.75$, respectively). These results suggest that structured, engaging science vocabulary and academic instruction can positively affect students' emotional and motivational orientation toward science, a key factor in long-term STEM engagement (Wiebe et al., 2013;

Christidou, 2011). Not all items showed significant change, such as interest in pursuing science careers, which may reflect the broader socio-academic challenges that refugee and immigrant MLLs-RD face, including access to STEM role models and systemic educational barriers (Tretter et al., 2017).

Perceptions of the Intervention

The overall results of the social validity survey indicated that students viewed the intervention positively, with higher ratings in lesson engagement and vocabulary learning. Group 1, which consisted of sixth graders, showed particularly strong satisfaction across both units. Students' high engagement levels and positive perception of vocabulary learning suggest that the multimodal format was well-suited to their learning preferences. These findings reinforce the importance of culturally responsive and universally designed instruction that incorporates multiple modalities to accommodate diverse learners (Kelly et al., 2023). This could be possibly because Group 1 was anecdotally noticed to be more homogenous, with students sharing similar interests and backgrounds and being in the same grade level.

On the other hand, Group 2, was larger and more heterogenous with students from different backgrounds and grade levels paired together. The group consisted of 7th and 8th graders, and having different cultural and linguistic backgrounds, (i.e., Swahili, Arabic and Pashto native speakers). This might influence collaboration dynamics and perception of the lesson (Gay, 2018; Hammond, 2015). Differences between Unit 1 and Unit 2 ratings across groups also suggest the need for ongoing adaptation of content complexity and cultural relevance to maintain engagement, especially in older students.

The intervention shows promise as a helpful and inclusive teaching tool for refugee and multilingual students. However, more long-term research is needed to see if the benefits last and if the program works well in different schools and with different groups of students.

Potential Implications

The data have potential implications for MLLs with reading difficulties including refugees. I will discuss the implications for practice and theory next in light of the guiding theories and principles of this research.

Implications for Practice

As the number of immigrant and refugee students in growing the U.S. school population, more research should be dedicated to academic interventions and instructional practices to address the unique needs of these students. After school education programs could provide a great learning opportunity in supporting MLLs, especially those from refugee backgrounds.

Future research should explore scaling up the intervention through examining long-term retention and testing the impact of explicit comprehension instruction such as text features and comprehension strategies for improving comprehension, particularly among older and refugee students.

Future research should also address the use of artificial intelligence and technology in enhancing the quality of academic instruction and instructional measures in the classroom (UNESCO, 2021).

Implications for Theory

While vocabulary is essential to reading comprehension, comprehension has more to do with other essential skills. Children's comprehension improvement is based upon developing

the skills of recognizing and decoding words, and comprehending the text (Cane & Oakhill, 2008). In same vein, the study results indicated that students with higher decoding and word recognition scores in diagnostic assessment, even those from a refugee background, performed better in the vocabulary and comprehension assessment.

To address this issue, teachers need to dedicate more of class instructional time to support students' comprehension skills through direct comprehension instruction and knowledge of text feature (Capin et al., 2025). In science reading, students need to learn how to read and think like scientists, including understanding specialized vocabulary and interpreting visuals and data representations (Shanahan & Shanahan, 2008). In addition, future interventions such as PACT adapted to science intervention and incorporated with multiple scaffolds such as the slow reveal math graph would be highly important in improving students' word knowledge and use in context while doing math activities

Culturally responsive instruction is important to increase interest and engagement among MLLs in the classroom (Gay, 2010; Ladson-Billings, 1995). Anecdotal evidence through classroom observation indicated students' showing more interest when the instruction incorporates elements from their native culture and their interests, such as talking about their favorite sport -soccer, using their native language in the class, doing experiments while making their favorite items-slime, food items, or incorporating technology in the classrooms.

It is important to take students' cultural and linguistic acculturation level into consideration. While students are labelled refugees or immigrants, students can vary in their closeness to both home and the host culture and adopting the host culture does not entail adopting the host language (Schumann, 1986). In other words, English language proficiency was low even for participants who self-reported higher levels of assimilations with the host

culture. Also, acculturation is a strong indicator of language as many as the language diagnostic tests of students with higher segregation levels from the host culture were lower than their peers.

Relatively critical tasks such as creative writing and individual- based activities represent challenges for MLLs with reading difficulties, especially those from a refugee background. The researcher noticed that refugee students and MLLs with disabilities faced difficulties in working on the creative writing activities such as the found poem and blackout poems, even with modelling and practice. However, pair and group activities such as the slow reveal graph and the word tournament were among their favorites. This could be possibly related to Vygotsky's sociocultural theory**,** especially the concept of the Zone of Proximal Development (ZPD) as the theory emphasizes the importance of social interaction in learning (Vygotsky, 1978).

In the same vein, the Affective Filter Theory stresses on the role of emotional factors such as anxiety, lack of confidence, and limited prior exposure can act as barriers to language acquisition by raising the affective filter. However, this filter can be lowered through supportive instructional strategies, such as culturally relevant content, peer collaboration, and multimodal scaffolds, which reduce anxiety and promote engagement. Overall, additional supports are needed for these creative writing projects as creating, thinking and applying requires higher order thinking processes according to Bloom's Taxonomy (1956, revised by Anderson & Krathwohl, 2001) compared with reading and remembering. For future implementations, coloring parts of speech, adding visuals, having students doing the creative writing projects as pairs and groups could be possible ways to increase engagement with these activities.

Limitations

While results revealed a positive impact on vocabulary acquisition, comprehension and attitude towards science, findings of this study cannot be generalized due to scoring, logistic, contextual and technical limitations. First, the study was conducted in a non-school setting with relaxed interactions and flexible scheduling where most participants shared similar backgrounds and are all newcomers to the United States. Most of the sessions ran for around 60 minutes, and the longest ran for 85 minutes, exceeding the average regular class time. The arrangement was different from regular schooling because students from two different grades (i.e., 7th and 8th) worked as a group. The familiarity between the researcher and participants is another potential limitation, as the interventionist had volunteered with the host organization for 2 years prior to the study. The researcher had established strong ties with families whom they shared common faith with 90% and similar linguistic background with 30% These unique contextual factors might have influenced students' engagements or outcomes, which would make it difficult to generalize these findings for a traditional public-school environment.

Second, the measures were mostly developed by the researcher. While study measures were developed using Diffit AI tool following the researcher's prompts, the created measures did not meet all requested items such as word and lexile limits, and the types of questions (i.e., open-ended or multiple choice). For example, when requesting Diffit to create a paragraph with 165-word count and multiple-choice questions with inference items, the generated text would exceed the limit by 200 words, and with no inference questions. Therefore, the researcher referred to another ai tool to adjust the text length and suggest possible inference questions or created the inference questions based on the passage content.

Implementation of the study measures presented major challenges as the assessments were administered electronically in which students were easily distracted and needed multiple redirections and reminders to stay on task. The Microsoft Forms tool was inclusive by providing read-aloud and translation options for students. Nonetheless, the tool did not support matching questions, which were addressed by using rating questions as an alternative. In this form, the statement side of the survey was used for the word definitions, and the rating side of the question was used for the words. Still, the Microsoft Forms system did not restrict multiple selections of the same item on the word side of the question. To overcome this issue, the researcher had to repeatedly remind students to select each word only once and included this directive in the administration protocol. In addition, the tool also did not support changing a single word choice to a new option if it was in a different row. This forced participants to use the erase tool to clear their entire selection and re-answer the question. View appendices for the administration protocol. Finally, I did control the time required for each intervention session, which may have varied based on activities and whether or not the students completed the homework. Future researchers should replicate the study while controlling the amount of time spent in each intervention session. The study could also be replicated by omitting the homework section or by completing the homework during the intervention session to ensure that all students completed it equally.

Conclusion

The study findings indicate the value of using extended multimodal vocabulary instruction with Science Generation, coupled with direct vocabulary instruction and culturally responsive instruction to support science vocabulary acquisition and improve student attitudes among MLLs-RD. While gains in comprehension were more modest, trends suggest that

continued implementation could have benefits in the long term. The study contributes to the limited but growing body of research on science literacy interventions tailored for multilingual learners with reading difficulties and disabilities and offers evidence for embedding vocabulary instruction within culturally responsive, universally designed frameworks.

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APPENDICES

Appendix A

Intervention Standards

Table A1

Units' Connection to Standards

Unit	Standards
Cells Teaming Up	**Missouri Learning Standards (MLS):** 6-8.LS1.A.1, 6-8.LS1.A.2, 6-8.LS1.A.3, 6-8.LS1.A.4 **Next Generation Science Standards (NGSS):** MS-LS1-1, MS-LS1-2, MS-LS1-3, MS-LS1-4.
Small, Smaller Smallest	**Missouri Learning Standards (MLS):** 6-8.PS1.A.1, 6-8.PS1.A.2, 6-8.PS1.B.1 **Next Generation Science Standards (NGSS):** MS-PS1-1, MS-PS1-2, MS-PS1-3

Table A2

SciGen Unit L6: Cells Teaming Up (SERP, n.d. c) Content Analysis

#	Category	Rubric Item	Evaluation	Rating
1	Representation	Characters and images reflect a variety of races/ethnicities.	No characters or culturally diverse visuals; content is strictly scientific and diagrammatic.	❌ No
	Representation	Includes experiences of people of color and underrepresented communities.	No mention of experiences or contributions from non-Western or racially diverse communities.	❌ No
	Representation	Includes positive representations of students' cultures.	No cultural context or representation relevant to Afghanistan, Egypt, Libya, or Tanzania.	❌ No
2	Social Justice	Acknowledges oppression, power, and privilege.	No references to power structures or systemic inequities.	❌ No
	Social Justice	Teaches students to thinl critically about injustice.	No opportunities for analysis or discussion of inequities.	❌ No

	Social Justice	Includes contributions of people of color to the discipline.	Non-Western scientists or global examples are not referenced.	❌ No
3	Student-Centered Instruction	Connects content to students' lives and communities.	No integration of community or cultural context into cell biology content.	❌ No
	Student-Centered Instruction	Students are positioned a knowledge holders.	Scripted delivery with no student-led or identity-affirming learning opportunities.	❌ No
	Student-Centered Instruction	Curriculum offers multiple ways for students to engage.	Limited to text and visual aids; lacks multimodal, culturally flexible access points.	⚠️ Partial
	Linguistically Responsive Practices	Key vocabulary is supported by visuals, repetition, and examples	Diagrams are present, but vocabulary is not scaffolde for MLLs.	⚠️ Partial
4	Linguistically Responsive Practices	Materials support students in using academic language.	Language is academic, but support strategies are not provided.	❌ No

	Linguistically Responsive Practices	Multilingualism is viewe as an asset.	No mention or use of students' home languages.	❌ No
5	Teachers' Materials & Supports	Teachers are encouraged to adapt content to student cultures.	No prompts or guidance fo culturally responsive adaptation.	❌ No
	Teachers' Materials & Supports	PD or background info o culturally relevant pedagogy is included.	No background or training support included.	❌ No
	Teachers' Materials & Supports	Suggestions for modifying instruction fo English learners or SWDs.	No ELL/MLL-specific supports or modifications provided.	❌ No

Note. This table summarizes AI-generated content analysis using ChatGPT of the SciGen Curriculum Unit L6 Cells Teaming Up and M1: Small, Smaller, Smallest's cultural responsiveness for multilingual learners (MLLs) from Afghanistan, Egypt, Libya and Tanzania.

Table A3

Unit M1: Small, Smaller, Smallest (SERP, n.d.- d) Content Analysis

#	Category	Rubric Item	Evaluation	Rating
1	Representation	Characters and images reflect diverse racial/ethnic identities.	No human characters or cultural visuals; content is entirely scientific.	❌ No
	Representation	Includes experiences of people of color or underrepresented communities.	No real-world context, storytelling, or cultural references; science is taught abstractly.	❌ No
	Representation	Positive representation o student cultures.	No mention or visual inclusion of cultures from Afghanistan, Egypt, Libya, or Tanzania.	❌ No
2	Social Justice	Acknowledges oppression, power, or marginalization.	No mention of equity, colonial science, or who	❌ No

			defines scientific knowledge.	
	Social Justice	Teaches students to analyze injustice.	No content or questioning prompts related to global inequalities in access to scienc or education.	✗ No
	Social Justice	Features contributions o non-Western scientists.	Does not mention historical scientifi contributions from Muslim or Africa civilizations.	✗ No
	Student-Centered Instruction	Connects to students' lives, cultures, or communities.	Focus is strictly o physical science concepts with no cultural or community-based application.	✗ No
3	Student-Centered Instruction	Positions students as knowledge holders.	Students are not prompted to bring personal or cultur	✗ No

			knowledge into th lesson.	
	Student-Centered Instruction	Offers multiple ways to engage with content.	Some interactive simulations are available, but all rely on English with minimal multimodal acces	⚠ Partial
4	Linguistically Responsive Practices	Vocabulary supported b visuals and repetition.	Scientific diagram support some vocabulary, but terms are complex and not scaffolded for MLLs.	⚠ Partial
	Linguistically Responsive Practices	Helps students use academic language.	No sentence stems glossaries, or modeling of scientific languag use.	❌ No
	Linguistically Responsive Practices	Values multilingualism.	No encouragemen or allowance for home languages;	❌ No

			English-only presentation.	
5	Teachers' Materials & Supports	Encourages adapting lessons to student cultures.	No teacher notes c sidebars promptin cultural adaptatior	❌ No
	Teachers' Materials & Supports	Provides background on culturally relevant pedagogy.	No embedded PD or support for culturally responsive teaching.	❌ No
	Teachers' Materials & Supports	Offers modifications for ELLs or students with disabilities.	No scaffolds, sentence frames, c multilingual resources provide	❌ No

Note. This table summarizes AI-generated content analysis using ChatGPT of the SciGen Curriculum Unit M1: Small, Smaller, Smallest's cultural responsiveness for multilingual learners (MLLs) from Afghanistan, Egypt, Libya and Tanzania.

Appendix B

Intervention Sample Materials

Table B1

Units' Summary and Scaffolds

Unit	Lesson	Printouts and Multimedia Link	Video Link
Cells Teaming Up **Day1**	1	-PowerPoint slides with vocabulary cards -Dialogue script included in appendices -Diffit AI Generated worksheets	-
Cells Teaming Up **Day 2**	2	-interactive chart: https://serpmedia.org/scigen/l6.2a.html -Hierarchy worksheet. -Dialogue script for the found poem. Diffit AI Generated worksheets.	https://serpmedia.org/scigen/l6.2b.html
Cells Teaming Up Day 3	3	Interactive map https ://www.google.com/maps/place/New+York,+NY Columbia Missouri Map Interactive human body chart: https://serpmedia.org/scigen/l6.3b.html Pulling Apart Systems slide: https://serpmedia.org/scigen/l6.3c.html	https://serpmedia.org/scigen/l6.2b.html

		Showing two systems slides: https://serpmedia.org/scigen/l6.3b.html Interactive human body chart: https://serpmedia.org/scigen/l6.3b.html Chart link: https://serpmedia.org/scigen/l6.3d.html What happens slide: https://serpmedia.org/scigen/l6.3e.html Diffit AI Generated worksheets
Cells Teaming Up Day 4	4	Cards: https://serpmedia.org/scigen/assets/l6.4-cards-master.pdf (54 identically sized cards) Showing rules slide (in slides): https://serpmedia.org/scigen/l6.4d.html For blackout poetry students can use paper or electronic (in the intervention paper format was used): Digital blackout maker:

		https://www.classes.cs.uchicago.edu/archive/2022/summer/19911-1/blackout-poetry/starter/index.html Adjusted dialogue script for the lesson: (check lesson plan 1 for Cells Teaming Up Unit) Original Lesson script PDF copies https ://serpmedia.org/scigen/assets/l6.1-scene.pdf Diffit AI Generated worksheets	
Cells Teaming Up Day 5	5	Comic PDF: https://serpmedia.org/scigen/assets/immune_comic-pdf.pdf Comprehension Question slides : https ://serpmedia.org/scigen/l6.5c.html Tournament : https ://www.flippity.net/TournamentBracket.htm	Video: https://serpmedia.org/scigen/l6.5a.html

Small, Smaller, 1 Smallest Day 1	Dialogue script : (check the adapted script in the lesson plan 1 of the unit) Forms of matters activities: Advanced activity (8th grade) https://studyjams.scholastic.com/studyjams/jams/science/matter/solids-liquids-gases.htm Easier activity (6th & 7th grades) https://www.abcya.com/games/states_of_matter Diffit AI Generated worksheets	What's matter video Particles videos
Small, Smaller, 2 Smallest Day 2	Diffit AI Generated worksheets	-
Small, Smaller, 3 Smallest Day 3	Beach interactive activity: https://serpmedia.org/scigen/m1.3a.html Interactive quiz: https://serpmedia.org/scigen/m1.3a_quiz.html Diffit AI Generated worksheets	-

Small, Smaller, 4 Smallest Day 4	Digital blackout maker: (we used paper format) https://www.classes.cs.uchicago.edu/archive/202summer/19911-1/blackout-poetry/starter/index.html OR: Blackout poetry maker: https://blackoutpoetry.glitch.me/ Diffit AI Generated worksheets Experiment: Slime	Video: https://serpmedia.orscigen/m1.4a.html Experiment: https://www.youtubcom/watch?v=l9szCnq7Pg
Small, Smaller, 5 Smallest Day 5	Worksheet: https://www.serpmedia.org/scigen/assets/m1.4_hotosynthesis.pdf Tournarment : https ://www.flippity.net/TournamentBracket.htm	Photosynthesis video: https://www.youtube.com/watch?v=D1Ymc311XS8

Instructional Materials: Adapted Lesson Plans

Note.

These lesson plans were adapted from the original SERP Institute curriculum (https://serpmedia.org/scigen/). All Items in **bold** are additions and changes made to the original lesson plans**.** This includes updates to examples, instructions, and supports added to meet students' cultural and language needs. **Culturally Responsive Pedagogy (CRP)** strategies are also included to help connect lessons to students' backgrounds and experiences.

Unit: L6 Cells Teaming Up **Topic:** Multicellular Systems **Vocabulary:** *Strategy, Specialize, Cooperate, Hierarchy, Organism, Tissue, Organ, System*				
Unit M6 - Lesson 1 Objectives 1. Students will describe how multicellular organisms function as systems with specialized roles. 2. Students will use key vocabulary terms such as organism, tissue, and system accurately in discussions. 3. Students will compare team sports with body systems to illustrate cooperation. 4. Students will analyze how cells specialize and cooperate within a human body. 5. Students will engage in a dialogue and use scientific vocabulary to explain multicellular concepts. 6. Students will reflect on the advantages of multicellular organisms over unicellular ones.				
Activity	**Description**	**Materials**	**Time**	**CRP*/ Scaffolds**

Objectives & Expectations	**Teacher reviews objectives, expectations, and agenda.** **Teacher warms up by asking students to talk about their name, native country, languages spoken, and favorite sports.**	**Slideshow**	**5**	**Talking about their native country and favorite sports**
Set the context	Teacher initiates a class discussion prior to beginning the Science Scene. Teacher asks the class to consider individual sports and team sports. Paraphrase: *What sports can you think of that people play only as individuals? Only as a team? What sports can be easily played one-on-one? What kinds of sports wouldn't work if played as teams?* Teacher shows: Slide of one-on-one **soccer** vs. team **soccer**. Teacher asks : *What's the difference between*	Slide https://serpmedia.org/scigen/l6.1a.html	**5 (10 minutes in original lesson plan)**	Changing the example to talk about soccer and cricket (famous local sports)

	*playing **soccer** one-on-one and playing on a team? How are they the same? Which is the better way to play?* One phrase your students may be familiar with is "The system is greater than the sum of the parts."			
Introduce new science terms	**-Teacher introduces new vocabulary using slides.** **-Teacher presents definitions, visuals, and context for 8 target words.** **- Teacher provides translation of each word into students' native language and breaks word into syllables to show students how to say it.** **-Teacher models what the word does and does not look like. Students turn and talk r responding to a prompt on each word.** **- Students practice using new words**	**word cards**	**20**	**Translating words to native languages, adding visual representation, students use native languages in learning their native language, Fryer organizer to journal definitions of each word.**

	in a quick written activity			
Engage with the script	Some teachers have several groups of students read at the same time. Other teachers select a few students to "perform" in front of the class. Teacher may want to read the entire passage out loud to the class once before assigning roles to students or dividing up into groups. While most of the Focus Words appear in this script, there are a few terms that appear in other activities in this unit but aren't used in the student dialogue: tissue organ system hierarchy immunity transplant infection bacteria	Adjusted dialogue script for the lesson (included after the lesson) Original Lesson script PDF copies https://serpmedia.org/scigen/assets/l6.1-scene.pdf	**10 (original time 20 min)**	Translation of script to native languages; Adding visual representation to the text
Review the dialogue in writing and discussion	When teacher is finished with the Science Scene, ask students to answer	Writing worksheet print PDF https://serpmedia.org/scigen/l6.1b.html	10	Translating prompt to native language; students work in peers

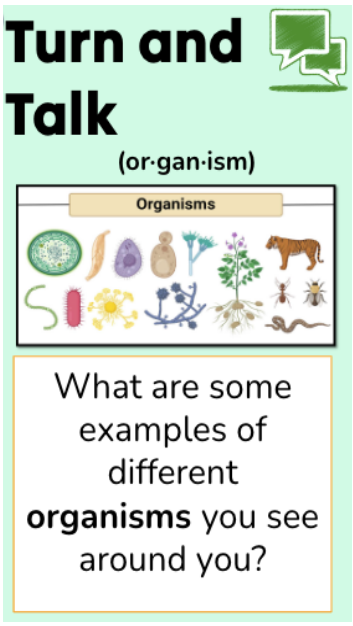
	these four questions. Teacher may opt to assign single questions in the third section, rather than having all the students answer all the questions. Students can discuss with their partners and try to reach an agreement about their answers to the questions. This activity is an opportunity for students to practice using scientific language as they discuss the questions. Paraphrase: *A single-celled organism (like an amoeba, a yeast cell, or a paramecium) performs all the basic functions it needs to live. In organisms with a few thousand to trillions of cells, known as multicellular organisms, the cells divide up the tasks necessary for the organism to live. The different types of human cells make different*			

	contributions for the benefit of the whole organism. And just like players on a well-coached team, these highly specialized cells all receive support from each other, to make up for the things they can't do for themselves. They all work together in a complex, cooperative division. When reviewing the answers, teacher can compare their replies to some of the advantages that multicellular organisms have over single-celled ones: Multicellular organisms can be more complex. Multicellular organisms can be larger. The cells of multicellular organisms can specialize—each kind of cell having specific functions that benefit the whole system of cells.			

Turn & Talk	Before turning to the discussion questions, the teacher make a bridge between the team metaphor in the dialogue and what the students know about multicellular organisms. The topic of multicellularity will be explored in greater depth over the course of the week. Paraphrase: What would happen if we cut a finger off of our body? Would it continue to inch around the room? Assign students to one or more of the questions. Have students discuss with their partners and try to reach an agreement. This activity is an opportunity for students to practice using scientific language as they discuss the questions.	Prompt slide: https://serpmedia.org/scigen/l6.1c.html	10	

Homework 1	Vocabulary homework Practice: Teacher introduces matching word with definition vocabulary task and models it and assigns student homework sheets. Students complete the task as a homework.			

Sample Cards



Adapted dialogue and visualization for Unit M6 Lesson 1 using ChatGPT

Unit M6 • Cells Teaming Up
SCENE: IN THE LOCKER ROOM
Setting: Asia and Jalen chat between classes on their way to their lockers. Their friend Adam has an adjacent locker.

Asia: I think Coach Kim hates me.

Jalen: I seriously doubt that. I have her for gym, and she's really cool.

Asia: She doesn't yell at you?

Jalen: Nope! Never.

Asia: Yesterday at practice, she kept shouting, "There's no 'I' in the team!" What does that even mean? Adam was there. He can tell you.

Adam: It means you're focusing on yourself instead of the team. You need to pass more!

Asia: But I'm trying to score, like I used to with my brother.

Jalen: Didn't you ever play with other kids?

Asia: There weren't any kids where we lived. We only played one-on-one.

Adam: Well, you can't do that in soccer! It's a team sport. We need to work together, not just run solo.

Asia: OK, I get it. I'll try to pass more.

Adam: I'll believe it when I see it.

Jalen: Asia, you're like an amoeba on the field.

Asia: Excuse me?

Adam: Remember in science? Amoebas do everything alone!

Jalen: Exactly! In soccer, it's about teamwork. If all players did their own thing, we'd never win.

Asia: So, I need to be part of a team, not an amoeba?

Adam: Exactly! Each player has a role—like a multicellular organism!

Jalen: (high-fiving Adam) Score!

Adam: Teams win when we work together. You're tall—maybe you can play defense!

Asia: I'll talk to Coach Kim about it. If that doesn't work, maybe I'll try another sport.

Jalen: How about golf? That's one-on-one too!

Asia & Adam:
HOLES in one, Jalen!

Jalen: (rolling eyes) Sheesh, what's with all these sports terms?

Unit M6- Lesson 2

Unit M6 - Lesson 2 Objectives
1. Students will review and apply vocabulary to describe biological systems. 2. Students will interpret scientific graphs showing data about immune cells. 3. Students will define and illustrate biological hierarchies from cells to organisms. 4. Students will identify the relationship between body systems using real-life examples. 5. Students will analyze a video to explain interactions among organ systems. 6. Students will create a hierarchy diagram to demonstrate understanding.

Activity	**Description**	**Materials**	**Time in minutes**	**CRP*/ Scaffolds**
Objectives & Expectations	**The teacher reviews objectives, expectations, and agenda. T opens the class with a shark attack game. Students try to guess the hidden word.**	**Slides.**	**5**	**Students use word glossary with visuals and translation to support them while doing the reading task**
Word Review	**After the warm up, students review taught words using Quizlet matching activity. Teacher introduces task and shows the code, students scan and use their iPads to practice individually.**	**Quizlet QR code Students school iPad**	**5**	**Word glossary with word, translation in native language, definition and pictures.**
Slow-Reveal Graph	**Teacher reviews numbers with them: thousands, millions,**	**Activity sheets- slides**	**7**	**Visuals- slow reveal graph- peer support-**

	billions and introduces the word 'trillion'. Students will look at numbers and say what they represent (i.e., :value million, billion, trillion); students will say words in their own language and write numbers in their own language (Indian or Arabic numbers). **Teacher shows a slow reveal graph for the number of immune cells in billions in the human body. Teacher first shows bars, then axes and finally labels.** **Students review graph items and discuss the data in the graph.** **Teacher introduces a task on the graph and models the first one.** **Students work on pairs to answer the question on the graph.**			
Set the context: Introduce the concept of hierarchies	Initiate a class discussion prior to beginning the activity. Paraphrase: *A hierarchy is a system of ranking things. They can be ranked in at least two ways:*	Realia: **Measuring multi-color nested measuring spoons** **Video of Russian Matrioshka (https://w**	**10 (original time is 20)**	**Teacher partner students who have better academic achievement withs students with lower academic performance and ensure in**

	how important they are (like army ranks) *how inclusive they are (like organisms made up of systems, organs, tissues, and cells.* *A hierarchy can help to explain how specialized parts work together in a cooperative whole.* Try (using the interactive nested diagram or by drawing on the board): apartment, building, block, neighborhood, city, county, state, nation Make concentric, nested diagrams of hierarchies. Some examples: hemisphere, planet, solar system, galaxy, supercluster, universe letter, word, sentence, paragraph, story, book animal, family, pack, population, species, biosphere desk, classroom, hall, floor/building, school, district leaf, branch, limb, tree, grove, forest (Note: the five examples above are included on this printable.)	**ww.youtubeeducation.com/watch?v=nKPM-z6y1w4)** In Pickle game Russian "matrioshka" nesting doll PDF hierarchy activity sheet: https://serpmedia.org/scigen/assets/l6.2-printable-hierarchy.pdf Interactive chart: https://serpmedia.org/scigen/l6.2a.html		**groups of two or three from the same gender taking into account cultural considerations).**

Watch the video (10 minutes)	Students watch this video as a group or individually. This video demonstrates how organisms are made up of organ systems (such as the cardiovascular system), and these are in turn made up of organs (like the heart, in the cardiovascular system), and organs are made up of tissues which are made up of cells. The video will take a close look at the cardiovascular system and how it works with the body's other organ systems, then drill down to show how cells make up the tissues that make up the heart which, along with the blood vessels and blood, form the cardiovascular system. Paraphrase: Most plants and animals are multicellular organisms, including us. In a multicellular organism, the cells all help each other out in a	Video link: https://serpmedia.org/scigen/l6.2b.html Speakers Display screen	10	**Teacher provides a script and shows text caption**

	cooperative community. But how? If you pick two cells in your body at random (say, a muscle cell in your shoulder and an epithelial cell in the lining of your stomach), it might be hard to see an obvious connection between them. It's easier to see how the cells in your body help each other if you look at the steps of the hierarchy through which they cooperate: cell, tissue, organ, system, organism. The transcript of the video has been included for your reference. We do not recommend distributing this text to your class.			
Review the video	As students finish watching the video, the teacher goes back to the idea of hierarchies from the prompt. Draw a Venn diagram that shows the hierarchical relationship of cell, tissue, organ, organ system, organism. The teacher asks students to answer the first four comprehension		**10 minutes (original time 20)**	

	questions and the fifth and sixth questions, which are more like discussion questions since the answers may not seem as straightforward to the students. Possible answers: 1. The integumentary system protects the body from the outside world. It contains sense receptors for temperature, pain, and touch. The muscular system moves the body, moves materials within the body, and generates heat. The skeletal system provides shape, support, and protection to the body, while allowing it to move. The lymphatic system scans for signs of infectious disease. The urinary system gets rid of waste and helps control blood volume and blood chemistry. 2. The cardiovascular system picks up oxygen that's been breathed in by the respiratory system. Blood flowing through the arteries carries the oxygen to cells throughout the body. Then the blood flows back through the veins,			

	carrying waste carbon dioxide back to the respiratory system to be breathed out. The blood leaves the heart to deliver oxygen to cells throughout the body and pick up carbon dioxide and other waste. Then the blood returns to the heart. Next, the blood is sent on a shorter trip to the lungs to get rid of carbon dioxide and pick up a new batch of oxygen. The oxygen-rich blood returns to the heart again, and starts all over. 3. The blood, the blood vessels, and the heart are the main parts of the cardiovascular system. 4. Three kinds of tissues make up the wall of the heart. (Extra credit for naming them: epicardium, myocardium, endocardium.) 5. They cooperate successfully by being organized into tissues, which are organized into organs, which are organized into organ systems that support each other.			

	6. Neither strategy—being single-celled or multicellular—is "better." They are different strategies. By numbers and sheer biomass, single-celled bacteria are the most successful kind of organism on the planet.			
Found poetry activity	**Teacher introduces a poem on the body by Robert Louis Stevenson (1850–1894). Students elicit key ideas from the poem. Then, Teacher introduces found poems and shows an example.** **Teacher introduces the activity and models. The teacher set a timer for 5:00 minutes with light music in the background. The teacher provides students with paper, glue, and text excerpts. Students work individually. Teacher supports students.**	**Glue Construction paper**	**10 minutes**	**Activity prompt in native language**
Review with a hierarchy diagram	Teacher closes by revisiting the nested diagrams from the first part of the activity. Paraphrase:	Writing prompt: slide and PDF https://serpmedia.org/s	5	

	The cells in a human (or other multicellular organism) are specialized parts in a cooperative whole. Write the following words on the board in a random order. cell, tissue, organ, organ system, organism Return to the list you wrote at the start of class. Ask again: How do these words relate to each other? What is within what?	cigen/l6.2c.html		
Homework 2	Word pyramid copying words			

Unit M6- Lesson 3

Unit M6 - Lesson 3 Objectives
1. Students will explore and compare different mapping systems. 2. Students will identify and describe the 11 human body organ systems. 3. Students will analyze system interactions using interactive digital tools. 4. Students will construct diagrams showing the overlap between systems. 5. Students will explain the cooperation of organ systems using case examples. 6. Students will present their system maps and discuss body system complexity.

Activity	**Description**	**Materials**		
Opener	**Teacher displays definition. Students say the words.**	**slides**	**5**	**Word glossary. Quizlet word cards**
Introduce mapping complex systems (10 minutes)	This activation activity gets students thinking about very complex maps, in this case New York City with its layers of the city from satellite, to live traffic, to subway. Paraphrase: How do we show the interactions of different, complex systems? City maps don't include every piece of information. They might include the names of streets and landmarks or not. In interactive maps like this OpenStreetMap of parts of New York City, we can switch	Interactive map https://www.google.com/maps/place/New+York,+NY	10	

	between views and add a layer of transit or bike paths. To communicate, sometimes a map needs lots of detail, sometimes it needs less. Sometimes it shows things below the surface. Maps can help us understand how things relate spatially (that is, in space). Some maps of New York City include subway lines, but they aren't shown on traffic maps because most subway lines are built above and below the ground and don't relate to the flow of traffic. Show: OpenStreetMap (or a Google map) of parts of New York City or of your local neighborhood. If your connectivity is poor, there are some screenshots of NYC maps in the slides. In OpenStreetMap, use the layers icon along the right side to see the different options (Standard / Cycle / Transport /Humanitarian) for viewing data. In Google maps, use the hamburger icon in the upper left corner to see the different options for viewing data. Have students work in small group or pairs to			

	look at different types of maps of local areas (with different levels of complexity) to compare and contrast what they see in teams. Paraphrase: Notice how these different city maps emphasize different things. The human body is similarly complex and layered. It has 11 organ systems, more if you divide up the systems differently. Showing how these overlap into one big system is as complicated as mapping a city. How can we map the interacting organ systems of the human body? Let's take a look.... (This introduces the next section, when students will use an interactive diagram of the human body's 11 organ systems.) Students check Columbia Missouri map and discuss differences.	Columbia Missouri map https://www.google.com/maps/place/Columbia,+MO/@38.9465985,-92.41324,12z/data=!3m1!4b1!4m6!3m5!1s0x87dcabf3bb8182c9:0xa011692dbabd6f20!8m2!3d38.9517053!4d-92.3340724!16zL20vMDF6MWM?entry=ttu&g_ep=EgoyMDI0MDkxOC4xIKXMDSoASAFQAw%3D%3D		
Explore the interactive body (20 minutes)	In this part of the activity, students will begin to consider how complex the human body is and how its complexity is often taken for granted. Things just seem to function day after day, year after year, until	Video link: https://serpmedia.org/scigen/l6.2b.html iPads		

	something disrupts one or more of the systems – just as in a city the subway moves or traffic flows, until it doesn't. Connect the mapping introduction to the human body interactive. Ask students to discuss: *How are those maps related to the human body system?* *How many organ systems can they name?* *How can we create a map of the interacting organ systems of the human body?* *What would that look like?* Have the students open the Interactive Human Body activity. Paraphrase: Scientists classify the systems of the human body in various ways. Eleven organ systems of the human body are pictured on your screens. You can blend different systems together. Add each system by moving its slider to the right. Read about what makes each system unique, and take notes. If students need more guidance in how to get	Interactive human body chart: https://serpmedia.org/scigen/l6.3b.html Colored printouts: https://serpmedia.org/scigen/assets/l6.3-printable-human-organ-systems-layers.pdf		

	started, have them select either a female or male integumentary system. Next add the muscular system. What happens when you add another system? What happens when you remove a system? Have students play with the available options before reading about function and parts. The interactive activity was designed for students working as individuals, pairs, or triads to explore on an electronic device. However, teacher may not be able to use electronic devices in classroom, so a printable version is included below. Of course, it does not have the same variable opacity of the interactive activity. Teacher might consider printing the layers on clear printer paper, sold as "computer-printable transparent plastic sheets" or "transparency film." If using this method, consider backing the explanatory text with opaque paper to aid legibility. Alternatively, if you have an overhead projector or light table at your school, you can use that for students to lay the different systems on top of one another and see how			

	systems co-locate. Finally, a last option is to let students lay the sheets on a large window on a non-gloomy day. Using standard paper, up to 5 sheets of paper might be somewhat translucent when backlit, but you'll get the best results when you overlay just 2 or 3 sheets at a time. Some teachers opt to have the physical layers available to all groups regardless of whether the students also use electronic devices. If you make these tangible layers part of the activity, extend the time by five minutes. And have an overhead projector or light table on hand.			
Make maps of two interacting organ systems	As students finish watching the video, go back to the idea of hierarchies from the prompt. Teacher draw a Venn diagram that shows the hierarchical relationship of cell, tissue, organ, organ system, organism. Teacher sk students to answer the first four comprehension questions and the fifth and sixth questions, which are more like discussion questions since the answers may not	Pulling Apart Systems slide: https://serpmedia.org/scigen/l6.3c.html Systems riddles: https://serpmedia.org/scigen/assets/l6.3-six-body-system-riddles.pdf	10 minutes	

	seem as straightforward to the students. Possible answers: 1. The integumentary system protects the body from the outside world. It contains sense receptors for temperature, pain, and touch. The muscular system moves the body, moves materials within the body, and generates heat. The skeletal system provides shape, support, and protection to the body, while allowing it to move. The lymphatic system scans for signs of infectious disease. The urinary system gets rid of waste and helps control blood volume and blood chemistry. 2. The cardiovascular system picks up oxygen that's been breathed in by the respiratory system. Blood flowing through the arteries carries the oxygen to cells throughout the body. Then the blood flows back through the veins, carrying waste carbon dioxide back to the respiratory system to be breathed out. The blood leaves the heart to deliver oxygen to cells throughout the body and pick up carbon dioxide and other waste. Then the blood returns to the heart. Next, the blood is sent on a	Showing two systems slides: https://serpmedia.org/scigen/l6.3b.html Look at the simulation open for them to use that to help them: Interactive human body chart: https://serpmedia.org/scigen/l6.3b.html		

	shorter trip to the lungs to get rid of carbon dioxide and pick up a new batch of oxygen. The oxygen-rich blood returns to the heart again, and starts all over. 3. The blood, the blood vessels, and the heart are the main parts of the cardiovascular system. 4. Three kinds of tissues make up the wall of the heart. (Extra credit for naming them: epicardium, myocardium, endocardium.) 5. They cooperate successfully by being organized into tissues, which are organized into organs, which are organized into organ systems that support each other. 6. Neither strategy—being single-celled or multicellular—is "better." They are different strategies. By numbers and sheer biomass, single-celled bacteria are the most successful kind of organism on the planet.			
Share maps of two interacting organ systems	As the students finish the activity, ask them to share their two-system diagrams mapping the two systems. Teacher can have them print out and then post their diagrams and blurb	Chart link: https://serpmedia.org/scigen/l6.3d.html	10	**Teacher partner students who have better academic achievement withs students with lower**

	directly onto the projected chart. Or can make the chart a shared Google doc that they can add their images and text to. When students solve the riddle and then share with the class, ask them to explain why they chose the two systems they did. What was their thought process? As the table is completed, whether or not the students have made diagrams, use the sliders to show what each pair of organ systems look like together. Solution: Cardiovascular + Muscular Nervous + Respiratory Cardiovascular + Respiratory Cardiovascular + Digestive Nervous + Muscular Nervous + Digestive Or, to fill in the chart:			**academic performance and ensure in groups of two or three from the same gender taking into account cultural consideration**
Wrap-up: Our bodies react Turn and talk	In this part of the activity, students expand what they just learned about how different systems in our body must work together so that we can function the way we do as a whole system. This activity can be done as a writing exercise or a class discussion.	What happens slide: https://serpmedia.org/scigen/l6.3e.html	10	Translating prompts

	Pose situations to your students as a class, or distribute different scenarios to different students to give them a chance to consider their answers in greater depth. Encourage the students to use the interactive slider to review the body systems and consider what role each one might play in the interaction. Some of these scenarios may involve two or three body systems, and a case can be made that others may involve nearly all of the systems of the body! Whatever answers they come up with, have students explain their thinking and use the opportunity for a rich discussion about how students see similar scenarios differently. If the students work in pairs or small groups rather than as a class, save some time to review the students' responses as a class. If time remains, ask the students to generate other situations and consider how their bodies would react. They can challenge other groups to find out the answer to their riddles! Some students will rise to			

	the occasion to engage in this game. If you'd like for student groups to come up with scenarios and challenge the other groups to decipher which systems are involved, more time may be needed for this activity. Ask the students to reflect on how the different systems interact in different ways in the riddles and these reaction scenarios. Ask: How do all these functions add up to a more general service performed for the human body organism?			
Homework 3	Word pyramid: copy the rest of words			

Unit M6- Lesson 4

Unit M6 - Lesson 4 Objectives
1. Students will review vocabulary and identify organs using visual clues. 2. Students will analyze how cells, tissues, and organs interrelate. 3. Students will participate in a card-based game simulating organ system cooperation. 4. Students will categorize and organize biological components in a body map. 5. Students will discuss game outcomes and reflect on system interactions. 6. Students will express understanding through creative blackout poetry.

Activity	**Description**	**Materials**	**Time in Minutes**	**CRP*/ Scaffolds**
Opener	**Teacher displays Quizlet QR code. Students scan and test themselves in words Students say the words. T reviews the word organ with students and asks them to brainstorm organs in the body. Students list organs. Teacher shows images of organs under the microscope. Students guess the organ. Then, students explore the virtual microscope.**	**Slides**	**10**	**Word glossary. Quizlet word cards** **interactive microscope: https://interactives.bscs.org/3dmss/microscope.html**
Set the context	In this unit we've been looking at how cells cooperate to form a larger, multicellular organism, focusing on the human body. If we were	Cards: https://serpmedia.org/scigen/assets/l6.4-cards-master.pdf	10	

	to make a diagram of what makes up the body, it might look a little like this. Show slide. Add smaller elements to the map. Ask: Where does heart tissue (like epicardium, the myocardium, and the endocardium) fit in this diagram? Draw a line from the pink square on the right labeled "Heart" and attach a square labeled "Heart Tissue." Challenge the students to think of other tissues or organs to add to the map. Add more elements to the map. Ask: Where do cells fit in this diagram? After students have a chance to offer some answers, draw a line from the square teacher just made, labeled "Heart Tissue." Label this new square "Cells" (or, more specifically: epithelial cells, fat cells, muscle cells). Challenge the students to think of other organs, tissues, or cells to add to the map.	(54 identically sized cards) Map of the human body: https://serpmedia.org/scigen/l6.4a.html		

	Once you've added some elements to the map and "fleshed" it out a bit, take a step back at the map and look at the pink and yellow areas, labeled Cardiovascular System and Nervous System, respectively. Paraphrase: *Today we are going to build this part of the map from the outside in, while playing a game!*			
Set up the game	Print and cut the cards before class. Split the class into six teams (or 12 teams if teacher want to use two decks). The Cell-or-System deck consists of 54 cards with nine cards each of six different suits: three N or gold suits of the Nervous System: Brain, Sensory Nerves, and Motor Nerves; three C or red suits of the Cardiovascular System: Heart, Vessels, and Blood. Show the slide that displays all the cards. Explain how the suits are organized and the object of the game: *As a team, you will try to get all of one organ (shown as one horizontal*	Slide link: https://serpmedia.org/scigen/l6.4b.html Display screen Cards link: https://serpmedia.org/scigen/assets/l6.4-cards-master.pdf	5	

	row in the slide) and have your organ system (shown as 27 cards in one color) be collected when two other teams collect organs in your color. Shuffle the deck. Each team gets nine cards. Allow teams a minute or so to group their cards into suits and decide on which organ (Brain, Sensory Nerves, Motor Nerves, Heart, Vessels, or Blood) they will collect. Teams should try to corner the organ suit (Br, S, M, H, V, Bl) of which they hold the most cards.			
Introduce the rules and play the game	Show the slide to review the rules of the game with the class. Open a round by ringing the bell. Teams blindly trade at least one and as many as four cards with another team (one for one, two for two, and so on). To trade two cards, the team pulls out the two cards from their hand and shouts "Two cells! Two cells!" Team members then listen and look for another team looking to trade two cards. Traded cards must be the same suit (all Br, all S, all M, all H, all V, or all Bl) and the same in number (1, 2,	Showing rules slide: https://serpmedia.org/scigen/l6.4d.html	15 minutes, 30 for original intervention	

	3, or 4 cards). They keep shouting the numbers they want to trade until the cards are exchanged, face down, WITHOUT revealing the cards, i.e. until they are in the new team's hands. Teams do not take turns (see "Slower version" below for alternative). Instead, everyone plays at the same time, trading with other teams until one team collects all the cards in a suit. When a team acquires a full hand of nine matching cards, they ring the bell and place the organ on the board at the front of the classroom. The game ends when one half of the class first organizes three organs within one color—that is, all three gold suits of the Nervous System: Br, S, M; OR all three red suits of the Cardiovascular System: H, V, Bl. Have students play a quick round (about 5 minutes) while teacher monitor their understanding of the rules. Teams may mistakenly try one of these rule-breaking moves: trading different numbers of cards (like two cards for three cards)			

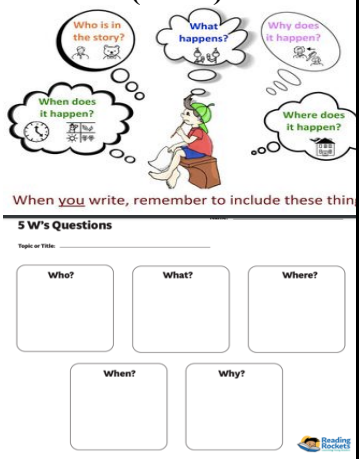
	trading heterogeneous sets (containing more than one kind of suit) revealing what they are trading (in words or by flashing the cards to the other team) calling "Three! Three!" as in the original Pit game, rather than "Tissue! Tissue!" **Winning** When a team matches all 9 cards into three sets of "ti-ss-ue" cards, the team rings the bell and puts their organ on the board. When all three organs from that system are claimed, the system wins and that half of the class wins.			
Review the game	Review the game with the students when they are done.	Follow up questions slide: https://serpmedia.org/scigen/l6.4f.html	5	Modeling and visual representation

Create a blackout poetry	**Teacher closes the lesson by revisiting the words studied and introducing the blackout poetry concept.** **Teacher provides a text and asks students to create a blackout poetry.** **Students shared their poems.**	**Video script printout, colors, crayons, markers, pencils and erasers**	**10**	**Teacher plays video again with subtitle while students are working.**
Homework 4	**Use words in sentences**			

Unit M6- Lesson 5

Unit M6 - Lesson 5 Objectives				
1. Students will observe immune response through video and discussion. 2. Students will make personal connections with prior experiences (e.g., splinters). 3. Students will read and analyze a comic to identify immune system functions. 4. Students will answer comprehension questions on cell specialization and defense. 5. Students will review vocabulary through a tournament format. 6. Students will describe how body cells coordinate for immune response.				
Activity	**Description**	**Materials**	**Time**	**CRP*/ Scaffolds**

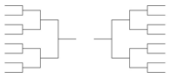
Set the context by seeing a white blood cell in action	Initiate a class discussion prior to reading the comic, eliciting student observations and inferences. Watch this animated simulation of a microscopic view of a white blood cell. Paraphrase: *What's happening here?* *Can you spot the germs that this white blood cell is destroying?*	Video link: https://serpmedia.org/scigen/l6.5a.html	5	
Background overview	**Teacher shows a picture of wood splinter and asks the students about its name and what it mean. Then asks them about their experience with splinters and how they did when having a splinter. Teacher introduces questions about the splinters (How to clan splinter area?; How to remove splinter?). Teacher shows students a video about splinters. Students watch and answer questions**	**Slides** **Video: https://www.youtube.com/watch?v=21lK38lr7L0&pp=0gcJCdgAo7VqN5tD&themeRefresh=1**	**5**	**Teacher gives students space to use their native language and talk about their own experiences**

Read the comic	**Teacher introduces the book and introduces main characters. Teacher introduces the graphic organizer and ask students to rad and answer those 5 questions.** This is a 16-page comic explainer that deepens students' understanding of one innovative advantage of multicellular organisms: immune response. The comic dramatizes how multicellular cooperation plays out at a cellular level. Assigning different cells distinct characterizations and using humor to engage students, it depicts a simplified bacterial infection. The comic stars a cast of human cells whose behavior offers an entertaining and useful review about how cells work together for immune response when faced with an invasion by single-celled infectious opponents. In contrast, all the pathogenic bacteria in the comic are alike; they don't use the same kind of division of labor as	Comic PDF: https://serpmedia.org/scigen/assets/immune_comic-pdf.pdf	40	**Printed copy of the comic. Copy of graphic organizer on story elements (Wh's)** 

	multicellular organisms. Students stay on task best when reading this out loud with at least one other student.			
Review the story	When the class finishes reading, ask students to answer these questions. There are more comprehension questions than usual on this list. Teacher can assign each student one or two questions or treat the nine questions as a comic scavenger hunt. Possible answers: Examples of specialization by human cells in the comic could include nerve cells, macrophage, neutrophils, dendritic cells, skin cells, red blood cells, fibroblast, and lymphocytes Macrophages identify germs by checking cell membranes for molecules that germs would have. (Receptor cells on macrophages fit the shapes of molecules that are characterize germs.)	Comprehension Question slides: https://serpmedia.org/scigen/l6.5c.html	20	

	The macroscopic signs of inflammation are redness, heat, swelling, and pain. White blood cells like macrophages help trigger inflammation with chemical signals. When epithelial cells that make up blood vessels get those signals, they change their shape, widening the vessels to allow more blood flow (which causes redness and heat), and allowing more fluid out into the infected area (causing swelling). The swelling causes pressure. The pressure, and also the initial chemical signs of infection, cause nerve cells to carry pain signals to the brain. Pus is made mostly of dead neutrophils. Cells communicate using chemical signals. (Nerve cells also pass electrical signals along their membrane, so that would be an acceptable student answer; but although this comic doesn't go into detail, even a nerve cell uses a chemical signal to tell the next nerve cell to			

	initial its electrical signal.) Two ways germs can do damage to the cells in people are using up their food and leaving unhealthy waste. Antibody molecules attach to germ surfaces. Antibodies can then interfere with germs' functioning, make germs stick together, and encourage white blood cells to eat the germs faster. The immune system takes molecules from the germs themselves (antigen), and chooses a lymphocyte that makes exactly the right antibody to attack that antigen. (An antigen-presenting white blood cell like a dendritic cell helps show antigen to lymphocytes.) It is important for the immune system to keep a lookout in all those places because the areas where macrophages are concentrated are exactly the places where stuff from outside the body (including stuff passing through the digestive system) is most likely to get into the body. These			

	surfaces are where germs are most likely to attack.			
Word Tournament activity	Review unit words Use brackets to create a word tournament.	Flippity website Tournament chart 		Glossary modeling Multimedia using native language
Homework 5	Using rest of words in sentences			

Small, Smaller, Smallest Unit

Unit: M1 Small, Smaller, Smallest

Topic: Structure of Matter

Vocabulary: *Particle, Element, Atom, Molecule, Compound, Particulate, Continuous, Conservation, Reaction*

Unit M – Lesson 1 Objectives

1. Students will compare continuous versus particulate models of matter using examples.
2. Students will learn and use key terminology: particle, element, molecule, atom, compound, conservation.
3. Students will discuss and model the idea that matter can be divided indefinitely (e.g., brownies script).
4. Students will identify matter versus non-matter (light, sound, thought).
5. Students will begin matching vocabulary with definitions.

Activity	Description	Materials	Time	CRP*/ Scaffolds
Set the context	Ask students to turn and talk in order to discuss whether they think that the matter that makes up a nugget of silver, a glass of water, and the air inside of a balloon is made up of tiny particles or is made of a continuous substance. Let students know that by the end of the lesson		10	**Visuals and per mediated discussion**

	they will now much more about this.			
Introduce new science terms	**Introduce new science terms - Teacher introduces new vocabulary using slides.** **-Teacher presents definitions, visuals, and context for 8 target words.** **- Teacher provides translation of each word into students' native language and breaks word into syllables to show students how to say it.** **-Teacher models what the word does and does not look like.** **Students turn and talk r responding to a prompt on each word.** **- Students practice using new words in a quick written activity** **Target words: "Particle- element- molecule- atom- compound- particulate- conservation"**	**Lesson word cards**	**20**	**Examples from students' lives, Use of Students' native language, visuals and word glossary**
Watch a video on matters	**- Teacher presents questions about the topic and asks students to watch and answer question**	**YouTube videos on matter and particles:**		

		https://www.youtube.com/watch?v=ELchwUIlWa8 https://www.youtube.com/watch?v=npv74D2MO6Q		
Engage with the Script	**In pairs, Teacher assigns students to try to cut it in half forever and asks them about this experience.** **Teacher chooses four students to read the parts of Adam, Zena, Aunt Lucy, and Olivia in the Science Scene. The script is an informal introduction to atomic theory and the nature of matter. The students will be discussing what would happen if they could continue to divide a brownie in half. Would the smallest part still be a brownie, or does it become something else?** **Teacher clarifies what an atom is and how those come together to make the matter that we can see. It might also be**	**Brownies, nan bread, traditional deserts, plastic knives, plates** **Dialogue script (adapted)**	**10**	**Adapted script** **Visual representation of the dialogue** **Assign roles for students and provide them with individual opportunities to read the script before reading it aloud in front of the group.**

	beneficial here to talk about what things are NOT matter (light, sound, thought).			
Summative Activity	Teacher introduces the matching activity and models. Students do one on their own. Teacher asks students to do the rest as homework.		**5**	**Modeling and peer support**
Homework 1	Match word with definition.			**Use native language**

Unit M, Lesson 2 Objectives
1. Students will apply unit vocabulary in a competitive, structured vocabulary game. 2. Students will categorize substances using the terms atom, element, molecule, and compound. 3. Students will calculate atomic ratios within common molecules (e.g., water, carbon dioxide, ammonia). 4. Students will complete a classification table using learned terms and examples. 5. Students will construct a found poem integrating science vocabulary meaningfully.

Activity	**Description**	**Materials**	**Time**	**CRP*/ Scaffolds**
Opener and vocabulary game	-Teacher reviews with students the unit words using shark attack vocabulary game.	**Cards and slides** **Frayer model cards**	**5**	**Games and poetry**
Define and discuss terms for particles	Introduce the concepts and vocabulary associated with atomic theory as shown on the slides.	**https://serpmedia.org/scigen/m1.2a.html**	10 (original time 15)	**Visuals, definition, examples and translation to native languages**
Turn and Talk: Determine the proportions of three compounds (10 minutes)	Using the models students can determine the proportions of several common compounds. **Answers:** *Water has 2 hydrogen atoms per 1 oxygen atom. Carbon dioxide has 2 oxygen atoms*	**https:/https://serpmedia.org/scigen/m1.2a.html/serpmedia.org/scigen/m1.2b.html**	10	**Partner discussions** **Everyday substances as examples**

	per 1 carbon atom. Ammonia has 3 hydrogen atoms per 1 nitrogen atom.			
Partner Work: Complete a table using the terms atom, element, molecule, and compound (20 minutes)	To practice determining the atomic makeup of particular particles, students complete a table. The first two examples are done for them.	**https://serpmedia.org/scigen/assets/m1.2_partner_work_table.pdf**	20	**Frayer models, guided table work**
Found poetry activity	**Understand the vocabulary, show me the found poem. Setting a timer for 5:00 minutes with light music in the background.**		10	**Slide visuals, sentence prompts**
Homework 2	Word pyramid copying words			

Unit M, Lesson 3 Objectives
1. Students will describe the particulate makeup of air and related substances using visual models. 2. Students will analyze particulate-level differences among beach-related materials (e.g., saltwater, wet sand, air). 3. Students will identify substances based on particulate structure in a web-based interactive quiz. 4. Students will organize vocabulary into a structured format through word pyramid activities. 5. Students will revise initial ideas based on new scientific evidence presented in the lesson.

Activity	**Description**	**Materials**	**Time**	**CRP*/Scaffolds**
Discussion: A thing is more than a thing	Invite students to think about common items they encounter everyday. Offer the example of air. It's often something we think of as a simple singular thing. Ask students to turn and talk about what they think air really is. Entertain various thoughts and then present the slide of air with the atomic model. Second, show the "key" that displays the various atoms	**Slide link: https://serpmedia.org/scigen/m1.3a1.html**	**10**	Daily life examples (air, beach) **Peer discussion and checking and use of native language**

	and their associated colors (the colors arbitrary, of course!) and have the students offer a new statement as to what air actually is. About 78% nitrogen gas (N2) and 21% oxygen gas (O2), with smaller amounts of other gasses including water vapor, carbon dioxide, and argon. (Carbon dioxide and argon are not show in this model.) Note: Student access to the "element key" may be helpful during the next part of this activity.			
Interactive: Explore the beach at the particulate level	Here students are asked to examine "close-up views" of air, cloud, saltwater, foam, wet sand, dry sand, and fresh water. Their goal is to familiarize themselves with the element makeup and other properties of each. When students are ready, they may move on to an informal interactive quiz.	**https://serpmedia.org/scigen/m1.3a.html**	10 (original time 15)	**Students scan the website code and use school iPad to explore website.**

Interactive: informal beach quiz (15 minutes)	Students test themselves to see if they can recognize the various beach-related items at the particulate level.	**https://serpmedia.org/scigen/m1.3a_quiz.html**		**Students scan the website code and use school iPad to explore website. Students check work in peers.**
Homework 3	**Word pyramid. Copying rest of the words**			**Modeling**

Unit M, Lesson 4

1. Students will explain the Law of Conservation of Matter through verbal and written responses.
2. Students will observe and record changes in matter during experiments and multimedia activities.
3. Students will construct models of atomic rearrangement before and after chemical changes.
4. Students will compose a blackout poem that integrates key vocabulary and concepts.
5. Students will relate physical changes (e.g., burning candle, slime formation) to scientific laws.

Activity	Description	Materials	Time	CRP*/ Scaffolds
Discussion: Law of Conservation of Matter	Teacher asks students to think about a burning birthday candle. Have them turn and talk about whether part of the candle is "gone" once it has burned awhile. Teacher entertains various responses, but guide students to an understanding that matter is neither created nor destroyed, but it can change. With the candle example the wax that has burned is now in the form of leftover wax that is	https://serpmedia.org/scigen/m1.4a.html	10	Familiar examples (candles, slime)

	liquid, solid, and gasses that have drifted into the air. The Law of Conservation of Matter is also known as the law of conservation of mass. It states that matter cannot be created or destroyed; it can only change its form.			
Conservation of Matter Video	**Teacher develops a model to describe atomic composition to help students to be able to recognize the model of a molecule and to make a model of the molecules. The PhEt activity can do both of those.**	https://www.youtube.com/watch?v=l9szOanq7Pg	5	Multiple ways to respond (visuals)
Create a blackout poetry	**Teacher closes the activity by revisiting the words studied.** **Teacher provides a text and ask students to create a blackout poetry.**	**Dialogue script** **Markers** **Paper colors**	**10**	Multiple ways to respond (poetry)
Slime activity	**Teacher explains the law of Conservation** **-What changes do you notice? /What do you notice/**	**Slime ingredients (glue- lenses liquid)** **Measuring cups- scale**	**15**	

	What do you wonder? **-Was mass conserved? What evidence do we have?** **(The mass is no longer liquid: it is something completely new and you cannot turn them back to liquids).**			
Homework 4	**Use words in sentences**			**Modeling and guidance**

Unit M, Lesson 5 Objectives
1. Students will explain how photosynthesis transforms matter from air into plant mass. 2. Students will interpret the photosynthesis chemical equation and label its molecular components. 3. Students will evaluate models of photosynthesis and recommend improvements. 4. Students will justify vocabulary usage by debating word relevance in a bracket-style tournament. **5.** Students will construct original sentences using vocabulary to demonstrate conceptual understanding.

Activity	**Description**	**Materials**	**Time**	**CRP*/ Scaffolds**
Review	*Considering that trees can be huge and grow from tiny seeds, how can it be true that matter cannot be created? Where does all that matter in a big tree (or any plant) come from?* Hardly any of the matter in the tree comes from the seed, but it has to come from somewhere. A lot of people think it comes from soil, but really most of the matter that makes the tree comes from molecules in the air.		10	Connections to prior learning
Photosynthesis video	**Students watch a short video on synthesis and answer questions.**	**https://www.youtube.com/watch?v=D1Ymc311XS8**	**5**	
Review writing the chemical equation	Teacher starts with H2O and reviews with students what does h mean.			

Reading: photosynthesis	Teacher work with students on labeling the chemical items and identifying the formula. Teacher acknowledges that students have probably heard of photosynthesis before in elementary school, but tell them that they will be thinking about it in a more advanced way now. Teacher assigns reading and worksheet in partners or individually.		**20 minutes**	Guided reading, visual diagrams Model critique, word tournament
Critique: model of photosynthesis (10 minutes)	Students examine this model that shows the process of photosynthesis. Teacher asks: Are you able to explain the model? If you were going to design a model of photosynthesis, how would you go about it? (It might be helpful to compare this animation with others, such as this one: https://www.youtube.com/watch?v=prFaSe3s9e0.) Allow brainstorming or model development (if feasible).			
Word Tournament activity	Teacher reviews unit words -Teacher introduces the activity. selects 8 words from the words -Students	Flippity website-worksheet	10	**Connections to prior learning**

	use in the blackout poetry. -Students use brackets to create a word tournament. Two different words: **make a sentence using the two words (one sentence summarizes everything)** Discussing: ***Why is your word more important?***			**Hands-on modeling & vocabulary debates**
Homework 5	**Use words in sentences**			**Modeling and guidance**

Appendix C

Study Measures

Non-curricular Pre-Study Measures

Acculturation Short Assessment Survey

The following is the Acculturation Short Assessment Survey used in the study. It is designed to capture students' cultural preferences and backgrounds.

Section 1: Background Information

1. **Student Code** (e.g., G5ELHA): _____
2. **Grade**: ☐ 6 ☐ 7 ☐ 8
3. **Years in the US**: ☐ Less than one year ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
4. **US Citizen**: ☐ Yes ☐ No
5. **Country of origin (Where is your family from?):** _____
6. **Languages spoken at home:** _____

Section 2: Cultural Preferences Survey

Read the following questions and choose the option that best describes your experience or preferences:

7. **I am most comfortable being with people from...**

   ☐ a. The United States

   ☐ b. The country my family is from

☐ c. Both

☐ d. Neither

8. **My best friends are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

9. **The people I fit in with best are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

10. **My favorite music is from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

11. **My favorite TV shows are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

12. **The holidays I celebrate are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

13. **The food I eat at home is from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

14. **The way I do things and the way I think about things are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

15. Any other comments? _____ (Write N/A if none)

Language Acculturation Survey Instrument

Section 1: Background Information

1. **Student Code** (e.g., G5ELHA): _____
2. **Grade**: ☐ 6 ☐ 7 ☐ 8
3. **Country of origin** (Where is your family from?): _____
4. **Languages spoken at home**: _____

Section 2: Survey Questions

Read the following questions and choose the option that best represents your language preference.

5. **What languages do you watch TV shows/YouTube/videos in?**

   ☐ a. English only

   ☐ b. Mostly English

   ☐ c. English and another language

   ☐ d. Mostly another language

   ☐ e. Another language only

6. *(Optional open text question)*

   Now, please describe your language preference in your own words:

---

7. **In general, in what language do you read and speak?**

   ☐ a. English only

   ☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

8. **What languages do you usually speak at home?**

☐ a. English only

☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

9. **In what language do you usually think?**

☐ a. English only

☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

10. **What language do you usually speak with friends?**

☐ a. English only

☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

Non-curricular Progress Monitoring Measures Summary and Description

Measure	Description
Student Exit Ticket Electronic- Microsoft Forms	Social validity survey to rate students' thoughts about the quality of intervention. Survey items: **<u>Please fill this quick survey and let us know your feelings and thoughts about today's lesson:</u>** **1** is for the **LOWEST** and **5** is for the **HIGHEST** **1**=😠 I'm very frustrated and didn't understand much **(Not good at all)**. **2**=😕 I'm confused and found the lesson difficult **(Not good)**. **3**=😐 I'm somewhat clear but still unsure about some parts **(Okay)**. **4**=🙂I'm feeling good, I understood most of the lesson **(Good)**. **5**=😁 I'm confident, I fully understood the lesson and enjoyed it! **(Very good)**.

Lesson Exit Ticket Instrument

This exit ticket was administered to collect student feedback about the Science lesson.

Section 1: Student Information

1. **Student Code** (e.g., G5ELHA): _____
2. **Grade**:
    a. 6
    b. 7
    c. 8
3. **Implementation Unit**:
    a. Week 1/2: Cells and human body systems
    b. Week 3/4: Structure and properties of matter
4. **Choose the implementation day**:
    a. Day 1
    b. Day 2
    c. Day 3
    d. Day 4
    e. Day 5

Section 2: Student Reflections

Please circle one response per item.

Rating scale:

- **1** = 😠 I'm very frustrated and didn't understand much (Not good at all)
- **2** = 😕 I'm confused and found the lesson difficult (Not good)
- **3** = 😐 I'm somewhat clear but still unsure about some parts (Okay)
- **4** = 🙂 I'm feeling good, I understood most of the lesson (Good)
- **5** = 😄 I'm confident, I fully understood the lesson and enjoyed it! (Very good)

5. **Today's lesson was**:
    a. 1 – Not good at all 😠
    b. 2 – Not good 😕
    c. 3 – Okay 😐
    d. 4 – Good 🙂
    e. 5 – Very good 😄
6. **My engagement was**:
    a. 1 – Not good at all 😠
    b. 2 – Not good 😕
    c. 3 – Okay 😐
    d. 4 – Good 🙂
    e. 5 – Very good 😄
7. **My science learning was**:
    a. 1 – Not good at all 😠
    b. 2 – Not good 😕

c. 3 – Okay 😐

d. 4 – Good 🙂

e. 5 – Very good 😄

8. **My vocabulary learning was**:

a. 1 – Not good at all 😠

b. 2 – Not good 😕

c. 3 – Okay 😐

d. 4 – Good 🙂

e. 5 – Very good 😄

9. **My interest in today's topic was**:

a. 1 – Not good at all 😠

b. 2 – Not good 😕

c. 3 – Okay 😐

d. 4 – Good 🙂

e. 5 – Very good 😄

Curricular Progress Monitoring Measures Summary

Week#	Tier 2 Vocabulary (Academic words)	Tier 3 Vocabulary (Science content words)
1	Strategy, Specialize, Cooperate, Hierarchy	Organism, Tissue, Organ, System (in a biological context)
2	Structure, Function, Organic, Fuel, Cycle	Specimen, Membrane, Osmosis, Producer, Consumer
3	Conservation	Particle, Element, Atom, Molecule, Compound, Particulate
4	Expand, Irregular, Reference Point	Density, Volume, Mass, Fluid, Displacement, Eureka!

Week 1: Seeing Inside Cells, *Science Word Acquisition and comprehension*

Science Word Acquisition F (1)

Student Code: _____ **Date: ___/___/_____**

Grade: _____

Day: _____ **Week: _____**

Section 1: Match words with definitions

1-Fuel	( )The basic form or support underlying something.
2-Structure	( ) A sample that represents a larger group of things, often examined or analyzed.
3-Specimen	( ) A very thin, flexible layer that encloses something.
4-Membrane	( )A way of ranking or organizing things.
5-Osmosis	( )An energy source that feeds a living thing; food.
	( )A defined group of goals and the functions to achieve them.
	( ) Movement through a partially permeable membrane.

Section 2: Reading Comprehension

Read the passage and answer the following questions:

Cells are the basic building blocks of all living things. Every living organism, from tiny bacteria to large plants and animals, is made of cells. Think of cells as tiny factories that do all the work needed to keep an organism alive. Inside each cell, there are parts called organelles, which each have a specific job to help the cell function properly.

One important part of a cell is the plasma membrane. The plasma membrane surrounds the cell and controls what goes in and out, helping the cell stay stable. It is made of special molecules called phospholipids, which form a flexible barrier around the cell. Inside the cell, there is a jelly-like substance called cytoplasm, which holds the organelles and gives the cell its shape.

One of the most important organelles is the nucleus. The nucleus acts like the control center of the cell. It contains DNA, which carries the instructions for how the cell should work, grow, and reproduce. Cells need energy to function. This energy comes from the mitochondria, which are the powerhouses of the cell.

Mitochondria turn food and oxygen into energy the cell can use to perform its tasks. Different cells have different jobs. For example, muscle cells help the body move, while nerve cells send signals quickly throughout the body. These special features allow cells to carry out the many important functions that keep an organism alive.

Cells are the foundation of life, allowing living things to grow, develop, and stay healthy.

Comprehension Questions

1. **What is the cytoplasm?**

    a. The cytoplasm is a jelly-like substance that surrounds the cell and controls what goes in and out.

    b. The cytoplasm is the control center of the cell and contains the cell's DNA.

    c. The cytoplasm is like the factory floor where all the work happens.

    d. The cytoplasm is the power plant of the cell and produces energy.

2. **What is the relationship between organelles and cells, according to the text?**

    a. Organelles are larger structures made up of cells.

    b. Organelles are parts of cells that work together to keep them functioning.

    c. Organelles are independent units that do not relate to cells.

    d. Organelles are the same as cells but have different names.

3. **What is the main idea of the text?**

    a. Cells help organisms move and make energy.

    b. Cells are the basic units of life that work together.

    c. Cells are made of plasma membranes and cytoplasm.

    d. Cells control movement and send signals.

4. **How does the nucleus function in the cell?**

    a. The nucleus produces energy for the cell.

    b. The nucleus acts as the control center and contains the cell's DNA.

    c. The nucleus surrounds the cell and controls what goes in and out.

    d. The nucleus serves as the factory floor where work happens.

5. **What might happen to a cell if its nucleus is damaged?**

    a. The cell will produce more energy.

    b. The cell will continue to function normally.

    c. The cell may not be able to carry out its functions properly.

    d. The cell will become larger and stronger.

Note. Definitions 4 and 6 are outliers

Week 2: Cells Teaming Up, *Science Word Acquisition and Reading Comprehension*

Science Word Acquisition F (2)

Student Code: _____ **Date: ___/___/_____**

Grade: _____

Day: _____ **Week: _____**

Section 1: Match words with definitions

1-Hierarchy	( ) A separate, complete living thing, such as animal, plant, fungus or microorganism.
2-Specialize	( ) A group of similar cells working together to do a specific job.
3-Organism	( ) To focus on a particular area; to distinguish oneself by form or function.
4-Tissue	( ) A group of parts that depend on each other to function.
5-System	( ) A sample that represents a larger group of things, often examined or analyzed.
	( ) A way of ranking or organizing things.
	( ) An period of time in which a set of events or phenomena is completed.

Section 2: ***Read the Passage and Answer the Questions***

Passage:
Your body is made up of trillions of tiny cells that work together like a team. These cells are organized into groups called tissues. Tissues are like the different players on a sports team, each with a special job. For example, muscle tissue helps you move, and nerve tissue sends messages throughout your body.

Tissues work together to form organs. Organs are like the different positions on a sports team, each with a specific role. For example, your heart is an organ that pumps blood throughout your body, and your lungs are organs that help you breathe.

Organs work together to form organ systems. Organ systems are like the different parts of a team, each working together to achieve a common goal. For example, your digestive system helps you break down food, and your circulatory system carries blood throughout your body.

All of the organ systems work together to form an organism, which is a complete living thing. You are an organism, and so are plants and animals. Your body is like a complex machine, with many parts that work together to keep you alive and functioning.

The way your body is organized is called a hierarchy. This means there are different levels of organization, with each level building on the one below it. The hierarchy ensures that all of the cells, tissues, organs, and organ systems work together in a coordinated way.

Your body is a complex and amazing machine made up of many parts that work together to keep you alive and healthy. Just like a sports team, each part is important, and they all need to cooperate to win.

Comprehension Questions

1. **A complete living thing is:**

    a. An organism

    b. An organ

    c. A hierarchy

    d. A cell

2. **What is an example of an organ system and its function?**

    a. The heart is an organ that pumps blood

    b. The lungs are organs that help you breathe

    c. The digestive system helps you break down food

    d. The circulatory system carries blood throughout the body

3. **What is the main idea of the text?**

    a. The human body is made up of many different parts that work together

    b. The human body is like a sports team, with different parts working together to achieve a common goal

    c. The human body is a complex machine with many different systems

    d. The human body is made up of trillions of cells that work together

4. **Why is the human body compared to a sports team?**

    a. Both have many different parts that work together

    b. Both have a coach who tells them what to do

    c. Both have a captain who leads the team

    d. Both have different players with different skills

5. **Based on the text, why is it important for the different parts of the body to work** together?

    a. To perform specific tasks independently

    b. To ensure the body functions properly and stays healthy

    c. To compete with each other like sports teams

    d. To keep the body looking good

Note. Definitions 5 and 7 are outliers.

Week 3: Determining Density, Science Word Acquisition

Science Word Acquisition F (3)

Student Code: _____ **Date: ___/___/_____**

Grade: _____

Day: _____ **Week: _____**

Section 1: Match words with definitions:

1-Irregular	( ) A substance that is in a liquid or gaseous phase.
2-Reference Point	**( )** Not following a common or expected pattern.
3-Mass	**( )** A measure of the quantity of matter in an object.
4-Displacement	**( )** An exclamation expressing the excitement of a discovery or breakthrough, meaning "I found (it)".
5-Fluid	**( )** The space taken up by an object submerged in a fluid.
	( ) The preservation of some quantity despite some kind of transformation.
	( ) A starting value for measurement, or basis of comparison.

Section 2: Reading Comprehension Passage

Passage:

Density is a measurement of how much mass is packed into a certain amount of space. It tells us how tightly packed the matter is in an object. We can compare the density of two materials by looking at their mass and volume. If two objects have the same volume but different masses, the one with greater mass has a higher density.

For example, imagine a block of wood and a block of metal that are the same size. The metal block is much heavier because it is denser than the wood; its atoms are packed closer together.

We can also compare the density of objects with the same mass but different volumes. The object with the smaller volume will have a higher density. Think of a balloon filled with air and a bowling ball. They might have the same mass, but the bowling ball is much smaller and denser.

An interesting story about density comes from Archimedes, a famous ancient Greek scientist. Legend has it that he discovered the principle of buoyancy while taking a bath. He noticed the water level rising as he got in and exclaimed, “Eureka!” meaning “I found it!” This moment helped him understand that the density of an object affects whether it sinks or floats.

Density is important for identifying substances and understanding how objects behave in fluids. If an object is denser than the fluid, it will sink; if it is less dense, it will float.

Comprehension Questions

1. **What does the word *"Eureka!"* mean?**

    a. I am happy!

    b. I have found it!

    c. I am hungry!

    d. I am tired!

2. **According to the text, what is a good example of something that has a high density?**

    a. A feather

    b. A rock

    c. A balloon filled with air

    d. A piece of paper

3. **What is the main idea of the story about Archimedes?**

    a. Archimedes discovered how to make gold crowns

    b. Archimedes figured out how to measure the volume of a crown

    c. Archimedes invented the bathtub

    d. Archimedes was a king who loved gold

4. **What can we say about how objects with different densities act in water, according to the text?**

    a. Objects with higher densities will always float

    b. Objects with lower densities will always sink

    c. Objects with higher densities will sink in a fluid

    d. Density has no effect on whether an object will float or sink

5. **Why might understanding density be important for engineers designing ships or boats?**

    a. It helps them choose colors for the vessels

    b. It allows them to predict how much cargo can be carried

    c. It ensures the ships will look good in water

    d. It helps them understand how to build larger boats

Note. Definitions 4 and 5 are outliers.

Week 4: Small, smaller, smallest Science Word Acquisition and Comprehension

Science Word Acquisition F (4)

Student Code: _____ **Date: ___/___/_____**

Grade: _____

Day: _____ **Week: _____**

Section 1: Match words with definitions

1-Conservation	( ) A substance that cannot be separated chemically into simpler substances.
2-Atom	( ) A group of atoms linked together to form the smallest particle of a compound.
3-Compound	( ) The smallest particle of an element.
4-Element	( ) The ratio of mass to volume.
5-Molecule	( ) The preservation of some quantity despite some kind of transformation.
	( ) A substance made of definite proportions of two or more elements.
	( ) A starting value for measurement, or basis of comparison.

Section 2: Reading Comprehension

Read the passage and answer the following questions:

Everything around us, from the air we breathe to the chair you're sitting on, is made of tiny particles called atoms. These atoms are the small building blocks of everything! Atoms can join together to form molecules. For example, a water molecule is made of two hydrogen atoms and one oxygen atom.

Sometimes, different types of atoms join together to form a new substance called a compound. Imagine mixing different colors of paint to make a new shade. Water is a compound because it's made of hydrogen and oxygen atoms.

Salt is another example of a compound, made of sodium and chlorine atoms. Each element, like hydrogen or oxygen, is made up of only one type of atom. So, water is a compound, but hydrogen and oxygen are elements.

Even though we can't see them, these tiny particles are always moving and changing. They can be arranged in different ways, which affects the properties of the substance. For example, sand is made of tiny grains of silica, a compound. These grains are arranged in a solid structure, making sand feel hard and gritty.

Saltwater, on the other hand, is a mixture of salt and water. The salt particles are dissolved in the water, making it taste salty. Clouds are made of tiny water droplets suspended in the air. These droplets are so small that they appear as a fluffy, white mass.

One important rule is the law of conservation of mass. This law states that matter cannot be created or destroyed, only transformed. Think of it like playing with building blocks. You can rearrange the blocks to make different shapes, but you always have the same number of blocks.

Everything around us is made of tiny particles, and understanding how these particles interact helps us understand the world around us.

Comprehension Questions

1. **What are atoms?**
    a. Molecules that form compounds.
    b. Small particles that form the building blocks of everything.
    c. The smallest elements that form compounds.
    d. Particles that are visible under a microscope.
2. **What is the relationship between water and hydrogen, according to the text?**
    a. Water is an element made only of hydrogen atoms.
    b. Water is a compound made of hydrogen and oxygen atoms.
    c. Hydrogen is a compound made of water molecules.
    d. Water and hydrogen are both compounds made of different atoms.
3. **What is the main idea of the text?**
    a. How atoms and molecules form different substances.
    b. The structure of compounds like water and salt.
    c. The role of particles in creating large structures.
    d. The importance of the law of conservation of mass.

4. **How does the text describe the law of conservation of mass?**

    a. Matter can be transformed, but the total number of atoms remains the same.

    b. Atoms can be created during chemical reactions.

    c. Matter can be created, but not destroyed.

    d. Atoms can change into different elements during reactions.

5. **If you mix lemon juice with water, it will be**

    a. A mixture, because the lemon juice and water remain as separate substances.

    b. A compound, because lemon and water form a new substance.

    c. An element, because lemon and water are made of the same type of atoms.

    d. A solid, because the lemon juice solidifies in water.

Note. Definitions 4 and 7 are outliers.

Acculturation Short Assessment Survey

The following is the Acculturation Short Assessment Survey used in the study. It is designed to capture students' cultural preferences and backgrounds.

Section 1: Background Information

7. **Student Code** (e.g., G5ELHA): _____
8. **Grade**: ☐ 6 ☐ 7 ☐ 8
9. **Years in the US**: ☐ Less than one year ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
10. **US Citizen**: ☐ Yes ☐ No
11. **Country of origin (Where is your family from?):** _____
12. **Languages spoken at home:** _____

Section 2: Cultural Preferences Survey

Read the following questions and choose the option that best describes your experience or preferences:

15. **I am most comfortable being with people from...**

    ☐ a. The United States

    ☐ b. The country my family is from

    ☐ c. Both

    ☐ d. Neither

16. **My best friends are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

17. **The people I fit in with best are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

18. **My favorite music is from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

19. **My favorite TV shows are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

20. **The holidays I celebrate are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

21. **The food I eat at home is from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

22. **The way I do things and the way I think about things are from...**

☐ a. The United States

☐ b. The country my family is from

☐ c. Both

☐ d. Neither

15. Any other comments? _____ (Write N/A if none)

Language Acculturation Survey Instrument

Section 1: Background Information

5. **Student Code** (e.g., G5ELHA): _____
6. **Grade**: ☐ 6 ☐ 7 ☐ 8
7. **Country of origin** (Where is your family from?): _____
8. **Languages spoken at home**: _____

Section 2: Survey Questions

Read the following questions and choose the option that best represents your language preference.

7. **What languages do you watch TV shows/YouTube/videos in?**

   ☐ a. English only

   ☐ b. Mostly English

   ☐ c. English and another language

   ☐ d. Mostly another language

   ☐ e. Another language only

8. *(Optional open text question)*

   Now, please describe your language preference in your own words:

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11. **In general, in what language do you read and speak?**

    ☐ a. English only

    ☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

12. **What languages do you usually speak at home?**

☐ a. English only

☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

13. **In what language do you usually think?**

☐ a. English only

☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

14. **What language do you usually speak with friends?**

☐ a. English only

☐ b. Mostly English

☐ c. English and another language

☐ d. Mostly another language

☐ e. Another language only

Science Word Acquisition Pre-Post Test

Fall 2024 A comprehensive assessment for science vocabulary knowledge. Estimated time: 30 minutes

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Section 1: Background Information

1. **Student Code** (e.g., G5ELHA): _____
2. **Grade**:
    - a. 6
    - b. 7
    - c. 8
3. **Date** (e.g., 06/08/2024): _____
4. **Time Now** (e.g., 5:15 p.m.): _____

Section 2: Vocabulary Matching Questions

Question 1: Match the word with the correct definition.

Word	Definition
1-Organism	D) A separate, complete living thing, such as an animal, plant, fungus, or microorganism.
2-Tissue	A) A group of similar cells working together to do a specific job.
3-Organ	C) A group of tissues that does a specific job within an organism.
4-Strategy	G) A defined group of goals and the functions to achieve them.

5- Specialize	E) To focus on a particular area; to distinguish oneself by form or function.

Question 2: Match the word with the correct definition.

Word	**Definition**
6-Fuel	H) An energy source that feeds a living thing; food.
7-Cycle	L) A period of time in which a set of events or phenomena is completed.
8-Producer	K) A living thing that makes its own food through light and simple substances.
9-Organic	M) Related to living things; carbon-based or naturally occurring.
10-Specimen	I) A sample that represents a larger group of things, often examined or analyzed.

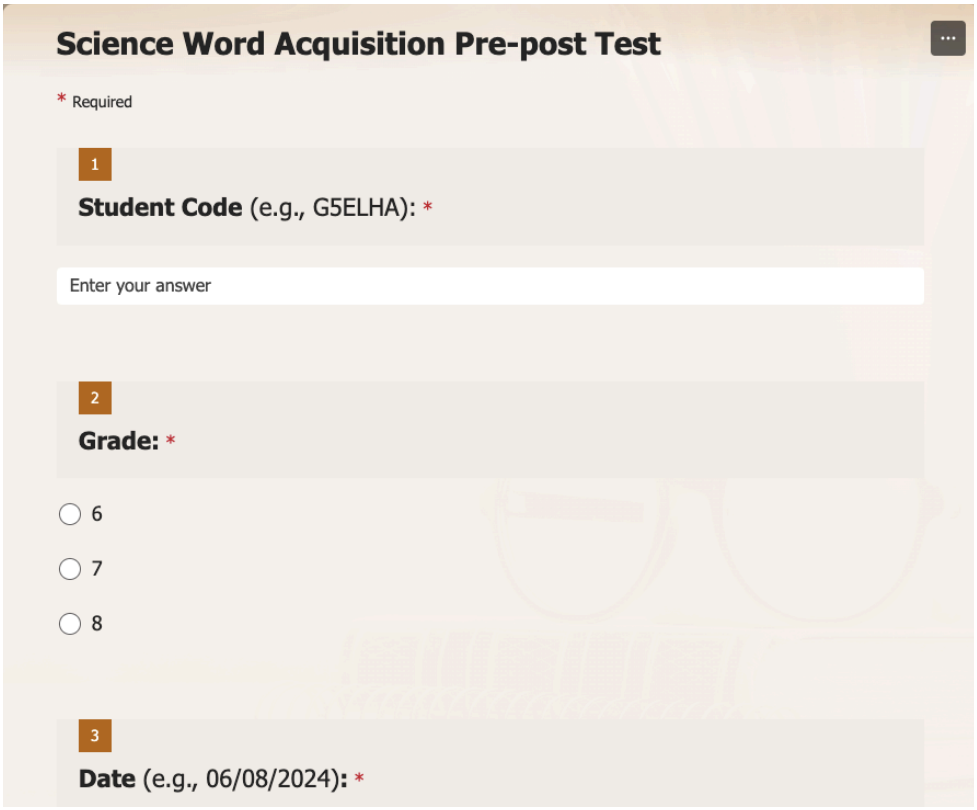
Question 3: Match the word with the correct definition.

Word	**Definition**
11-Atom	O) The smallest particle of an element.
12- Compound	R) A substance made of definite proportions of two or more elements.
13-Molecule	P) A group of atoms linked together to form the smallest particle of a compound.
14- Particulate	Q) Made of particles, such as molecules and atoms (at a microscopic scale); or of small solid pieces like grains of sand (at a macroscopic scale).
15-Particle	T) A small piece of matter (often an atom or molecule).

Question 4: Match the word with the correct definition.

Word	Definition
16-Density	AA) The ratio of mass to volume.
17-Volume	Z) The amount of space taken up by an object.
18-Expand	X) To spread out, to enlarge.
19-Reference point	W) A starting value for measurement, or basis of comparison.
20-Fluid	AB) A substance that is in a liquid or gaseous phase.

Sample Electronic Matching Measure: Curricular Pre and Post Tier 2 and 3 Word Knowledge Measure



5

Question 1: Match word with definition:

	1-Organism	2-Tissue	3-Organ	4-Strategy	5-Specialize
A) A group of similar cells working together to do a specific job.	○	○	○	○	○
B) A way of ranking or organizing things.	○	○	○	○	○
C) A group of tissues that does a specific job within an organism.	○	○	○	○	○
D) A separate, complete living thing, such as an animal, plant, fungus, or microorganism.	○	○	○	○	○
E) To focus on a particular area; to distinguish oneself by form or function.	○	○	○	○	○
F) The preservation of some quantity despite transformation.	○	○	○	○	○
G) A defined group of goals and the functions to achieve them.	○	○	○	○	○

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Question 2: Match word with definition:

	6-Fuel	7-Cycle	8-Producer	9-Organic	10-Specimen
H) An energy source that feeds a living thing; food.	○	○	○	○	○
I) A sample that represents a larger group of things, often examined or analyzed.	○	○	○	○	○
J) Movement through a partially permeable membrane.	○	○	○	○	○
K) A living thing that makes its own food through light and very simple substances.	○	○	○	○	○
L) A period of time in which a set of events or phenomena is completed.	○	○	○	○	○
M) Related to living things; carbon-based or naturally occurring.	○	○	○	○	○
N) A substance that is in a liquid or gaseous phase.	○	○	○	○	○

Generalization and Maintenance Curricular Tier 2 and 3 Word Knowledge Measure

Science Word Acquisition Pre-Post Test

Fall 2024 A comprehensive assessment for science vocabulary knowledge. Words were not thematically organized in the matching sets . Estimated time: 30 minutes

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Section 1: Background Information

1. **Student Code** (e.g., G5ELHA): _____
2. **Grade**:
    - a. 6
    - b. 7
    - c. 8
3. **Date** (e.g., 06/08/2024): _____
4. **Time Now** (e.g., 5:15 p.m.): _____

Section 2: Vocabulary Review Sets

Set 1: Match the word with the correct definition.

Word	Definition
Hierarchy	W) A starting value for measurement, or basis of comparison.

Compound	AA) The ratio of mass to volume.
Cycle	M) Related to living things; carbon-based or naturally occurring.
Organ	G) A defined group of goals and the functions to achieve them.
Producer	K) A living thing that makes its own food through light and simple substances.

Set 2: Match the word with the correct definition.

Word	**Definition**
Particle	T) A small piece of matter (often an atom or molecule).
Fluid	AB) A substance that is in a liquid or gaseous phase.
Tissue	A) A group of similar cells working together to do a specific job.
Fuel	H) An energy source that feeds a living thing; food.
Specialize	E) To focus on a particular area; to distinguish oneself by form or function.

Set 3: Match the word with the correct definition.

Word	Definition
Strategy	G) A defined group of goals and the functions to achieve them.
Organic	M) Related to living things; carbon-based or naturally occurring.
Volume	Z) The amount of space taken up by an object.
Organism	D) A separate, complete living thing, such as an animal or plant.
System	S) The basic form or support underlying something.

Set 4: Match the word with the correct definition.

Word	Definition
Atom	O) The smallest particle of an element.
Reference Point	W) A starting value for measurement, or basis of comparison.
Molecule	P) A group of atoms linked together to form the smallest particle of a compound.
Expand	X) To spread out, to enlarge.
Density	AA) The ratio of mass to volume.

Science Attitude Pre-Post Survey

Fall 2024 A quick survey on your feelings and thoughts about science

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Section 1: Background Information

1. **Student Code** (e.g., G5ELHA): _____
2. **Grade**:
    - a. 6
    - b. 7
    - c. 8

Section 2: Practice Questions (Food Preference Ratings) Please orally rate the following statements about food: 1 = Strongly Disagree 😠 2 = Disagree 😕 3 = Neutral 😐 4 = Agree 🙂 5 = Strongly Agree 😄

Example 1: I love kebab

- 1 = Strongly Disagree 😠
- 2 = Disagree 😕
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😄

Example 2: I would like to eat broccoli pizza

- 1 = Strongly Disagree 😠
- 2 = Disagree 🙁
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😁

Example 3: I love to drink broccoli juice 🥦

- 1 = Strongly Disagree 😠
- 2 = Disagree 🙁
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😁

Example 4: Burger is delicious

- 1 = Strongly Disagree 😠
- 2 = Disagree 🙁
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😁

Section 3: Science Attitude Items Please rate the following statements: 1 = Strongly Disagree 😠 2 = Disagree 😕 3 = Neutral 😐 4 = Agree 🙂 5 = Strongly Agree 😄

1. I would like to do more science at school

- 1 = Strongly Disagree 😠
- 2 = Disagree 😕
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😄

2. Science is boring

- 1 = Strongly Disagree 😠
- 2 = Disagree 😕
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😄

3. I find science difficult

- 1 = Strongly Disagree 😠
- 2 = Disagree 😕

- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😁

4. In my Science class, I understand everything

- 1 = Strongly Disagree 😠
- 2 = Disagree 😕
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😁

5. I would like to have a job working with science

- 1 = Strongly Disagree 😠
- 2 = Disagree 😕
- 3 = Neutral 😐
- 4 = Agree 🙂
- 5 = Strongly Agree 😁

6. **Any other comments?** (Write N/A if none): _____

Appendix D

Fidelity Materials

Pre-Post, Generalization and Maintenance Vocabulary Measure

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Observed Material	**…….**
Observation Item	**Observed (Yes=1/ No=0)**
1) The interventionist says: "I'm going to share a digital reading check survey on the iPad. This survey is 4 sets of words, 7 definitions and 5 science words in each. You will independently answer the questions and match each vocabulary word with its correct meaning. Remember, there are two extra definitions." Remember you can click on the icon to read the text aloud. When you're finished, please set the iPad down. (Wording can vary as student might work on already opened link).	
2)The interventionist gives the student the performance assessment code to scan on the iPad or open the evaluation link from another device (i.e., laptop).	
3)The interventionist provides the student with headphones (if needed).	

4)The interventionist ensures the student knows how to access the digital reading check survey.	
5)The interventionist says: “You may begin.” (The interventionist may phrase this in various ways to prompt the student to start.)	
6)The interventionist only answers questions related to the task and encourages the student to do their best. [This can be marked as N/A. If you mark it as N/A, your total below should be out of 7 actions.]	
7) Students enter the finish time for question 1. Interventionist checks.	
8)The interventionist introduces section 2. The interventionist says, “You will independently read the text and choose the correct answer".	
9) Student completes the performance assessment, and the interventionist confirms submission.	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	_____%

During Measure Fidelity Check for Comprehension and Vocabulary Measure

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Implementation Fidelity Checklist	
Observed Material	**……..**
Observation Item	**Observed (Yes=1/ No=0)**
1) The interventionist says: "I'm going to share a digital reading check survey on the iPad. This survey is 4 sets of words, 7 definitions and 5 science words in each. You will independently answer the questions and match each vocabulary word with its correct meaning. Remember, there are two extra definitions." Remember you can click on the icon to read the text aloud. When you're finished, please set the iPad down. (Wording can vary as student might work on already opened link)	
2)The interventionist gives the student the performance assessment code to scan on the iPad or open the evaluation link from another device (i.e., laptop).	
3)The interventionist provides the student with headphones (if needed). This can be marked as N/A	

4)The interventionist ensures the student knows how to access the digital reading check survey.	
5)The interventionist says: “You may begin.” (The interventionist may phrase this in various ways to prompt the student to start.)	
6)The interventionist only answers questions related to the task and encourages the student to do their best. [This can be marked as N/A. If you mark it as N/A, your total below should be out of 7 actions.]	
7) Students enter finish time for question 1. Interventionist checks.	
8)The interventionist introduces section 2. The interventionist says, “You will independently read the text and choose the correct answer".	
9) Student completes the performance assessment, and the interventionist confirms submission.	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	_____%

Unit 1- Lesson 1 Fidelity Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 2- Lesson1 _18__/18	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives.	
2) The interventionist reviews expectations.	
3) The interventionist reviews the agenda.	
4) The interventionist introduces new vocabulary.	
5) The interventionist reviews examples and non-examples of each word.	
6) The interventionist gives the student the chance to use words in context.	
7) The interventionist gives the student the first controlled practice (match).	
8) The interventionist gives the student the dialogue sheet.	
9) The interventionist assigns students reading roles.	
10) The interventionist gives the student time to practice individually.	
11) The interventionist asks students to read together.	
12) The interventionist discusses with the students the dialogue theme. Then, the interventionist models a question, then the interventionist asks students to do work in pairs/groups.	

13) The interventionist introduces to students' fun facts about the human body.	
14) The interventionist asks students to turn and talk about the most interesting thing they learned today.	
15) The interventionist asks students to do vocabulary practice 1 as homework for next time.	
16) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
17) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
18a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
18b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
18c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____	____%

Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	

Unit1- Lesson Fidelity 2 Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 2-Lesson 2 ___/18	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives, expectations, and agenda and opens lesson with an interactive warm-up activity (e.g., Shark Attack game).	
2) The interventionist reviews vocabulary through a Quizlet matching activity using iPads.	
3)The interventionist introduces new vocabulary using visuals, translations, and definitions.	
4) The interventionist reviews examples and non-examples using visual supports such as a slow-reveal graph.	
5)The interventionist gives students opportunities to use vocabulary in context (e.g., reading numbers in different formats).	
6)The interventionist provides controlled practice tasks (e.g., interpreting graph data in pairs).	
7)The interventionist supports comprehension using visual aids, realia, and interactive diagrams.	

8)The interventionist assigns student roles during collaborative reading or viewing tasks.	
9)The interventionist allows time for individual practice (e.g., viewing educational video independently or in groups).	
10)The interventionist facilitates discussion through activities such as Venn diagram construction.	
11)The interventionist guides students through comprehension questions and prompts analytical discussion.	
12)The interventionist models a writing activity (e.g., found poetry) and explains its structure clearly.	
13)The interventionist provides support during individual creative expression activities (e.g., poem creation).	
14)The interventionist leads a review discussion using a hierarchy diagram to reinforce learning.	
15)The interventionist assigns relevant and structured homework (e.g., vocabulary word pyramid).	
16) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	

17) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
18a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
18b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
18c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit1- Lesson Fidelity 3 Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 2- Lesson 3 ___/18	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives.	
2) The interventionist reviews expectations.	
3)The interventionist reviews the agenda.	
4)The interventionist reviews vocabulary using the Quizlet flashcards. Students will read words and definitions aloud.	
5) The interventionist opens class with a word guessing game. Students read definitions and say the word.	
6) The interventionist asks students to order parts of biodiversity in terms of hierarchy.	
7) The interventionist gives the student a matching activity as a controlled practice.	
8) The interventionist shows students the maps of New York and Missouri.	
9)The interventionist asks students to discuss the difference between both maps.	
10)The interventionist shows students the interactive body map.	

11) The interventionist asks students to review maps. Students discuss their observations.	
12) The interventionist introduces the task and asks students to use the map to find answers. While students work, the instructor provides feedback.	
13)The interventionist discusses the students' answers.	
14) The interventionist introduces to the students the new task. Students think and respond orally to each prompt.	
15) The interventionist asks students to turn and talk about the most interesting thing they learned today.	
16) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
17) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
18a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
18b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
18c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	

Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit1- Lesson Fidelity 4 Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 2- Lesson 2 ___/18	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives, expectations, and agenda.	
2) The interventionist displays the Quizlet QR code and facilitates vocabulary self-testing and word review.	
3) The interventionist reviews the word "organ" and guides students in brainstorming and listing organs.	
4) The interventionist shows microscopic images and engages students in guessing organs and exploring the interactive microscope.	
5) The interventionist introduces a diagram and engages students in mapping organs, tissues, and cells.	
6) The interventionist facilitates student additions to the map and discusses system-level groupings.	
7) The interventionist prepares and distributes the Cell-or-System card game materials.	
8) The interventionist explains the rules of the game using visuals and clear instructions.	

9) The interventionist initiates gameplay and ensures students follow rules while trading.	
10) The interventionist monitors and supports students during the card game.	
11) The interventionist reviews gameplay outcomes and facilitates class discussion.	
12) The interventionist introduces blackout poetry and models how to create it using a text.	
13) The interventionist provides materials and supports students during the blackout poetry activity.	
14) The interventionist facilitates poetry sharing and discussion among students.	
15) The interventionist assigns vocabulary-based homework to reinforce the lesson.	
16) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
17) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
18a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	

18b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
18c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit1- Lesson Fidelity 5 Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 2- Lesson 5 ___/18	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives, expectations, and agenda.	
2) The interventionist initiates a class discussion based on an animated simulation of a white blood cell.	
3) The interventionist elicits prior knowledge using a splinter image and student storytelling.	
4) The interventionist shows a video about splinters and prompts student engagement.	
5) The interventionist introduces the comic and sets up expectations for paired reading.	
6) The interventionist provides printed comic copies and monitors reading engagement.	
7) The interventionist introduces comprehension questions related to the comic.	
8) The interventionist facilitates whole-class or group discussion using comic questions.	

9) The interventionist clarifies concepts such as inflammation and immune response from the comic.	
10) The interventionist checks understanding of immune cell roles (e.g., macrophages, lymphocytes).	
11) The interventionist explains how pathogens damage cells and how antibodies function.	
12) The interventionist discusses why immune surveillance is critical across body entry points.	
13) The interventionist introduces the Word Tournament activity using Flippity or chart.	
14) The interventionist supports students during the vocabulary competition.	
15) The interventionist assigns homework requiring vocabulary usage in sentences.	
16) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
17) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
18a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	

18b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
18c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit 2- Lesson Fidelity 1 Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 4- Lesson1 ___/18	**Observed (Yes=1/ No= 0)**
1) The interventionist reviews objectives, expectations, and agenda.	
2) The interventionist sets the context by prompting discussion on whether matter is made of particles or continuous substance.	
3) The interventionist introduces new science terms using visuals, definitions, and native language translation.	
4) The interventionist models what the vocabulary words do and do not look like.	
5) The interventionist facilitates student turn-and-talk and short written practice with new vocabulary.	
6) The interventionist presents video content and poses questions related to the nature of matter.	
7) The interventionist sets up the script activity and models the concept of continued division.	
8) The interventionist assigns student roles for the Science Scene and provides reading preparation.	
9) The interventionist facilitates student reading of the adapted dialogue.	

10) The interventionist introduces and models the matching vocabulary activity.	
11) The interventionist assigns the remaining vocabulary matching activity as homework.	
12) The interventionist incorporates culturally relevant materials (e.g., brownies, traditional desserts) and visuals.	
13) The interventionist supports student learning with adapted scripts, translation, and word glossaries.	
14) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
15) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
16a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
16b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
16c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	

Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit 2- Lesson 2 Fidelity Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 4- Lesson 2 ___/15	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives, expectations, and agenda.	
2) The interventionist reviews vocabulary using a shark attack game.	
3) The interventionist introduces terms for atomic theory using slides.	
4) The interventionist supports student understanding of particle structure and models.	
5) The interventionist leads a turn-and-talk activity on compound proportions.	
6) The interventionist guides students in using models to identify atomic ratios.	
7) The interventionist facilitates partner work to complete a table on atoms, molecules, and compounds.	
8) The interventionist checks understanding of vocabulary and terms using guided questions.	
9) The interventionist supports student collaboration and discussion.	
10) The interventionist introduces the found poetry activity with vocabulary review.	

11) The interventionist sets up the learning environment for creative expression.	
12) The interventionist assigns a word pyramid task as homework.	
13) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
14) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
15a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
15b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
15c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit 2- Lesson 3 Fidelity Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 4-Lesson 3 ___/14	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives, expectations, and agenda.	
2) The interventionist facilitates discussion about what air is made of.	
3) The interventionist uses visuals and atomic models to build understanding.	
4) The interventionist introduces the color key for elements and supports interpretation.	
5) The interventionist presents interactive visual materials showing beach particles.	
6) The interventionist guides students in exploring particulate-level environments.	
7) The interventionist prepares and monitors an informal interactive quiz.	
8) The interventionist encourages students to check answers with peers.	
9) The interventionist reviews and discusses quiz findings.	
10) The interventionist assigns word pyramid copying task for vocabulary review.	

11) The interventionist asks students to turn and talk about the most interesting thing they learned today.	
12) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
13) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
14a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
14b) The interventionist provided Multiple Means (ways) of Representation (UDL)	
14c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit 2- Lesson 4 Fidelity Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 4-4 ___/18	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives, expectations, and agenda.	
2) The interventionist initiates discussion about the Law of Conservation of Matter.	
3) The interventionist engages students in turn-and-talk about the birthday candle example.	
4) The interventionist provides clarification using real-life transformations of matter.	
5) The interventionist presents and explains the conservation of matter video.	
6) The interventionist models atomic composition using the video content.	
7) The interventionist introduces blackout poetry using unit vocabulary.	
8) The interventionist provides materials and instructions for blackout poetry creation.	
9) The interventionist monitors and supports students during the poetry task.	
10) The interventionist initiates discussion on the slime activity and guides observation.	

11) The interventionist prompts students with “What do you notice/wonder?” during the activity.	
12) The interventionist discusses evidence of matter conservation during slime transformation.	
13) The interventionist summarizes key learning points through group discussion.	
14) The interventionist assigns sentence writing using lesson vocabulary as homework.	
15) The interventionist asks students to turn and talk about the most interesting thing they learned today.	
16) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
17) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
18a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
18b) The interventionist provided Multiple Means (ways) of Representation (UDL)	

18c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

Unit1- Lesson 5 Fidelity Checklist

Instructions: Please indicate completion of each item by writing "1" on the line if the interventionist performed the described action, or "0" if the action was not performed. After completing all items, calculate the total number of completed actions and determine the percentage of implementation.

Intervention Week 4-5___/18	**Observed (Yes=1/ No=0)**
1) The interventionist reviews objectives, expectations, and agenda.	
2) The interventionist initiates discussion on tree growth and the source of plant matter.	
3) The interventionist facilitates a turn-and-talk around matter origins in plants.	
4) The interventionist shows the photosynthesis video and previews guiding questions.	
5) The interventionist prompts student responses and clarifies video content.	
6) The interventionist introduces chemical symbols and notation (e.g., H2O).	
7) The interventionist leads discussion on student understanding of chemical elements.	
8) The interventionist distributes photosynthesis reading materials and assigns partner work.	
9) The interventionist guides students through identifying and labeling chemical components.	

10) The interventionist reviews how photosynthesis relates to the Law of Conservation of Matter.	
11) The interventionist displays and analyzes a model of photosynthesis with the class.	
12) The interventionist initiates critique questions to prompt model redesign or interpretation.	
13) The interventionist introduces the Word Tournament activity to review vocabulary.	
14) The interventionist supports sentence generation using paired vocabulary words.	
15) The interventionist assigns vocabulary sentence writing as homework.	
16) The interventionist incorporated culturally responsive teaching strategies (e.g.: Commit to knowing your students well - academically, socially, and emotionally, build on the life experiences of your students, create a classroom learning community, hold high academic standards and expectations for all of your students, Understand your own cultural identity and its consequences.)	
17) The interventionist Followed "I do- We do- You do" in activities and instruction (Gradual Release of responsibility/ scaffolding)	
18a) The interventionist provided Multiple Means (opportunities) of Engagement (UDL)	
18b) The interventionist provided Multiple Means (ways) of Representation (UDL)	

18c) The interventionist provided Multiple Means (opportunities) of Actions and Expression (UDL)	
Scoring: Total Number of Observed Items: _____ Number of Items Followed Correctly: _____ Percentage Fidelity: (Number Followed Correctly / Total Number of Items) * 100 =	____%

VITA

Heba a Palestinian refugee originally from Jaffa, grew up in Gaza City, a coastal city by the Mediterranean Sea, Palestine. In 2008, she finished her bachelor's degree in education from the Islamic University of Gaza.

Since 2009, Heba joined the field of education as an educator and later as an educational content developer at the United Nations Relief and Work Agency for Palestine Refugees in the Near East (UNRWA). She served Palestinian refugee students at elementary and middle school levels in the Gaza Strip. During her work at UNRWA TV as a content developer, Heba facilitated planning and creation of English language learning educational content for Palestinian refugees in the UNRWA 5 fields of operations: Gaza, West Bank, Jordan, Syria and Lebanon. She facilitated professional trainings for pre- and in-service teachers in the Gaza Strip.

Through her school experience, Heba realized an urgent need to provide instructional support for bilingual and multilingual learners including refugees and students with disabilities. She followed her passion and was awarded the Fulbright scholarship to complete a graduate degree in special education with focus on learning disabilities and later continued to pursue her PhD in the same field. Heba's current research focuses on reading interventions, instruction, and support in ELA and content areas for preschool, elementary and middle school students including those with disabilities or who are culturally and linguistically diverse. Heba believes that every child, including students with disabilities, should have access to the general education reading curriculum through effective academic instruction, intervention, and support.

Outside the academia, Heba enjoys spending time with her husband, Nader and her kids Eslam, Ahmed and Mariam, and friends. She enjoys walking, reading, and learning about others while volunteering in local non-profit organizations.