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Hands-on, Guided Inquiry Science Investigation And Science Vocabulary Acquisition In A Rural Elementary School

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HANDS-ON, GUIDED INQUIRY SCIENCE INVESTIGATION AND SCIENCE VOCABULARY ACQUISITION IN A RURAL ELEMENTARY SCHOOL

by

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Much research has been done to show how inquiry science instruction and inquiry student investigation provide students with hands-on experiences to effectively learn science content in the classroom. Additionally, many methods to efficaciously teach students vocabulary has been thoroughly investigated. However, not much research has been done to study what effect hands-on, guided inquiry science investigation has on student content vocabulary acquisition. Within one rural classroom, fourth graders engaged in hands-on, guided inquiry investigation, and then vocabulary words were explicitly taught and discussed. After that, students practiced the vocabulary words in a variety of ways in pairs and as a class. For the first two science units taught, students were administered a pre-test, a second test after the inquiry investigation and vocabulary instruction, and a post-test following the vocabulary practice. Following inquiry investigation and explicit vocabulary instruction and discussion, students showed growth on the vocabulary tests, however more time to practice with the vocabulary words seemed to be required for students to develop proficiency. Due to this observation, students were assessed with a pre-test and a post-test in the third unit.

Keywords: inquiry science, hands-on inquiry science, inquiry science investigations, inquiry science instruction, inquiry science and vocabulary instruction

DEDICATION

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CHAPTER 1: INTRODUCTION

Problem Statement

Hands-on, inquiry science investigation motivates students and effectively teaches them science content, however what effect does it have on students' understanding and knowledge of science vocabulary? While much research has been completed on inquiry investigation's positive effect on students' achievement in learning science content and, separately, on how students learn vocabulary, there is little research on the effect of hands-on, inquiry investigation and science content vocabulary development. Therefore, this action research study will address the gap in the research.

Purpose and Research Questions

The goal of this action research investigation is to ascertain if students can use inquiry investigations to enhance their understanding of content vocabulary. This study hopes to answer the following questions:

1. How do hands-on, guided inquiry investigations impact students' scores on science content vocabulary tests?
2. How does extra practice, specifically games, impact students' scores on science content vocabulary tests?
3. How do student-created actions to represent vocabulary words and definitions impact students' scores on science content vocabulary tests?

Methods Overview

This is an action research where the teacher gave students hands-on, guided inquiry investigation to discover phenomena and then explicit instruction of the

vocabulary words and an opportunity to practice the words. Eight sets of quantitative data came from student scores on pre-tests before the unit was investigated, second tests after the inquiry investigation and explicit instruction and discussion of the vocabulary words, and post-tests following practice of the words at the end of each unit. The final unit did not include a second vocabulary test, only a pre-test and a post-test. Additionally, student interviews comprised the qualitative data for the study.

Definition of Key Terms

Guided inquiry science investigation: students take responsibility for learning by exploring hands-on activities with guiding questions from the teacher.

Scaffolding (instruction): when a teacher decreases the amount of support for a student as the student gains a grasp on the skill or concept.

CHAPTER 2: LITERATURE REVIEW

Overview

Inquiry has been a "buzz-word" in science that has been around for some time now. Minner, Levy, and Century (2010) synthesized investigations using research from as long as 35 years ago and Furtak, Seidel, Iverson, and Briggs (2012) completed a meta-analysis including research in the years up to 2006. Both the synthesis and meta-analysis seemed to show that inquiry science had a positive effect on student learning compared to traditional methods of teaching. Today, inquiry continues to play a role within Next Generation Science Standards (NGSS Lead States, 2013) in the science and engineering practices, which are one of the three dimensions of these standards. In an NGSS appendix clarifying the practices, it is explained that students will be assessed using a blend of the three dimensions to show how "...students can use their understanding (of core disciplinary ideas and cross cutting concepts) to investigate the natural world through the practices of science inquiry, or solve meaningful problems through the practices of engineering design" (Next Generation Science Standards [NGSS] Lead States, 2013)., Appendix F, p. 1. Several studies (Scruggs, Mastropieri, Bakken, & Brigham, 1993; Schroeder, Scott, Tolson, Huang, & Lee, 2007; Amaral, Garrison, & Klentschy, 2002) of hands-on inquiry investigations suggest it is motivating for students to participate in this type of activity. However, what are inquiry science investigations? Moreover, is inquiry science instruction an effective way to impact student achievement in science? Finally, how should teachers teach science vocabulary when hands-on, inquiry investigation is used to teach science content?

Inquiry Science Defined

Several researchers have taken the time to define inquiry science through investigation and looking to the experts. One of these analysts, Anderson (2002), discussed how inquiry is defined in many different ways. Moreover, when inquiry science is discussed in schools, is it "science as inquiry, learning as inquiry, teaching as inquiry or all of the above?" (Anderson, 2002, p. 1). To illustrate this point, Anderson (2002) draws from the National Science Education Standards (NSES; National Research Council, 1996) and its use of inquiry in the variety of ways as he suggested. One of these ways is related to how scientists learn about nature and the world. Another describes the specific way students actively learn as opposed to being passive learners. A third describes the method of teaching that has no stable definition but can be total or partial inquiry.

According to Anderson (2002), the research literature describes inquiry in multifarious ways, as well. Furthermore, Anderson (2002) reports that not only do the studies of inquiry use the term differently, but he lays claim that inquiry has other labels, as well. Delving deeper, Anderson (2002) concludes that, while the terminology may not match, the process described in the different studies appear to be inquiry.

Anderson (2002) concluded that inquiry seems to describe when teachers are coaches and facilitators instead of the 'answer keepers.' The students become self-directed learners during inquiry as opposed to passive receivers memorizing information in traditional methods of learning. Anderson (2002) asserts that during inquiry, students collaborate among peers as well as create something to show learning of a topic instead of completing the same worksheets as each other in traditional learning.

Through a traditional meta-analysis, researchers Schroeder, Scott, Tolson, Huang, and Lee (2007) similarly defined inquiry science strategies as when "Teachers use student-centered instruction that is less step-by-step and teacher-directed than traditional instruction; students answer scientific research questions by analyzing data (e.g., using guided or facilitated inquiry activities, laboratory inquiries)" (Schroeder, Scott, Tolson, Huang, & Lee, 2007, p. 1446).

In another study, Minner, Levy, and Century (2010) defined science instruction as inquiry when it has these three components: "(1) the presence of science content, (2) student engagement with science content, and (3) student responsibility for learning, student active thinking, or student motivation within at least one component of instruction— question, design, data, conclusion, or communication." (Minner, Levy, & Century, et al., 2010, p. 478)). Moreover, the study revealed a contrast between open inquiry, where the student directs the learning, and guided inquiry, where the teacher designs the direction of the investigation.

These summaries of inquiry help define my action research plan where students are guided to discuss among peers to show their comprehension of the investigation as guided, or partial, inquiry.

The Efficacy of Inquiry Science

Several researchers have conducted studies to determine the efficaciousness of inquiry science investigations in the classroom. From simply studying inquiry science instruction alone to comparing it to the varying degree of inquiry from open to guided, as well as traditional methods of instruction, inquiry science has been at the forefront of researchers' minds for many years. Additionally, researchers have studied its effects on

English learners and learning disabilities. Others have looked at it with the additional use of science notebooks to aid concept comprehension.

Schroeder, Scott, Tolson, Huang, and Lee (2007) completed a traditional meta-analysis that included sixty-one studies conducted in the United States from 1980-2004, investigating what effect size various teaching techniques have on student performance. Their meta-analysis concurred that a statistically significant positive influence was documented when students used inquiry strategies as compared to traditional passive methods of instruction in the control group. This is one of many studies to show the efficaciousness of guided inquiry instruction in the classroom.

In another study, Minner, Levy, and Century (2010) completed a research synthesis of the years 1984 to 2002 to learn what was the impact of inquiry science instruction on K-12 student outcomes. The study found a positive impact of inquiry-based instruction on student learning of science concepts. This synthesis suggests that when students were actively reasoning and engaging with the data during science investigations, students learning increased more than when students were passively learning through traditional textbooks.

Criteria for research in this synthesis were chosen provided the investigations included K-12 students and inquiry-based instruction as the foundation. Minner, Levy, and Century (2010) defined inquiry-based instruction as teaching that contains characteristics of student responsibility for learning, active thinking, and motivation. Over different instructional stages called “Question, Design, Data, Conclusion, and Communication” (Minner, Levy, & Century, 2010, p. 479) the three characteristics of inquiry-based instruction were analyzed, and studies were categorized into low,

moderate, or high based on their standard deviation score. Then student understanding and retention were coded and calculated. Qualitative and quantitative studies were coded differently to allow for the types of data collected and their conclusions to be categorized in different manners according to the type of study. Studies were classified by rigor, as well, according to descriptive clarity, data quality, and analytic integrity. A limitation of this synthesis could be the atypical analytic approach as it may skew data, especially since there were mixed-methods studies included. Minner, Levy, and Century concluded that students who participated in high-inquiry investigations with hands-on activities "did statistically significantly better than those in treatments with lower amounts of inquiry" (Minner, Levy, & Century, 2010, p. 493). This shows how inquiry investigations can have a positive effect on learning in science.

Through an additional meta-analysis of almost forty studies from 1996 to 2006 when inquiry teaching was a vogue term regarding science instruction, Furtak, Seidel, Iverson, and Briggs (2012) desired to establish how traditional instruction affected student learning compared to inquiry instruction affected student learning. Through the research, this study created a continuum for inquiry where teacher-guided inquiry was mid-distance between traditional instruction and student-led inquiry, or discovery. Research for this study was selected with several specific criteria, including experimental or quasi-experimental designs that comprised all students within regular K-12 science classrooms with the data to calculate an effect size. One of the authors was familiar with some research that was not included in this selection, so another search with different terms yielded those and other studies. These were funneled with the criteria again and a total of thirty-seven studies were identified for this meta-analysis. After a detailed

analysis, Furtak, Seidel, Iverson, and Briggs (2012) suggest that inquiry-based teaching has a positive effect on the students' learning when the students engage in creating knowledge and procedure using collaboration. The study also suggests a larger effect on student learning is gained when teachers guide the inquiry than in traditional instruction or more open inquiry investigations that students lead. This is important to my research as I am investigating how inquiry investigations affect student learning of science vocabulary. This meta-analysis shows that inquiry leads to students' gains in content. It also seems to indicate that students learn better when teachers give a direction to the investigation. If gains in content can be made, the question of gains in student vocabulary is not a large leap.

With a slightly varied approach, Scruggs, Mastropieri, Bakken, and Brigham (1993) investigated what effects do textbook-based and inquiry-oriented approaches have in special education classrooms on science learning. This study revealed higher scores on tests that were given at the end of the study and a week later when students were taught with activity and inquiry approaches. Moreover, students showed they appreciated the activity-based instruction more than the textbook approach. Students indicated they tried harder, learned more, and would like to repeat the activity-based methods compared to the textbook approaches. However, Scruggs, Mastropieri, Bakken, and Brigham (1993) noted in the study that in both textbook and inquiry approaches, vocabulary was not learned well. This was attributed to the explicit memory challenges of the subjects in the study. Moreover, vocabulary was not explicit to the study. This paper is important to my study because it shows that inquiry instruction had more of an effect on the learning-disabled students content knowledge than the textbook instruction. While vocabulary

may not have been learned well, it was not specifically studied, and it is possible that the learning difficulties of the students were a roadblock in this, as suggested by the researchers.

With a different specialized group of students, Amaral, Garrison, and Klentschy (2002) researched the effects of inquiry-based science instruction on student achievement scores in science, writing, reading and mathematics on the SAT-9 test in rural California. In this program, the use of science notebooks was required of students. Moreover, students in high-support English Learner classrooms were allowed to listen to directions, discuss, and write in Spanish during the inquiry science program, as needed. In other classrooms, students were only allowed to use Spanish to discuss a concept with peers, but English was expected otherwise. Additionally, students were only included in the study if they had attended school in the district for all four years of the study. Since not all schools in the district participated in the study, students may not have been a part of the program each year. This allowed researchers to use these students as a comparison, or control group for the study. Support for teachers, including professional development and restocked kits of materials for each unit, were included in the program. Both of these helped maintain the efficacy of the program by ensuring teachers had the same materials for each unit and that teachers had the same training provided to them.

In conclusion, English learner student scores on science, reading, writing, and mathematics achievement tests suggested the more time the students participated in the program, the better scores they earned in each of the four subjects. However, data was only collected one time and students were categorized based on number of years they participated in the inquiry kit program, fourth or sixth grade, and English language

proficiency level. Then data was segregated by subject. Since the data was only collected once, individual student growth is not shown. It is possible that other factors, such as innovations in reading and math, influenced the growth in these subject areas.

Future studies are needed, such as growth of a specific group throughout the program. Another aspect of the kit program that could be studied is how the use of a science notebook with or without teacher professional development affects the achievement level of students. This study is important to mine because it shows a positive correlation between student achievement and inquiry science in the English Learner classroom, as the other studies showed a positive relationship between inquiry science and growth in learning science content in regular instructional classrooms and Special Education classrooms, too.

These studies lead one to believe that guided inquiry science shows positive results on students' learning. Guided inquiry science investigations consist of students interacting with the data and drawing conclusions based on their own observations and discussions with peers. The teachers give students directions during guided inquiry and lead them rather than allowing students to drift alone. However, the students become the answer-seekers, rather than the teachers being the answer-keepers to share it while students sit and passively listen. Using guided inquiry investigations, the students in this study will search for answers and link their found knowledge to vocabulary that is explicitly taught to them after the investigations.

Methods of Learning Vocabulary

In the following studies on vocabulary, most do not focus on academic content vocabulary. However, the principle of learning vocabulary is studied through many

methods. One aspect seems to weave through all of the studies, which is: students need to spend time considering a small amount of words to really gain an understanding of them.

Beginning with a textbook on vocabulary learning, Scot and Nagy (2009) wrote the chapter of the book from *Essential Readings on Vocabulary Instruction* that tells of a research project that lasted seven years named The Gift of Words, where teachers explicitly taught word consciousness to students by "providing an enriched focus on word use during reading, writing, and discussions" (p. 109). The foundation of the project came from the work of Lev Vgotsky whose Social Development Theory (McLeod, 2018) stressed that our cognitive development grows from our community and social interactions. This seven-year project focused on teaching and learning words as a community with scaffolded instruction from the teachers. The social aspect of learning words was completed through discussion during read alouds of carefully selected poems and books. Explicit discussions of figurative language and word forms was a focus. Students learned from discussing great phrases from authors and then using those phrases to create their own. Finally, they would use their created phrases in their own writing. Scot and Nagy (2009) concluded that developing word consciousness in students contributes to vocabulary growth by giving students reason to grow their vocabulary and empower themselves with words to express themselves in writing and, as well as a better understanding of what they read in book, including textbooks. Scot and Nagy (2009) suggest teachers exercise a substantial vocabulary in their classrooms, create a deep understanding of words within students, and find vocabulary coaches in the school or other community. These activities will encourage students to enrich their lives with words. This book chapter shows how important it is to use words in a social context to

develop understanding and grow students' vocabulary. Students in my class used their peers and games as social activities to utilize their science vocabulary.

Blachowicz, Fisher, Ogle, and Watts-Taffe (2006) seem to echo Scot and Nagy's (2009) recommendation for teaching vocabulary well by creating an environment that is rich in language and words. Teachers explicitly teaching words and allowing for multiple exposures and practice is also essential. Additionally, teaching students words and word forms, as well as ways to learn new words without instruction is included for teachers to be efficacious in vocabulary instruction.

Kelley, Lesaux, Kieffer, and Faller (2010) questioned what effect would consistent, methodical instruction would have on student reading comprehension skills in regular classrooms. Principals selected English Language Arts (ELA) teachers based on students' profiles and classroom achievement, then twelve of those teachers chose to try the vocabulary program, or treatment. For comparison, teachers who did not volunteer to participate in the treatment group were assembled as the control group. Kelley, Lesaux, Kieffer, and Faller (2010) found teachers' backgrounds in both groups were similar in quality of teaching and general classroom practices outside of the intervention. Student achievement was compared between the twelve volunteer classroom teachers and the seven other teachers who didn't volunteer. Students comprised of 476 sixth graders, 346 Language Minority learners, or students who speak another language at home, and 130 native English speakers. Participating schools ranged from 67- to 96% percent students of color and 58-100% percent free or reduced-price lunch. The study utilized Gates-MacGinitie reading comprehension test (MacGinitie & MacGinitie, 1992) and SAT-10 reading vocabulary test to show pretreatment scores to be about 35th percentile and

learned treatment and control classroom were an approximate match. Then teachers administered an eighteen-week vocabulary program consisting of eight, two-week units and two review weeks total. Each lesson cycle consisted of 8eight days with each lesson suggested length 45 minutes, four days per week. Teachers were provided a program specialist, a former teacher who regularly met with the teachers to answer any questions about the curriculum.

From teacher journals and observations, the study gleaned that the program was taught with about 80% percent fidelity across all of the teachers. This study suggests that it is important for students to spend time considering words - explicitly learning them, having repeat exposures to them, and learning how to use them in writing. The students who received the treatment had greater increases on standardized tests scores in vocabulary and reading comprehension. (Kelley et al., 2010).

Kelley, Lesaux, Kieffer, and Faller (2010) recommend teachers use academic vocabulary in conversations with students, choose a small amount of words at a time for students to study, complete oral and written activities that allow students to think while they use the words, give students opportunities to have conversations about the words in which they are required to consider each word, and explicitly discuss ways the words could be used incorrectly. In addition, teachers should instruct students how context clues are shown in a variety of ways. In short, students need a small group of words to engage in numerous ways over time after being explicitly taught the words and how to use them. This is important to my study because it shows how academic vocabulary is important for students to know to increase their reading comprehension and understanding of texts.

Another study by McKeown and Beck (2004) shares that direct vocabulary instruction is efficacious when students have multiple opportunities to actively consider and apply new words. Additionally, words should continue to be recycled in the classroom throughout the year. Context clues are useful if types of context clues are explicitly taught to students as not all words' meanings can be derived from context.

This is important to my study because it is after students developed their own vocabulary for terms in science that they were taught the words for the phenomenon or related words that were selected for them. At that time, students' knowledge that they developed from investigation was linked to the academic content vocabulary. After that, students had time to work with the words before the test.

Another method to learn vocabulary was gleaned from research by Skoning, Wegner, and Mason-Williams (2017) who studied the outcomes for children when vocabulary was taught through movement. The study concluded that the inclusion of movement to teach character-trait vocabulary appeared effective, supporting other studies that investigated similar approaches. (Skoning, Wegner, & Mason-Williams, 2017, p. 7) Seventy-nine students in second through fourth grades participated in the study. Most of the students were white and did not qualify for free and reduced meals. Two hours of professional development was provided to introduce teachers to movement theory based on a 1974 model by Laban and Lawrence. Students would discuss with the teachers how a character with a specific character trait would move and collaborate with their peers to define the movement for each trait. Throughout the eight-week study, students were given tests four times to ascertain how intervention affected their learning beginning with a pretest and ending with a posttest.

Skoning, Wegner, and Mason-Williams (2017) concluded from this study that using movement seemed to increase learning when teaching students character-trait vocabulary. However, it is possible the reading and character trait vocabulary instructions earlier in the year affected the outcomes of the testing. Also, students' willingness to take the test that may have seemed long to them was a factor that may have influenced the outcomes. Finally, there was no control group to compare the results and verify influence. Nonetheless, more research should be done on this method of vocabulary instruction.

In the third unit, my students created movements to mimic the vocabulary words to help them recall their meanings for the test. This method seemed to help a lot of the students, so I added it to our repertoire of practices to help the students recall vocabulary definitions on the tests. It was another way for students to make the words meaningful to them.

Another approach to learning vocabulary was studied by Biemiller (2012) who advocates that children need to acquire vocabulary to increase their comprehension. Biemiller (2012) suggests children can increase their vocabulary up to 400 words a year. If this can be done every year for three years, about sixty percent of the words children need to learn to bring them from below average to average levels in reading comprehension would be accomplished. Different tactics could be employed by teachers, such as "Word of the Day" where a word that would be used in the classroom would be presented as a challenge to students to learn how to use it. To effectively intervene and help a child gain essential vocabulary about 30 minutes a day would be required for direct instruction. This prospect overwhelms many teachers, however Biemiller insists developing vocabulary is what will "begin to close the gaps between advantaged and

disadvantaged children" (Biemiller, 2012, p. 48). The idea of spending time with words to really learn and understand them is echoed in Biemiller's (2012) research. What each of these studies on vocabulary seem to have in common are time and thought. In other words, student need to take time with words and use that time to thoughtfully consider the word.

Vocabulary and Inquiry Investigations

Zwiep, Straits, Stons, Beltran, and Furtado (2011) researched what effect on vocabulary comprehension would blending science and English Language Development (ELD) lessons for English Language Learners had on vocabulary comprehension. Prior to the study, students were missing science to attend ELD lessons to increase their English proficiency. Researchers wondered if the ELD could be combined with science to increase students' vocabulary comprehension. Initially, ELD lessons were combined with inquiry science where the subjects were still treated as separate. This caused teachers to teach one or the other, but not both due to time restraints or teacher comfort levels with either language or science.

During the second quarter of school, science and ELD teachers worked together to fuse the curriculum by adapting the ELD lesson goals into the inquiry science curriculum. Vocabulary words were analyzed and divided into terms that were taught prior to the lessons and others were taught after the inquiry activities. The study suggests that blending inquiry science and ELD lessons well creates a positive learning experience for English Language Learners to successfully develop vocabulary. Students seemed motivated by this fuse of the curriculums because they enjoyed the hands-on activities provided by inquiry science lessons (Zwiep et al., 2011).

Prior to this study, students in the ELD program were not participating in science curriculum, so this may have limited their experience with the vocabulary they were learning in the lessons. Moreover, the students did not view the inquiry science as ELD lessons, however this limitation was seen as motivation because the stigma of being a student who needed ELD lessons was taken away from them. This was important to my study because it indicated that inquiry science can provide input that the students understand and can help connect to the vocabulary words making them more accessible to students.

Another study involving inquiry science and academic content vocabulary words by Jackson and Ash (2012) researched if providing professional development with support and training to develop inquiry science lessons using the 5E model (Engage, Explore, Explain, Elaborate, and Evaluate) and the use of multisensory, interactive word walls would impact science achievement scores of fifth grade English Language Learners and economically disadvantaged students.

Initially, K-5 teachers on grade-level teams at one high poverty, ethnically diverse public elementary school in Texas participated in professional development studying state standards and cooperatively writing purposeful science instructional activities based on the state standards using the 5-E model. For two years, students in grades Kindergarten to fifth grade participated in inquiry science activities with their teachers receiving continual professional development as support for the program. Additionally, multisensory interactive word walls were implemented to support key academic-content vocabulary. The vocabulary words were content-specific. To add words to the multisensory interactive word wall, a teacher or student would place an object or a photo

in a plastic baggie that would hang on the wall with the word on the bag. This would give students a concrete example of the word. (Jackson & Ash, 2012).

In the third year, the first school continued the inquiry science activities with the interactive word wall without professional development support as a test to check the programs continued efficacy. Additionally, a second school joined the study to replicate the inquiry activities and the interactive word wall. The professional development was provided to the second school in the third year.

During the two-year treatment and in the third year of sustainability, the first school's Hispanic, Language English Proficient, and economically disadvantaged fifth grade students showed an increase of the percentage of students passing the science portion of the standardized test. Moreover, the percentage of students in the first school who passed continued to increase each year. Finally, the second school showed significant increase in the third year, which is the year this school joined the treatment phase. This study seems to show that inquiry science and a multisensory interactive word wall increases students' knowledge of science content and content vocabulary (Jackson & Ash, 2012).

Summary

All of this research shows that guided inquiry investigation has been defined as hands-on activities where students take responsibility for learning by exploring science concepts with guiding questions from the teacher. Moreover, the studies listed have shown that guided inquiry instruction using hands-on investigations is more efficacious than traditional methods of instruction and student-led inquiry where there is little to no teacher direction. Additionally, the positive relationship between inquiry investigations

and gains in content knowledge has been shown with different groups of students, such as students with learning-disabilities, English language learners, students from poor backgrounds, and Hispanic students.

Current vocabulary research shows that students need to spend time with words. While inquiry science would not give the students time with words, it would give them context and background to make the words meaningful, like the multisensory interactive word wall. (Jackson & Ash, 2012). Much research exists in the area of vocabulary development and inquiry science, however there is a gap that can be filled to learn how inquiry science can affect academic science content vocabulary knowledge.

CHAPTER 3: METHODS

Overview

In this action research study, students studied three units of science. The units were *Sound*, *Light*, and the *Birth of rocks*. Before the beginning of each unit, a vocabulary pre-test was administered. Following the hands-on, inquiry investigation and the first discussion of the vocabulary words in units one and two, students were given a second vocabulary test. Students practiced with the words. At the end of the unit, students took a vocabulary post-test. For the third unit, students were administered a pre-test, then participated in the inquiry activities to introduce them to the content. After that, they learned the vocabulary and studied it. Finally, they took a vocabulary post-test. Some students from the class were interviewed twice to learn their views on science and vocabulary. Two students were interviewed only once.

Context of the Study

The community where this study takes place is a a large town. At 23,000 residents, it's about the tenth largest city in Nebraska, and is the county seat. The nearest large cities are Omaha and Lincoln.

This study was conducted in a public school district comprised of 5 elementary schools, one middle school, and one high school. The district serves a total of about 3,900 students, about 1200 are elementary students and 375 attend the school where I teach fourth grade and where this study took place. Overall, the Hispanic population is increasing each year in the district while the Caucasian population is decreasing. The research site's attendance shows a decline in all populations, however last year was the first with no 5th graders in the building. Table 1 shows the school population summary

with ELL and Free and Reduced compared in the state, district, and my elementary school. The data is from Nebraska Department of Education website (2019).

Table 1

School Population

2017-2018	**Nebraska**	**District**	**School**
English Learner	7%	11%	28%
Free and Reduced Lunch	46%	59%	66%

Note. Both EL and Free and Reduced Lunch populations are larger at the school in comparison to the District and State.

Participants

Nineteen fourth grade students were in the homeroom class. The homeroom teacher taught science, social studies, spelling, and writing. Five of the nineteen students received free food through a backpack program each Friday. Students can apply for this program or be recommended by a teacher. Through this program, students receive food for free to take home on Friday so they will have something to eat over the weekend. Six of the nineteen (32%) students spoke another language at home. One of the nineteen students had incomplete data due to significant learning and behavior disabilities. Thirteen students have assent and consent papers signed. For the study, only students with assent and consent papers were included in individual data and interviews. Any data with averaged scores contained the eighteen students' scores from my homeroom.

As the classroom teacher, my role in the study was to instruct students using hands-on, guided inquiry investigations. It was my nineteenth-year teaching in 2018-

2019. I have received one half-day inquiry science training through Des Moines Public Schools to create inquiry science backpack kits through a grant and two-week training instructing me to understand NGSS and create 5E lesson plans using the NGSS from Wichita State University through a one-year STEM grant. To complete the class over the course of the school year, we wrote six lessons that we recorded and submitted to a coach who helped us improve our instruction related to the 5E's. Both of these gave me a proficient understanding of inquiry. As I am the researcher, I have access to the students, and they are familiar with me and my teaching methods.

Procedure

Prior to the unit studies in science, students took a vocabulary Pre-test on Google Forms. The first science unit was the study of sound. After this unit study, four students were interviewed regarding their views on activities done in science and vocabulary. Next was the second unit, the study of light. During both of these units, following the guided inquiry investigation and explicit vocabulary instruction and discussion, the class took the second vocabulary tests. The post-tests were administered after students practiced with flashcards, Quizlet, and Quizlet Live.

The third unit study was birth of rocks. A pretest was given before the unit study commenced. Students engaged in guided inquiry investigations and then vocabulary was explicitly taught and discussed. Vocabulary words were practiced individually with the Quizlet app, with partners studying flashcards, and as a group using Quizlet Live. Additionally, students played Around-the-World and created actions for the words. Finally, students completed the vocabulary post-test. Last, four students were interviewed again.

Data Collection

Both qualitative and quantitative data were collected. The qualitative data collected was student interviews that were conducted in March and May. The quantitative data collected was the vocabulary tests. A total of eight vocabulary tests were given. Three of them were pretests, one before each unit. Two tests during the first two units of study were given after the inquiry investigation and explicit instruction of the vocabulary words. Three were posttests at the end of each unit. Each unit repeated the same tests. These are included in the Appendix.

Vocabulary tests.

The quantitative data was collected through Google Forms. For each unit of science that was studied, a Google Form vocabulary test was created. These are in Appendices A, B, and C. The units were sound, light, and the birth of rocks. During each unit, the same vocabulary test was repeated. For unit one (sound) and unit two (light) students took the vocabulary test as a pretest, second test, and posttest. For unit three (the birth of rocks) students took the vocabulary test as a pretest and a posttest. There was no second test for that unit. A summary of the frequency of vocabulary tests is in Table 2.

Table 2

Data Collection

Vocabulary Test	**Unit 1, Sound**	**Unit 2, Light**	**Unit 3, Rocks**
Pretest	x	x	x
Second Test	x	x	
Posttest	x	x	x

Note: x represents a vocabulary test

Following the Pre-Tests, students engaged in guided inquiry investigations and then were given explicit vocabulary instruction with a discussion of the words for that unit. After that, students were given the second test to assess what vocabulary definitions they knew and what ones required more practice. Then students were given time to practice the words. Students studied flashcards in a variety of ways, used the Quizlet app to study the words, and played Quizlet Live as a class. The time spent on all of these activities was fifteen to twenty minutes a day for five days, which is a minimum total of one hour and fifteen minutes. Following that, they took the final vocabulary test for the unit, or the Post-Test. This was repeated for both units one and two, but unit three was different in two ways.

In unit three, students did not take a second test after the inquiry investigation and vocabulary instruction and discussion. Also, students engaged in two activities in addition to the Quizlet and flashcard practice. For one, students played Around the World with the flashcards and two students led the game. Also, students created actions to associate the vocabulary words and definitions. At the end of five days of studying, students took a vocabulary Post-Test.

Student Interviews.

Three students were interviewed in March and again in May. In addition, one extra student was interviewed in March and a different extra student was interviewed in May. Table 3 shows a summary of the students interviewed. The extra student was added in May when student four could not be reached. Both were about the same comprehension and interest levels in science. All students were asked the same questions.

The first set of interviews were conducted during school hours and recorded on the teacher's iPad provided by the school district. The second set of interviews were conducted a week after school had dismissed for the year on the phone and recorded on paper by the teacher. Interviews were coded using Open Coding by Case Study.

Table 3.

Student Interviews

Student Interviews	**Student 1**	**Student 2**	**Student 3**	**Student 4**	**Student 5**
March	x	x	x	x	
May	x	x	x		x

Note: x represents one interview

Students were asked 20 questions about their opinions related to what science activities look like in our class and their view of how well they know science. Additionally, there were 4 questions at the end of the interview testing their knowledge of the concepts we studied in class. A list of questions is included in Appendix D.

Data Analysis

Quantitative data was scored and a mean, median, and mode will be calculated for the class for each unit Pre-Test to Second Test. After that, data was scored and compared between the Second Test and Post-Test. Scores that increase or decrease were analyzed. Data was also analyzed to see how many students passed the final test. I also looked at students who do not improve. Any patterns were identified and analyzed.

Interview data was analyzed using qualitative analysis techniques. Themes were identified and grouped together for analysis. Direct quotes to support the themes were provided. Interview answers were grouped according to question and topic. Qualitative

data was first open coded to look for themes. Once themes were found, answers were grouped together for axial coding, from which themes emerged.

Summary

In summary, the quantitative data collected were results of scores on vocabulary tests that were given multiple times for each unit. Once as a pretest and Once as a posttest after the students practiced the vocabulary. In units one (sound) and two (light), students were administered a second vocabulary test after the guided inquiry investigation was completed and the vocabulary terms and definitions were introduced. In unit three (the birth of rocks), students were not given the second test and the reasons will be discussed in the following chapter. Each test was calculated for mean, median, and range scores. Also, questions that all students answered correctly or other findings that were interesting were highlighted. Data and themes will be discussed in chapter four. Implications will be discussed in chapter five.

The sequence of events was Unit 1 Pre-test, inquiry investigation, explicit vocabulary instruction, Second Test, vocabulary practice, and Post-test. After that, March interviews were conducted. Next, Unit 2 was taught similarly to Unit 1. Then Unit 3 sequence was Pre-test, inquiry investigation, explicit vocabulary instruction, vocabulary practice, and Post-test. Finally, May interviews were conducted. Unit 3 did not include a Second Test as it was discovered that most students needed both inquiry investigations and vocabulary practice to pass the Post-tests.

CHAPTER 4: FINDINGS

Overview

In this action research study, students studied three units of science. Data was gathered from vocabulary tests and student interviews during the spring semester of fourth grade. Vocabulary Pre-tests were administered to each student on iPads through Google Forms prior to each unit study. A second vocabulary test was given after the hands-on, inquiry investigation and the explicit vocabulary instruction and discussion in units one and two. The vocabulary Post-test was taken at the end of each unit after students practiced with the words. For the third unit, students were administered a Pre-test, then participated in the inquiry activities to introduce them to the content. After that, vocabulary was explicitly taught to students and they were given opportunities to practice the words and definitions. A vocabulary Post-test was given following a week of practice. In addition, three of the thirteen students with signed assent and consent forms were interviewed twice, once in March and again in May, to learn their views on science and vocabulary. An extra student was interviewed in March and one other student was interviewed in May.

Hands-On, Guided Inquiry Investigations and Vocabulary Acquisition

This study's main focus was to learn what effect hands-on, guided inquiry investigations had on students' science vocabulary test scores. Prior to each unit study, all of the students took a Pre-test on iPads through Google Forms. After students conducted hands-on, guided inquiry investigations, the teacher introduced the vocabulary words and explicitly taught the meaning of the words. During the instruction, discussions would be used to connect students' observations from the investigations to the words they were

learning. After all of the vocabulary words had been taught, a second vocabulary test was given to ascertain how much of the vocabulary and definitions the students seemed to acquire through investigation and explicit instruction. The class average score on the Pre-test for unit one (Sound) was 4.76/10. The class median score was 5/10. The class scores ranged from one to eight. After the inquiry investigation and the vocabulary was taught and discussed, the class average score on the second vocabulary test was 6.72/10. The class median score was 6/10. The class score range was three to ten. From the graph in Figure 1, it is easy to see that all but one student's scores increased from Pre-test to Second Test. Forty-four percent of students passed the second test on Sound.

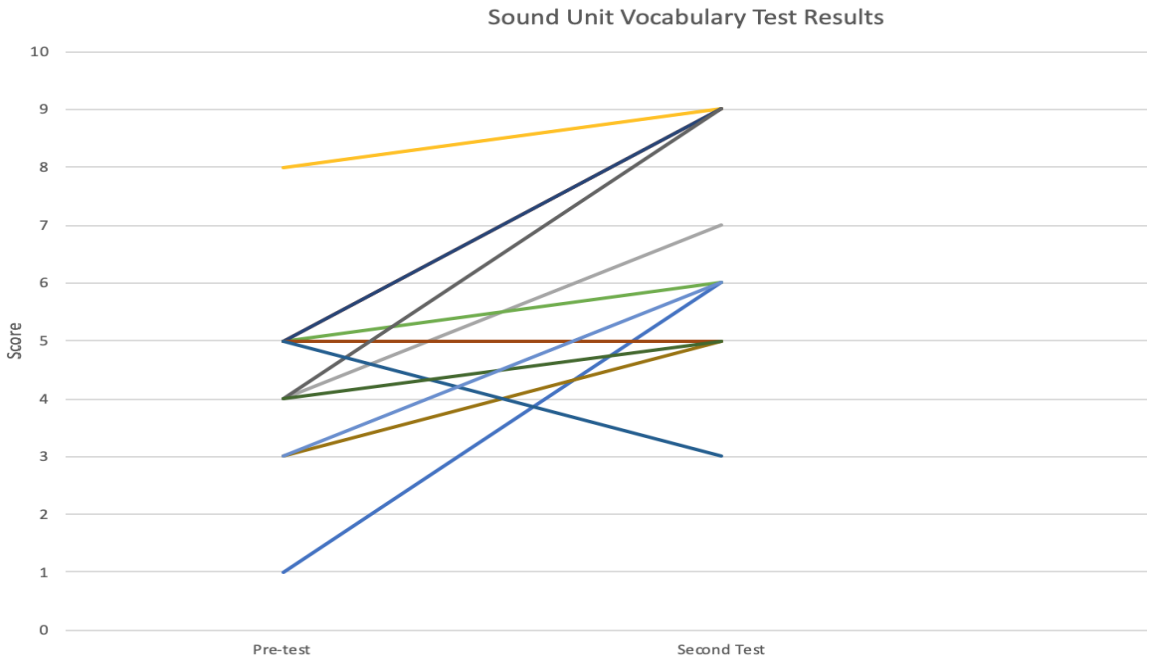

Figure 1. Students' pre-test and second test scores for the Sound Unit

For unit two (Light), the class average Pre-test score was 4.56/13. The class median score was 4/13, and the class range was one to seven points. After the inquiry investigations and the introduction and discussion of vocabulary, a second test was given. Class average and median scores increased to 10.61/13 and 10/13 respectively. The class range was seven

to thirteen. 2/13 questions were correctly answered by the majority of the students. Answers that the majority of students knew were the definition of reflection and the colors that create white light. Figure 2 shows the increase in students' scores from Pre-test to Second Test during the unit on Light. Fifty-six percent of students passed the second test on Light.

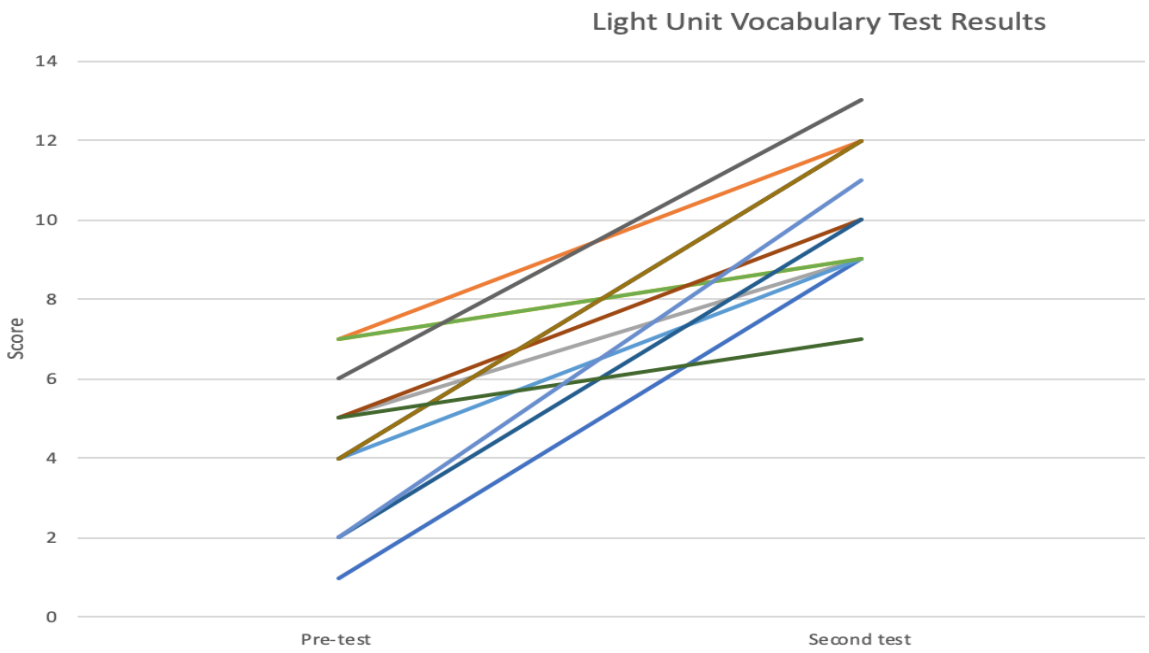

Figure 2. Students' pre-test and second test scores for the Light Unit

Games and Vocabulary Acquisition

Once students had access to the vocabulary words and definitions, they took time to play games, study flashcards, and have continued discussions about the words related to the science content. After four or five days of practice and discussions, students took a final vocabulary test. Both Sound and Light Units' tests from Pre-test to final Post-test results are pictured in figures 3 and 4 respectively.

The Sound Post-test was administered after students practiced with flashcards, Quizlet, and Quizlet Live. The class average score on the final test was 9/10. The class

median score was 10/10. The class scores' range was 5 to 10 points. Seventeen out of eighteen students, or ninety-four percent, scored 70 percent or above and obtained passing scores. Eight of these scored perfect 100 percent. One student did not seem to acquire any knowledge of the words and the score remained static from test to test. Three of the ten questions were answered with one hundred percent accuracy. Questions that all students answered correctly were the definitions of pitch and energy waves. All students also knew that sound waves cannot travel through space. Students' average and median scores increased for the sound unit Post-test. The overall range decreased from seven to five points.

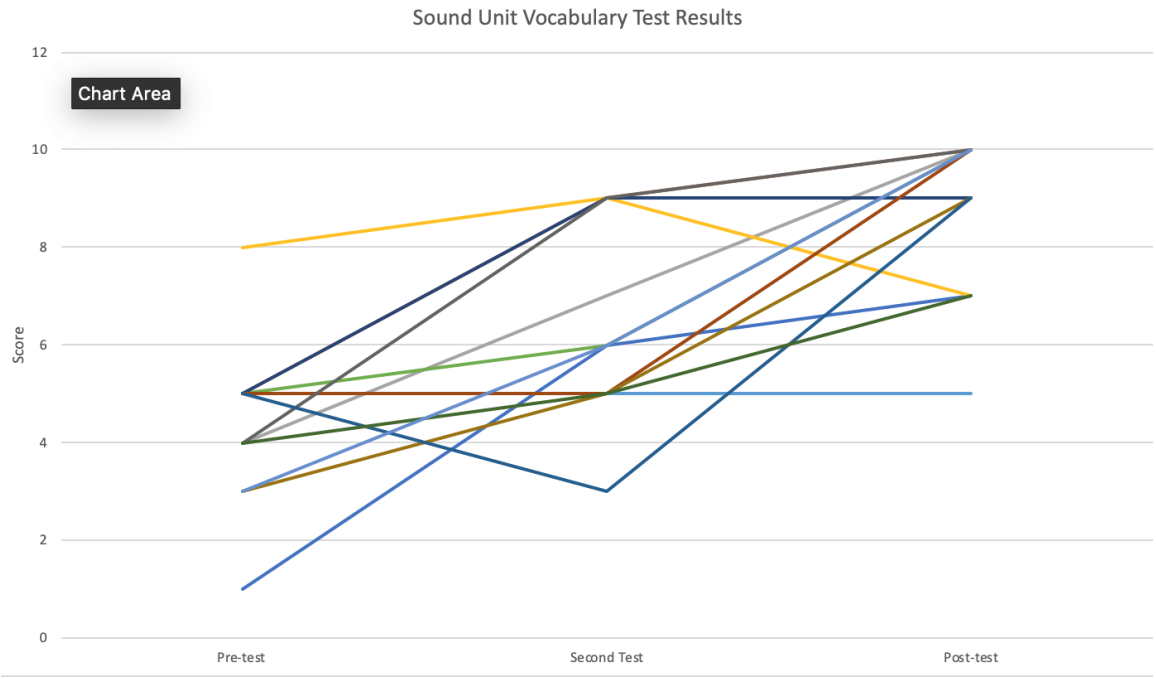

Figure 3. Students' pre-test, second test, and final post-test scores for the Sound Unit

Students were administered the Post-test for the Light unit after practicing with Quizlet, flashcards, and Quizlet Live. The Post-test average slightly increased to

10.88/13. The median increased to 12/13. The range decreased by one to eight through thirteen. Students scored one hundred percent on three of the thirteen questions. These were the definition of transparent, opaque, and prism. However, one student incorrectly answered opaque for the definition of translucent possibly giving evidence that the definition of opaque was not completely understood. Four students scored a perfect 100 percent on the Post-test. Sixty-one percent of students passed the Post-test. Five of eighteen students scored below seventy percent accuracy, therefore failing the vocabulary Post-test. Each of these students, except one, failed to gain any points following the time to study and discuss the words. They did make gains between the inquiry investigation and initial instruction and discussion of the words. Three of these had the same pattern in the Sound Unit, not gaining any understanding from the time spent studying the words and definitions with content discussions.

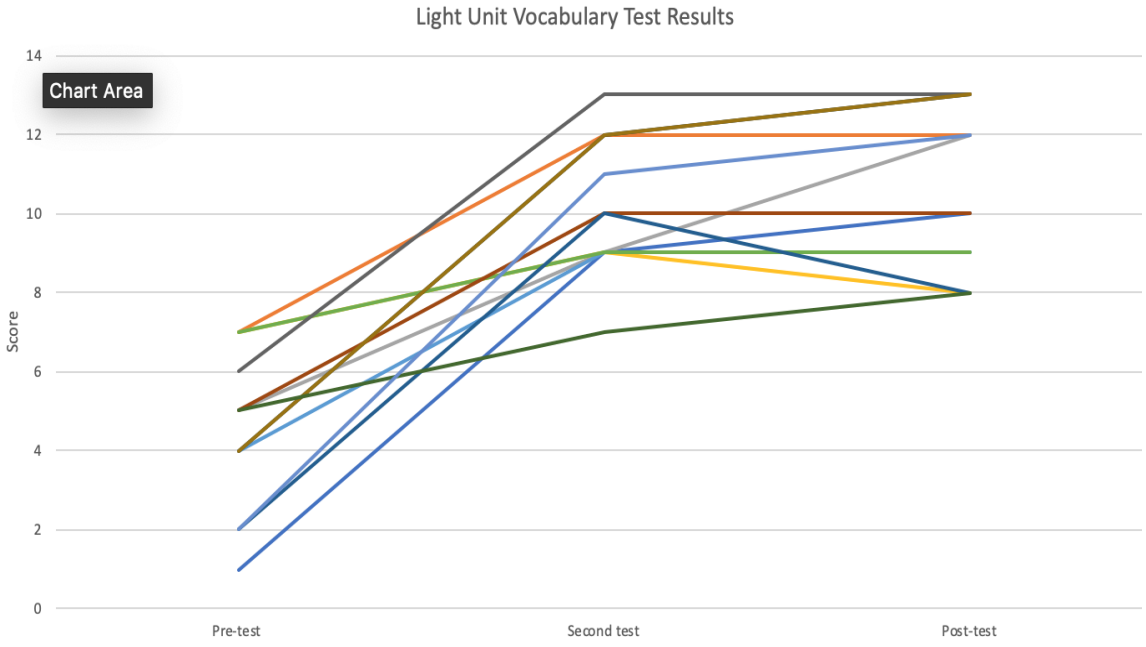

Figure 4. Students- pre-test, second test, and final post-test scores for the Light unit

Combining Guided Inquiry Investigation and Games to Acquire Vocabulary

For the final unit of study, The Birth of Rocks, students were administered a Pre-test and a Post-test. There was no Second Test for this unit. A discussion of this can be found in the following chapter. The class average score was 2.37/8 on the Pre-test and the class median score was 2/8. The class range was one to five. The majority of the students knew the definition for lava. After the inquiry investigations and the vocabulary introduction, students studied the words for the final test. The class average Post-test score was 7.33/8 and the class median score was 8/8. The class range was four to eight. Sixty-one percent of the class scored a perfect one hundred percent on the test and eighty-nine percent of the class passed the Post-test. The two students who did not pass were two of five students who scored one of eight on the pretest. While both of these students made gains, they were not sufficient to pass the final test. Interestingly, neither of these students had failed the other unit Post-tests. One hundred percent of students knew the correct answer to two of eight questions. The definition of weathering was incorrectly answered by 7/18 students.

The graph in figure 5 shows the results of the pre and post-tests. The line indicates students who did not gain knowledge from the activities between the tests. Since all scores are above the line, this shows that all students gained knowledge from the inquiry investigation and practice activities.

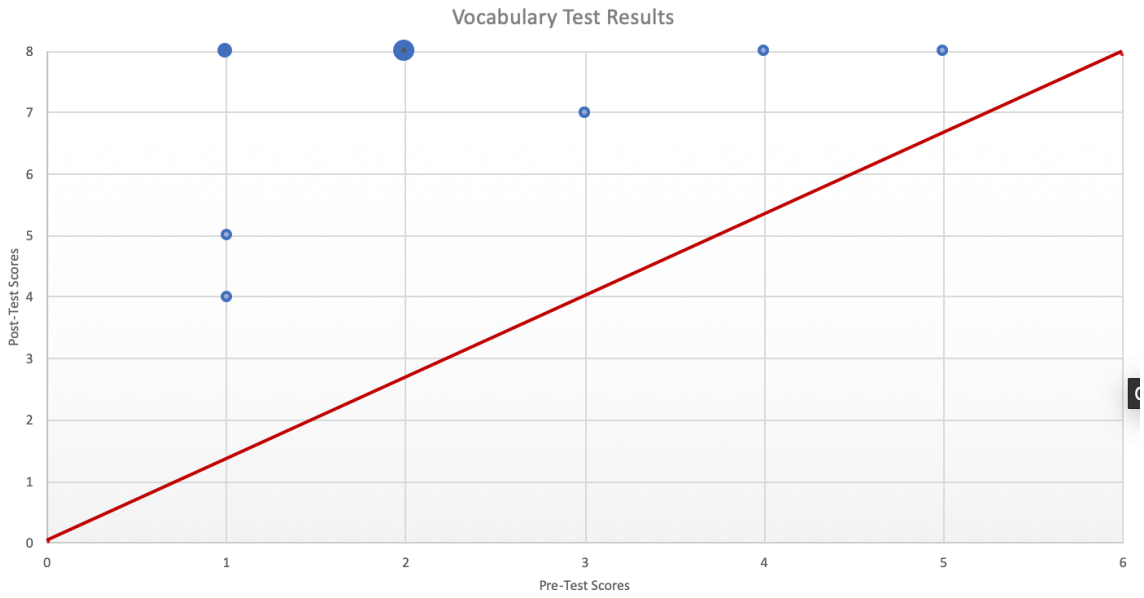

Figure 5. Students' pre-test and post-test scores for the Birth of Rocks unit.

Student Interviews

Student interviews were conducted with three students in both March and May. In addition, one extra student in March and a different additional student in May were interviewed. Interestingly, all of the students provided similar answers to the same questions, which easily led to two possible themes. These themes regarding guided inquiry science investigations and vocabulary from student interviews were "Fun" and "Real-World Applications."

The first theme regarding guided inquiry investigations showed up quickly and easily. Students answers about science activities in class and comparing science to other activities all produced the answer that the activities we do, which are hands-on guided investigation activities, are fun. One student commented, "We play and learn stuff." Another said, "It's interesting because we learn about things we never knew, like scientific things." Plus, one student commented, "We get to try different things in science

than other classes." One student that was interviewed both in March and May said, "I really liked the volcano experiments."

When it came to knowing why science vocabulary words are important, students gave answers that drew the theme, "Real World Applications." Students responses to the question, "Why is it important to know the meanings of vocabulary words you see in science?" One student answered, "Because when I grow up, I may use them in my job," and another replied, "For later like high school and in life." Students also mentioned passing a quiz or a test, which is expected.

Students telling a teacher that science is fun for a variety of reasons and that they like science more than other activities in school easily creates a theme of fun during open coding. Moreover, students mentioning that they will need knowledge from school for later in life shows that they understand what we do is not just the next test, which brought out the theme of real-world applications.

Summary

Quantitative data from the vocabulary tests and qualitative data from interviews can help tell a story of a classroom. This classroom shows that almost all students are increasing their test scores following guided inquiry investigations, explicit instruction, and practice with vocabulary words. It also shows that students consider science to be fun, and they think science gives them relevant words to use in the real world.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

Overview

This study showed that after engaging in hands-on, guided inquiry science investigations and explicit vocabulary instruction with discussion, most students showed growth on their vocabulary tests. Plus, after time to study the words in a variety of ways students' scores on the vocabulary tests continued to rise. However, the study also seemed to show that both investigation and time to study the words in a variety of ways are needed for the majority of students to score a passing grade.

Discussion

Not surprising was the rise in scores on the second tests after the guided inquiry investigations. Research supports that most students will learn content from guided inquiry instruction. (Schroeder, et al., 2007; Minner, et al., 2010; Furtak, et al., 2012, Scruggs, et al., 1993, Amaral, et al., 2002) However, the difference between the class average scores from Pre-test to Second-test require more investigation. The Sound Unit scores from Pre-test to Second Test rose 2 points on average, yet the Light Unit scores rose 5.6 points on average. The Sound Unit vocabulary tests had a total of 10 questions and the Light Unit vocabulary tests had a total of 13 questions. A possible reason scores rose more on the Light Unit than the Sound Unit could be due to the higher number of questions on the Light vocabulary tests. Another reason could be the specific word lists in each unit. It is possible that the Light Unit vocabulary was more easily understood by the investigations and explicit instruction with discussion than the Sound Unit vocabulary words.

Specifically focusing on the first science unit the study of sound, I learned after a discussion with the students that two of the words, volume and pitch, were familiar to them from music class. Most students gave the correct definitions for the words wavelength and vibration on the pretest also. One person correctly answered that sound waves cannot travel through space. Three correctly answered that sound is energy in the form of vibrations passing through matter and that sound travels fastest through solids. On the second test, all of the 18 students who took the test correctly answered the definitions of volume and pitch. One student missed the definition of vibration and chose volume instead, which seems to indicate that at least one person may not truly understand the correct definition of volume. Exactly half of the eighteen students knew the definition of sound and that sound waves cannot travel through space. The investigation and introduction of vocabulary words seemed to increase students' understanding of the vocabulary. Average students' scores shown increased by two points as did the class range of scores. The class median score increased only by one point. This seems to show that the inquiry investigations and initial vocabulary discussion helped students acquire some vocabulary for the sound unit. However, no student answered all of the questions correctly, indicating more practice was needed.

The sound posttest was administered after students practiced with flashcards, Quizlet, and Quizlet Live. The class average score on the final test was 9/10. The median score was 10/10. The range was five to ten points. 3/10 questions were answered with one hundred percent accuracy. Questions that all students answered correctly were the definitions of pitch and energy wave. All students also knew that sound waves cannot travel through space. Students' average and median scores increased for the sound unit.

The range decreased from seven to five. One student did not score high enough to pass the final test. This students' score stayed static across each test, which led me to wonder what needed to be done to reach this student.

Before the light unit study commenced, students were given a pretest. 2/13 questions were correctly answered by the majority of the students. Answers that the majority of students knew were the definition of reflection and the colors that create white light. Average score was 4.56/13. The median score was 4/13, and the range was one to seven points. After the inquiry investigations and the introduction of vocabulary, a second test was given. Average and median scores increased to 10.61/13 and 10/13 respectively. The range was seven to thirteen. This seems to indicate that the guided inquiry investigations and initial vocabulary instruction and discussion helped students acquire knowledge of the vocabulary definitions. Average increase of scores shown was 5.6 points. However, of the scores shown, only one student scored a perfect thirteen correct. Due to this, it seemed that students needed more time to acquire the definition of the vocabulary words. Students then practiced the vocabulary words and were given the final test. The average slightly increased to 10.88/13. The median increased by two points to 12/13. The range decreased by one showing eight to thirteen. Students scored one hundred percent on 3/13 questions. These were the definition of transparent, opaque, and prism. However, one student incorrectly answered opaque for the definition of translucent possibly giving evidence that the definition of opaque was not completely understood. Five students in the class did not pass the final test. One of these was the same that did not pass the final test for sound. This gave me the idea to incorporate movement into the practice time to help this person.

For the final unit the birth of rocks Pre-test was given before the unit study commenced. The average score was 2.37/8 and the median score was 2/8. The range was one to five. The majority of the students knew the definition for lava. After the inquiry investigations and the vocabulary introduction, students studied the words for the final test. As before, students used Quizlet and Quizlet Live. They also played a game of Around the World led by two students. Another addition to the study time called for students to create movement as a class that connected the vocabulary words and definitions. On the final Post-test, the average score was 7.33/8 and the median was 8/8. The range was four to eight. One hundred percent of students knew the correct answer to two of eight questions. The definition of weathering was missed by 7/18 students. Two students did not score high enough to pass the test.

In regard to the interviews, students believe science is fun for a variety of reasons. This belief combined with the thought that the learning has real world applications can be a motivation for students to participate in science.

Conclusions

The rise of student scores on vocabulary tests after guided inquiry investigation, explicit vocabulary instruction and discussion, as well as practice using games and movement seems to help students learn the words' meaning. Important to note is that all of the methods tested are important to utilize so that most students can be successful. It is not known if movement has any effect on student scores as this variable was not tested separately from the others.

Based on this action research, I will change how I teach science vocabulary in a few ways. First, I will select vocabulary more carefully with an academic word list in

addition to content vocabulary words. I will also eliminate vocabulary that is not necessary for students to know to understand the content. Furthermore, I will explicitly teach vocabulary words with definitions, examples, non-examples, and videos when necessary all with student-friendly language. Additionally, some words I will preteach and others will be taught after the inquiry investigations. These will be carefully differentiated. Words that cannot be identified through inquiry investigations will be taught before the activities. Conversely, if students can discover the phenomena during the investigations, the words will be taught after the investigations. Plus, I will limit the number of vocabulary words in each unit to ten or fewer words. Finally, students will be allowed plenty of practice with the words. This time will be intentional with some being teacher-guided in the beginning of the year. Later, student-led activities will be encouraged. In conclusion, some changes will be implemented in the way I instruct science vocabulary.

Limitations

In the future, it would help the research reliability to create a plan to explain open-ended questions to students. At times, students did not give an answer or asked what the question meant. With a plan, students will receive the same information, therefore making the questions more reliable.

Another limitation of this study is that it is possible students used their vocabulary flashcards to study at home. This may have helped some students pass the tests. Additionally, the vocabulary tests contained a varied number of total words. This may have affected the results of the tests. The results of my tests showed that more students passed the tests when there were ten words or less. Another limitation could be the words

themselves and how they were presented to the students. This may have been seen in the difference between the sound and light tests. The latter may have been easier to know the words and definitions from the research.

One more limitation could be using a different method of instruction and assessment. The instruction mostly consisted of hands-on, guided inquiry investigations and the assessment was traditional vocabulary tests on an iPad using Google Forms.

Future Research

Finally, when asked, "If I do this investigation to see how students learn vocabulary again, what might I do to make it easier for you to learn the vocabulary?" students overarching answer "more games, like Quizlet Live." Other answers included, "More activities to show us how to use the words," and "Doing the actions was helpful." With this in mind, following up with the students in fifth grade and checking to see if they recall the words from the three units would be another avenue to explore.

In summary, the methods of instruction that I will include in my teaching will be included in my future research. These include discovering if ten words or less in each unit helps students learn the words better, intentionally selecting vocabulary words with an academic and content list in mind, explicitly teaching academic words before the unit begins, and giving intentional guided practice and later student-led practice.

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APPENDIX A: Sound Vocabulary Test

Sound Vocabulary TEST

Your email address (**mulderj@discoverers.org**) will be recorded when you submit this form. Not **mulderj**? Sign out

* Required

1. **What is your first name?** *

_____

2. **the distance between a point on one wave and a similar point on the next** *

Mark only one oval.

- ◯ frequency
- ◯ wavelength
- ◯ pitch
- ◯ crest

3. **how high or low a sound is** *

Mark only one oval.

- ◯ pitch
- ◯ frequency
- ◯ vibration
- ◯ crest

4. **A measure of how strong, like loud or soft, a sound seems to us** *

Mark only one oval.

- ◯ pitch
- ◯ volume
- ◯ frequency
- ◯ height

5. **the height of a wave measured from its midline** *

Mark only one oval.

- ◯ pitch
- ◯ volume
- ◯ amplitude
- ◯ frequency

6. **quick back and forth movement that produces sound** *
Mark only one oval.

- frequency
- pitch
- volume
- vibration

7. **How often something vibrates per second; the number of waves past a point in a certain amount of time** *
Mark only one oval.

- frequency
- amplitude
- wavelength
- volume

8. **Energy in the form of vibrations passing through matter** *
Mark only one oval.

- sound
- vibrations
- space
- frequency

9. **Sounds travels fastest through this type of matter**
Mark only one oval.

- liquid
- gas
- solid
- space

10. **Sound waves cannot travel through this place** *
Mark only one oval.

- liquid
- gas
- solid
- space

11. **A wave that carries energy** *
Mark only one oval.

- hot flash
- energy wave
- rocket fuel
- crash wave

APPENDIX B: Light Vocabulary Test

Light Vocabulary Test

This is a pretest and is not graded. Just do your best.

* Required

1. **when light strikes a surface and bounces off** *
   Mark only one oval.
   - ◯ reflection
   - ◯ refraction
   - ◯ refrained
   - ◯ restrained

2. **Name** *
   _____

3. **The color of light results from mixing red and green light** *
   Mark only one oval.
   - ◯ turquoise
   - ◯ magenta
   - ◯ yellow
   - ◯ cyan

4. **color of light results from mixing blue and green light** *
   Mark only one oval.
   - ◯ turquoise
   - ◯ magenta
   - ◯ yellow
   - ◯ cyan

5. **color of light results from mixing red and blue light** *
   Mark only one oval.
   - ◯ turquoise
   - ◯ magenta
   - ◯ yellow
   - ◯ cyan

6. **Materials that let no light pass through are called:** *
Mark only one oval.

- reflective
- opaque
- transparent
- translucent

7. **Red, orange, yellow, green, blue, and _____ create white light** *
Mark only one oval.

- violin
- cyan
- magenta
- violet

8. **an object that separates white light into the colors that make it up is called a:** *
Mark only one oval.

- mirror
- prism
- rainbow
- unicorn

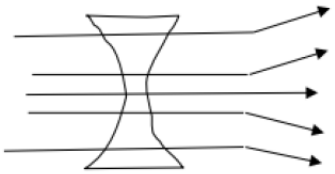
9. **materials that let some light pass through and you can see through them, but it's not completely clear are called:** *
Mark only one oval.

- translucent
- transparent
- reflective
- opaque

10. **the bending of light when it passes from one material into another.** *
Mark only one oval.

- reflection
- refraction
- refrained
- restrained

11. **What type of lens is this?** *



Mark only one oval.

- curved
- contorted
- concave
- convex

12. **Materials that let all light pass through and you can easily see through them are called:** *

Mark only one oval.

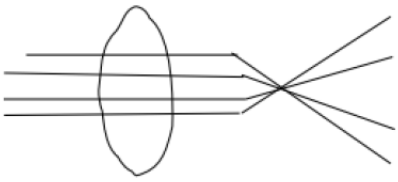
- opaque
- transparent
- translucent
- reflective

13. **a range of light waves with different wavelengths and energies is called:** *

Mark only one oval.

- rainbow
- visible spectrum
- shadow
- helix light

14. **What type of lens is this?** *



Mark only one oval.

- lemon
- contorted
- concave
- convex

APPENDIX C: The Birth of Rocks Vocabulary Test

The Birth of Rocks-Vocabulary Test

Your email address (**mulderj@discoverers.org**) will be recorded when you submit this form. Not **mulderj**? Sign out

* Required

1. **A person who studies fossils** *
   Mark only one oval.
   - ◯ Paleontologist
   - ◯ Geologist
   - ◯ Seismologist
   - ◯ Fossilogist

2. **Weathering is** *
   Mark only one oval.
   - ◯ what falls from the sky
   - ◯ what it looks like outside today
   - ◯ the breakdown and removal of rocks and soil by wind, water, ice, and gravity
   - ◯ the breakdown of rocks and soil by wind, water, ice, and gravity

3. **What time in our history is considered the Prehistoric times?** *
   Mark only one oval.
   - ◯ When my teacher was a child
   - ◯ When my great-grandparents were children
   - ◯ Before there were no written records of events, like births and deaths
   - ◯ Before computers were invented

4. **Lava is** *
   Mark only one oval.
   - ◯ molten rock inside the Earth
   - ◯ molten rock that has erupted from the volcano
   - ◯ black space rocks burned through Earth's atmosphere
   - ◯ a meteorite that has landed on Earth

5. **Erosion is** *
Mark only one oval.

- rocks and soil that stay in place with the use of any means necessary
- the removal of rocks and soil by wind, water, ice, and gravity after these are broken into smaller pieces
- wind, water, ice, and gravity rubbing on Earth and breaking the material into smaller pieces
- using cars in the Loop Canal to keep the soil in place

6. **A person who studies rocks and the earth's landscapes** *
Mark only one oval.

- Paleontologist
- Geologist
- Seismologist
- Rockyologist

7. **A person who studies earthquakes** *
Mark only one oval.

- Quakeologist
- Seismologist
- Paleontologist
- Geologist

8. **Magma is** *
Mark only one oval.

- molten rock inside the Earth
- molten rock that has erupted from the volcano
- black space rocks burned through Earth's atmosphere
- a meteorite that has landed on Earth

APPENDIX D: LIST OF STUDENT INTERVIEW QUESTIONS