IMPROVING VOCABULARY INSTRUCTION TO INCREASE STUDENT COMPREHENSION AND SCIENCE LITERACY

by

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A professional paper submitted in partial fulfillment of the requirements for the degree of Master of Science in Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2012
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Katherine Pearl Aune

July 2012
# TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND ................................................................. 1

CONCEPTUAL FRAMEWORK .............................................................................. 2

METHODOLOGY .................................................................................................. 8

DATA AND ANALYSIS ........................................................................................ 21

INTERPRETATION AND CONCLUSION ............................................................. 30

VALUE ................................................................................................................... 32

REFERENCES CITED .......................................................................................... 34

APPENDICES ........................................................................................................ 36

APPENDIX A: Vocabulary Terms and Word Parts Used in Treatment .......... 37
APPENDIX B: Science Vocabulary Questionnaire ........................................... 40
APPENDIX C: Unit Attitude Survey Example ................................................... 43
APPENDIX D: Formative Assessments .............................................................. 45
APPENDIX E: Formative Assessment Scoring Rubric ...................................... 47
APPENDIX E: Journal Prompts ......................................................................... 49
APPENDIX F: Science Literacy Rubric .............................................................. 51
APPENDIX G: Student Interview Questions ................................................... 53
APPENDIX H: Exemption for Implied Consent ................................................. 55
LIST OF TABLES

1. Treatment Unit Vocabulary Instruction Characteristics and Methods ................10

2. Data Triangulation Matrix ..................................................................................21
LIST OF FIGURES

1. Volcano Glossary Entry ........................................................................................................12
2. Possible Sentences Example ..............................................................................................13
3. Earth’s Surface Venn Diagram ..........................................................................................15
4. Surface Processes Unit Glossary Entry .............................................................................17
5. Semantic Feature Analysis Surface Processes Example ......................................................18
6. Surface Processes Synectic Comparisons Example ..........................................................18
7. Summative Assessment Scores Pre and Post Treatment ......................................................22
8. Formative Assessment Scores ..........................................................................................24
9. Unit Attitude Survey Comprehension Responses ............................................................25
10. Unit Attitude Survey Item One Responses .....................................................................26
11. Science Vocabulary Survey Science Literacy Items .........................................................27
13. Word Wall Picture ..........................................................................................................31
This project was designed to investigate whether spending more class time and instructor planning time on teaching vocabulary would lead to improvement of student learning, attitude toward scientific vocabulary, and science literacy skills. Throughout the treatment the students spent more time working with terms chosen for each unit. This included activities that encouraged analysis of word meaning and comparison and analysis of relationships between terms. Summative assessments showed improvement in student comprehension along with increased confidence in their ability to perform lesson objectives. Additionally, the attitude students had toward science vocabulary and science literacy skills were more positive. The students also improved in their writing skills and use of appropriate terminology when working in groups and on projects.
Science is loaded with vocabulary. Pick up any science text or listen to a lecture and the number of terms introduced and used to build conceptual understanding will far outnumber those in any other subject. Thus the importance of building a strong scientific vocabulary, which goes beyond introducing a list of terms and asking students to define those terms, is crucial in science education. I chose this topic of study because I felt my vocabulary instruction was inadequate. I did not see my students using the words they were taught to convey ideas. I wanted my vocabulary instruction to increase comprehension and improve science literacy.

I chose to conduct my study in a freshman Science One class. Science One is a survey course of Earth science, astronomy, chemistry and physics. Due to the breadth of material, the students are introduced to a large number of unfamiliar terms over a short period of time. This particular class had 18 students, 8 girls and 10 boys. They are a typical class with academic abilities ranging from high to low. They are cooperative and primarily receptive to new types of learning activities.

The study spanned several units including plate tectonics, earthquakes, volcanoes, landforms and surface water. The first two units were pre-treatment to gather baseline data. The remaining where treatment units and were used to collect data on the effectiveness of the treatment.

The students attend Frenchtown High School in Frenchtown, Montana. Frenchtown lies in the mountainous part of the state west of the Continental Divide and
the beautiful Clark Fork River runs along the edge of town. Frenchtown has 883 residents in the city limits and a large rural population in the surrounding area. It is a suburb of Missoula, Montana, which is a university town with a population of 71,390 (U.S. Census Bureau, 2002). The high school population hovers at around 400 students. The students are 90% white and a little over 30% of the students receive free or reduced lunch. The students value their “rural” lifestyle and many enjoy hunting and fishing. Most of the students are respectful toward adults and their peers. The school currently has a grant targeted at combating alcohol and drug abuse. The majority of the students value earning passing grades and the approval of parents and teachers. In 2011, 37% expected to go on to a four year university and 35% to a two year or technical college (V.Gibson, personal communication, 12/16/2011).

My capstone project targeted the effects of increasing the quality and quantity of vocabulary instruction on student comprehension and science literacy. Specifically, my focus questions were follows: How does improving vocabulary instruction and devoting more class time to vocabulary instruction affect student mastery of the learning objectives? and Will using methods that are considered best practice to teach science terms improve science literacy skills and student attitudes toward science literacy?

CONCEPTUAL FRAMEWORK

Vocabulary is defined by Armbruster and Osborn (2001) as “words we need to know to communicate effectively” (p. 38). Vocabulary can be split into two parts: oral, words used in speaking and listening, and reading, words understood when reading or
writing (Arbruster & Osborn, 2001). Graves (2003) classifies vocabulary into four parts: words understood when they are heard or “receptive-oral,” words that we can read or “receptive-written,” words we can use in our speech or “productive-oral,” and finally words we use when communicating with writing or “productive-written” (p.11). Students need a sufficient productive vocabulary to communicate scientific information with others adequately. This communication includes the ability to use proper scientific language to defend a scientific argument, write and read procedures and express concepts (National Science Education Standards, 1996).

Many studies have shown the connection between vocabulary knowledge and reading comprehension (Blachowicz, Fisher, & Ogle, 2006; Monroe & Orme, 2002; Nagy, 1988; National Reading Panel, 2006; Stahl & Fairbanks, 1986). In fact, insufficient vocabulary begins to impact reading comprehension starting in grade three when the complexity of terms found in reading material increases (Biemiller, 2003). Although reading can increase a student’s vocabulary, explicit instruction is required to improve contextual understanding (Armbruster & Osborn, 2001; Bromley, 2007). Glowacki, Lanucha, and Pietrus (2001) found that the combination of direct and indirect vocabulary instruction led to significant improvement in the students’ vocabulary knowledge and in turn reading comprehension.

The link between vocabulary and comprehension is especially evident in science class where many words required for understanding the text, relevant literature, classroom activities or teacher lecture are not encountered in everyday language. Additionally, science terms can have meanings that are different than the use of the word in everyday language (Rubley & Slough, 2010; Young, 2005). “The meanings are more
restrictive and carry the concepts represented in the text” (Rubley & Slough, p. 100). In fact, words used in science class often embody the concepts themselves. If understanding of these terms is lacking, students will not only have trouble with conceptual understanding but may fail to be engaged at all. Teaching vocabulary can create a link between the words used in science and the words used by the students. Additionally, vocabulary instruction can link science terms and concepts to background knowledge (Young, 2005). Word knowledge allows students to conceptualize what the text is describing, connect meaning between different sections of the text and determine relationships between what is being read and what the student already knows. Students with more vocabulary knowledge show higher comprehension of science texts (Cromley, Snyder-Hogan & Luciw-Dubas, 2010).

The relationship between knowledge of appropriate vocabulary and comprehension is clear considering the best indication of the difficulty of a text is the frequency of words that are not included in everyday language, and the best predictor of reading comprehension is the student’s vocabulary knowledge (Nagy, 1988). Thus, the overarching goal of science education, is to create scientifically literate students who can make informed decisions when the questions they are confronted with require scientific knowledge or ways of thinking requires some focus on building content specific vocabulary (National Science Education Standards, 1996). Young (2005) defines content literacy mastery as, ”being able to read, write, speak, listen, and communicate content knowledge with a high degree of competency and expertise” (p. 15). She explains that to achieve this literacy mastery students must first understand the terms and concepts associated with the content area.
Another relationship of importance is the connection between vocabulary and student achievement (Cromley, Snyder-Hogan & Luciw-Dubas, 2010; Stahl & Fairbanks, 1986). This achievement includes performance in science class and on tests such as the state standardized tests, SAT and ACT. The ability to use and understand the terms of science and how they are used to convey concepts allows students to perform scientific endeavors required to be successful in school and beyond. This success, along with the ability to understand the ideas behind the language of science, can be difficult if a student cannot read text in a fluent manner (Rubley & Slough, 2010). On the other hand, if a student’s ability to access the text is increased through vocabulary acquisition, the text will further develop their knowledge of the word meanings (Taylor, Mraz, Nichols, Rickelman & Wood, 2009) along with the concepts described by the text (Rubley & Slough).

A working knowledge of words and their usage is a standard by which a person’s intelligence and potential is measured, explaining its usage on college entrance exams (Goerss, Beck & Mckeown, 1999). McKeown, Beck, Omanson, and Pople (1985) found that “rich instruction” of vocabulary can lead to students responding more quickly to questions regarding word meaning or story recall (p. 533). It has been hypothesized that the poor performance on standardized science tests may be due to a failure on the part of educators to instruct students properly on what is required to understand science reading (Cromley, Snyder-Hogan & Luciw-Dubas, 2010). In part this failure is due to lack of attention to building scientific vocabulary and instead focusing on reading strategies (Fisher, Grant & Frey, 2009).
Teaching vocabulary in and of itself does not increase comprehension or achievement. Most studies that failed to show a link between vocabulary instruction and improvement of reading comprehension used teaching methods where students were provided limited exposure to the words and centered on the word-definition relationship (McKeown, Beck, Omanson, & Pople, 1985). Definitions do have an important place in word learning, but the inadequacies of using just the word-definition approach must be recognized and its use supplemented with more in depth engaging endeavors (Blachowicz, Fisher, & Ogle, 2006; Nagy, 1988).

The traditional definitional approach method of vocabulary instruction involves some variation of the teacher assigning words to be defined and the student looking up the meanings, writing them down and committing them to memory. This type of instruction often does not produce an increase in comprehension. One reason for this failure to increase comprehension comes from lack of teaching word meaning at the depth required for reading comprehension. The definition itself may be flawed in that it may contain words just as unfamiliar as the one being defined and usually will not provide the amount of information needed to use the word properly (Nagy, 1988). Additionally, this method of instruction fails to meet several of the requirements that define effective vocabulary teaching outlined by Blachowicz, Fisher, and Ogle (2006). These include students being involved in producing word meaning, integration of prior knowledge, providing contextual information, examination of how other words are similar and different and multiple exposures and opportunities to use the word. However, even with more exposure to the terms traditional vocabulary instruction fails to increase comprehension (McKeown, Beck, Omanson, & Pople, 1985).
Successful vocabulary instruction must include vocabulary instruction that not only builds knowledge of vocabulary terms, but also connects the meaning of these terms to the background knowledge of the learner (Allen, 1999; Rubley & Slough, 2010; Taylor, Mraz, Nichols, Rickelman & Wood, 2009). “Word study should be integrated with prior knowledge and with learning in the content areas in order to assist pupils in vocabulary development” (Glowacki, Lanucha, & Pietrus, 2001, p.35). Furthermore, students should be taught how to make connections between new word meanings and what they already know to create deep understanding of the vocabulary that can be applied in a variety of contexts (Taylor et al., 2009).

Although most texts supply a list of terms that are important to understanding the reading and subject matter, the teacher should personally select the words that are critical for the students to know in addition to or instead of the terms suggested. Further the teacher must decide what sorts of activities will best facilitate student learning of the terms selected. These might include pursuits such as structural analysis, graphic organizers, categorizing activities, literal-level vocabulary activities and application vocabulary activities (Misulis, 2011). Flanigan and Greenwood (2007) assign words to four levels depending on their importance in understanding the concept being taught. Level 1 are words that must be learned prior to reading or understanding the concept, Level 2 are words that only a minimal understanding is necessary prior to the learning task, Level 3 words can be taught or covered during or after reading content, and finally Level 4 words are words that do not need to be taught because students probably know the meanings, they are not pertinent to the objective at hand or the students will be able to figure out the meaning without direct instruction.
After deciding what words merit valuable instruction time, how they are taught should depend on the level of understanding required to meet learning objectives (Allen, 1997). Graves (2003) suggests the following guidelines for teaching individual words: include both definitional and contextual information, involve students in active and deep processing of the words, provide students with multiple exposures to the word, review, rehearse and remind the students about the word in various contexts over time, involve students in discussions of the words meaning, and spend a significant amount of time on the word. All vocabulary instruction must include integration, repetition and meaningful use (Nagy, 1988).

The importance of developing vocabulary to improve reading comprehension, student achievement and scientific literacy is clear. Also apparent is the need for vocabulary instruction to move beyond strictly definitional or context approaches which show limited or no gains in student understanding. Instruction must be tailored to the importance and familiarity of the word under consideration. Additionally, vocabulary lessons should be student centered, include multiple strategies to study the words, integrate and elicit prior knowledge and provide many opportunities to see and use the terms.

METHODOLOGY

Project Design

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained. The treatment for this study consisted of vocabulary instruction
considered best practice which was outlined in the literature review. The specific characteristics along with the teaching method used during each unit of the treatment are outlined in Table 1. In Table 1 and the methodology that follows I will only describe instruction that was explicitly designed for the study to teach vocabulary. Lectures, assignments, reading, labs and activities used in my other Science One classes, although they may have included use of and exposure to the targeted vocabulary, will not be described unless they were used to collect data for the study.
Table 1
*Treatment Unit Vocabulary Instruction Characteristics and Methods*

<table>
<thead>
<tr>
<th>Characteristic of Vocabulary Instruction</th>
<th>Volcanoes</th>
<th>Earth’s Surface-Land</th>
<th>Earth’s Surface-Water</th>
<th>Surface Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration of Prior Knowledge (Blacowitz, Fisher &amp; Ogle 2006)</td>
<td>List Group Label</td>
<td>Wordstorming</td>
<td>Wordstorming</td>
<td>Prediction exercise</td>
</tr>
<tr>
<td>Definitional Information (Blachowitz, Fisher, and Ogle, 2006; Nagy, 1988)</td>
<td>USGS Website Definitions Lecture</td>
<td>Context Relationship Procedure</td>
<td>Context Relationship Procedure</td>
<td>Context Relationship Procedure</td>
</tr>
<tr>
<td>Providing Contextual Information (Blacowitz, Fisher &amp; Ogle 2006)</td>
<td>Possible Sentences-textbook USGS site</td>
<td>Context Relationship Procedure</td>
<td>Possible Sentences- National Geographic</td>
<td>Context Relationship Procedure</td>
</tr>
<tr>
<td>Examination of How Other Words are Alike or Different (Blacowitz, Fisher &amp; Ogle 2006)</td>
<td>Semantic Feature Analysis Possible Sentences</td>
<td>Glossary Entries Venn Diagrams Possible Sentences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Exposure and Opportunities to Use the Word (Graves 2006)</td>
<td>Word Wall Possible Sentences</td>
<td>Word Wall Magic Square</td>
<td>Word Wall Magic Square</td>
<td></td>
</tr>
<tr>
<td>Active and Deep Processing of the Word (Graves 2006)</td>
<td>Semantic Feature Analysis</td>
<td>Semantic Feature Analysis</td>
<td></td>
<td>Semantic Feature Analysis cctic Comparisons</td>
</tr>
</tbody>
</table>
Pretreatment units focused on Plate Tectonics and Earthquakes. During these units vocabulary was only explicitly covered at the beginning of the unit with students looking up the definitions in the book and during the lecture on the topic. I collected data during these units for comparison to the data from the treatment units.

The units of study during the treatment included volcanoes, landforms, water, and surface processes. To begin each unit of the treatment I did an assessment of the chapter to determine which words should be taught to achieve the largest increase in comprehension rather than using the list of terms at the end of the chapter (Appendix A). After determining which words I was going to teach I designed the vocabulary enrichment activities described below for each unit.

The volcano unit began with an activity called *List, Group, Label* (Allan, 1999). Students are asked to list all the words that they can that relate to the topic at hand. Next they share their list with a partner and together they put the words into groups and finally give the groups they make a title. This encourages students to integrate their prior knowledge as well as discuss word meanings. I shared a couple good examples from the groups with the class. The next activity that they did was to produce glossary entries of a list of terms that were important to the chapter using the format shown in Figure 1 from a USGS site on volcanoes. The entries included the definition, a sketch that represents the term, and example and a non-example. This allowed the students to be involved in producing the word meanings and also making connections amongst the words.
The next vocabulary exercise from this unit was called *Possible Sentences* (Graves, 2006). Students were given a list of the terms from the unit representing some difficult concepts and a few more common terms such as ash and magma and asked to write three sentences that might be found in the text. This activity allows for a deeper understanding of the terms and how they are related, an example of this activity is shown in Figure 2. Each group was then asked to choose their best sentence and write it on the board. The class then read the section of the textbook on volcanoes and decided which sentences could have appeared in the reading.

*Figure 1. Volcano Glossary Entry.*
Students completed the semantic feature analysis activity shown in Figure 3 to compare the three types of volcanoes along with the features associated with volcanoes. Semantic feature analysis is done with grids that present students with a column of related words and a set of characteristics that the terms may or may not have in a row along the top. The students complete the grids—putting a plus sign if the feature is
present in or related to the term and a minus is the feature is absent or unrelated. This procedure requires that students analyze the words and the relationships among them.

The next unit in the treatment was focused on Earth’s landforms. The students were again asked to list the terms that they associate with the Earth’s surface in an activity called *Wordstorming* (Allen 1999). The students shared their lists with their partners and then we discussed them as a class. Next, the students used a technique for learning new words called the *Context-Relationship Procedure*, which I would use in all the remaining treatment units for the initial introduction to the words from the section (Appendix B). In this vocabulary teaching strategy a short selection is presented to the students in which the targeted term is used several times. Beneath the text are several possibilities for the definition students are asked to select the definition that represents meaning of the term (Graves, 2006). The students worked in groups to complete the activity and then as a class we checked the definitions that they had selected and discussed the meanings and misconceptions. The students then used these definitions and understandings to create glossary entries for the words in their notebooks.

Other vocabulary activities in this chapter included Venn diagrams where they compared the attributes of the different types of mountains, an example is shown in Figure 3 below.
Additionally, students completed Possible Sentences with a selection from the National Geographic website. Finally, students read about Montana’s mountain ranges and classified them based on descriptions of their formation using the terms from the chapter.

Much like the first two units of data collection, I chose to start the Earth’s water unit with wordstorming to elicit connections to prior knowledge. Next, after seeing good results from use in the previous unit, I used the Context Relationship Procedure to
introduce the terms I had selected for the unit. Again, the students were asked to make glossary entries and I had each group share one entry with the class and we discussed the meaning of the term.

The next vocabulary activity completed during this unit was a magic square (Appendix C). A magic square is created by listing the targeted terms with representative letters along with a numbered list of the definitions. The students then match the words with the correct definitions, placing the number of the definition in the box with the letter of the term. If the students are correct the rows and columns will all add up to the same number.

Also during this unit, I introduced a selection of ten prefixes, suffixes and root words that related to the terms or topics we were studying and asked the students to come up with examples of words that contained these word parts (Appendix A). This was an attempt to foster their ability to understand words from context as well as increase their awareness of using these word parts as tools for understanding word meanings. They were quizzed on the meanings of the word parts with the summative assessment at the end of the unit.

The final unit of the treatment period was focused on surface processes, specifically weathering, erosion and deposition on Earth’s surface. To begin the unit, I had the students look at a picture of a mountain and predict how it had changed over time by selecting one of four scenarios and then having them defend their choice (Appendix E). We then discussed their choices and any relevant terms that they used to defend their choices. Once again I used the Concept Relationship Procedure to introduce the selected...
terms and the students used the information to make glossary entries in their notebooks, an example of the entries is shown in Figure 4.

Figure 4. Surface Processes Unit Student Glossary Entry Example.

During this treatment unit a semantic feature analysis was completed a student example is shown below in Figure 5.
Additionally, the class completed another magic square activity and ten more word parts were introduced (Appendix F). The final activity, other than the vocabulary game to review, was called synectic comparisons (Appendix G). Students were given a term and asked to compare it to an unrelated object; they had four choices for the unrelated object. The idea behind this activity is that it forces them to analyze the meaning in order to come up with a good comparison, an example of a student comparison for this activity is shown in Figure 6.

<table>
<thead>
<tr>
<th>Chemical Weathering</th>
<th>Mechanical Weathering</th>
<th>Erosion</th>
<th>Deposition</th>
<th>Glaciers</th>
<th>Running Water</th>
<th>Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta</td>
<td></td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Drainage basin</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Floodplain</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tributary</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Meander</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>V-shaped valley</td>
<td></td>
<td></td>
<td>-</td>
<td></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Headwaters</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Cave</td>
<td></td>
<td></td>
<td>-</td>
<td></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>U-shaped valley</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Cirque</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 5.* Semantic Feature Analysis Surface Processes Student Example.

*Figure 6.* Surface Processes Synectic Comparisons Student Example.
During all treatment units a word wall was maintained at the front of the room. A word wall is a running list of all the terms that we encountered during the study of a specific topic. I attempted to refer to it often. Also, each unit ended with a review game focused on the terms to encourage students to enjoy studying words, their relationships and meanings.

Data Collection Methods

Many data sources were used to both collect baseline data and evaluate the effectiveness of the treatment (Table 2). Before and after the treatment, the students were given the Science Vocabulary Questionnaire to examine their perception of the importance of science literacy (Appendix B). The research questions related to the questionnaire were primarily measuring student attitude toward science literacy and confidence in science literacy skills. Three items on the survey related to the perceived importance of having a good knowledge of scientific vocabulary. Also related to science literacy, some questions on this survey asked about the skills students had to find the meaning of a word that they did not know. Additionally, at the end of each of the pre-treatment and post-treatment unit, the students were given the Unit Attitude Survey (Appendix C). This survey was based on the objectives for the unit and designed to gauge their confidence in their understanding of the material from the unit. The survey also had a question aimed at student confidence in using the terms from the unit. This item read “I can use science terms to talk about…” followed by the topic of the unit such as plate tectonics or volcanoes. Students were given formative assessments to measure comprehension and progress toward unit objectives (Appendix D). Teacher made tests were given at the end of the units to measure student comprehension.
Throughout the project the students and I maintained journals. The Student Journaling Prompts were designed to collect data on science literacy skills (Appendix E). These entries were graded using the Science Literacy Grading Rubric to look for improvements in science literacy and scored to look for comprehension (Appendices E and F). The observations made in the Teacher Journal, were also used to examine how I perceived the vocabulary instruction was impacting student attitudes toward science literacy as well as improvements in science literacy skills. I made notes on vocabulary words being used or discussed by the students while they were working. Finally, six randomly chosen students were interviewed pre and post treatment to gauge attitudes toward vocabulary and science literacy (Appendix G).

The data from each of my sources was analyzed for trends relating to each of my research questions. I used average scores from the summative unit tests and compared pre and post treatment results. The Unit Attitude Survey items were grouped based on what they were designed to measure; either confidence in their ability to perform the lesson objectives (comprehension) or the ability to use the terms to talk about the subject (science literacy). The responses to each item were tallied and the percentages of students responding to each of the possible choices were calculated. These percentages were compared pre and post treatment to look for trends. Formative assessments were scored and analyzed for comprehension as well. I scored each assessment on a scale of zero, not adequate to three, more than adequate, using the Formative Assessment Scoring Rubric (Appendix E). The Science Literacy Rubric allowed me to look for improvements in student writing after the treatment in the student journal entries (Appendix F).
Table 2
*Data Triangulation Matrix*

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Question:</strong> How does an approach to vocabulary instruction that is explicit, provides multiple exposures to the vocabulary terms, and is multifaceted affect student mastery of the learning objectives?</td>
<td>1 Formative assessments measuring progress toward learning objectives 2 Teacher made tests to measure comprehension-comparison of pre-treatment scores to post-treatment scores 3 Attitude scales to measure the student perception of their own understanding of the topic</td>
</tr>
<tr>
<td><strong>Secondary Questions:</strong> Does emphasis on vocabulary instruction affect student attitudes toward science literacy?</td>
<td>1 Science Vocabulary Questionnaire 2 Student Interviews 3 Teacher journals</td>
</tr>
<tr>
<td>Does targeted vocabulary instruction improve science literacy skills?</td>
<td>1 Student Journals 2 Teacher Journals 3 Formative Teacher Made Assessments</td>
</tr>
</tbody>
</table>

**DATA AND ANALYSIS**

The scores on the summative assessments improved in three of the four units of during treatment (Figure 7). The average score on the pretreatment plate tectonics test was 75% and the pretreatment earthquake test the average score was a 73% (N=18). This gave an average of 74% on the summative assessments in the pretreatment units. The average score on the treatment unit tests was 81%. The average score on the treatment
landforms unit test dipped slightly to 72%.

![Bar chart showing average grades for different units](chart.png)

*Figure 7. Summative assessment scores on pre and post-treatment units, \(N=18\).*

The scores on the formative assessments given during both pre and post treatment units fluctuated throughout the pre and post treatments (Figure 8). The percentage of students scoring adequate or more than adequate was 88% in the pretreatment plate tectonic unit and 50% in the pretreatment earthquake unit. This gives an average of 69% for both pretreatment units. The scores in the post treatment units included 94 % scoring adequate or more than adequate for the treatment volcano unit, 76% scored in this category for the second treatment unit on landforms, 59% scored adequate or more than adequate in the treatment water unit and finally 69% in the treatment surface processes unit received this score. The average percentage of students scoring adequate or more than adequate was 74.5% for the assessments given during the treatment unit.
Figure 8. Formative Assessment scores showing students receiving more than adequate or adequate score, \(N=18\).

The percentage of students responding \textit{very} or \textit{somewhat confident} to questions on the Unit Attitude Surveys related to ability to perform unit objectives rose from 80.5% during the pretreatment units to 92.25% during the treatment units. Additionally, students responding \textit{not at all confident} fell from an average of 19.5% to these questions during the initial units of study to 7.25% during the treatment period (Figure 9).
Figure 9. Unit Attitude Survey responses of not at all confident to items related to comprehension, (N=18).

The percentage of students responding very confident or somewhat confident to the Unit Attitude Survey question that inquired about student confidence in ability to use words from the unit was 100% in two of the four units during the treatment period (Figure 10). The 11% of students that responded not at all confident to these survey items in both pretreatment units and two of the treatment units were different in each time. The highest percentage of students answering very confident, at 50%, occurred in the water unit which was the third unit in the treatment survey. Also, the volcano unit had 39% of students giving this response which was the second highest of any unit. The final unit of data collection saw a drop in very confident responses to 22%. Despite the increase in student confidence in their ability to use the vocabulary, during the interviews students had a hard time remembering the last new word definition they learned on both
pre and post treatment interviews. In all cases, the students eventually came up with a term, and they were always science terms.

Figure 10. Unit Attitude Survey, very or somewhat confident Responses, (N=18).

When asked on the Science Vocabulary Questionnaire how they felt about the statement “Learning vocabulary is worthwhile” students choosing agree or tend to agree decreased by nine percent from the pre-treatment survey to the post-treatment responses. However, when the statement was changed to “It is important to build a scientific vocabulary” the percentage of students choosing agree or tend to agree increased by 5 with no students choosing tend to disagree or disagree. Also, students responding tend to disagree or disagree to the item “There are issues in the world and my community that requires scientific vocabulary to understand” decreased by ten percent. Student interviews echoed this trend. When asked if it is important to know the appropriate
vocabulary in a subject area all students responded positively in both pre and post treatment interviews. An example of a typical response was, “Yes a lot of science you have to know what words mean or you won’t know what the subject is about.”

Another theme from the Science Vocabulary Questionnaire related to student confidence in their science literacy (Figure 11). Confidence in their ability to use science terms to talk about topics rose from 63% pretreatment to 82% post treatment and students agreeing with their ability to use terms to defend an idea also rose 8 percent from 86% to 94%. Also, most students who were interviewed responded positively when asked whether they felt comfortable using science terms to talk to their classmates or teacher. One student response to this prompt pretreatment was, “I guess- I never really use them.” On the post treatment interviews this changed to, “Sometimes, if I really know the subjects and remember, if it was recent.” On the other hand their confidence in their ability to use the terms to summarize the main ideas from a unit fell from 87% to 75% according to the Questionnaire. Also on the Questionnaire, prior to the treatment period 59% chose agree or tend to agree with a statement I sometimes struggle with reading scientific information because of the terms, that percentage remained high post treatment at 51%. However, in the student interviews, only one student commented that science was the most difficult text to read. Students commonly commented that math was the most difficult text to read and understand. One student commented that, “Math explains stuff in numbers and stuff instead of words.”
The pretreatment survey revealed that only nine percent of students *often* used prefixes or suffixes to find the meaning of terms. This increased to 13% post treatment period along with an increase of 27% in students replying that they *sometimes* use this method to find word meanings. There was an increase in students responding that they *often* used context clues to find word meanings. The percentage of students that replied *rarely* and *never* responses to this statement increased after the treatment period (Figure 12).

*Figure 11.* Science Vocabulary Survey responses to items related to science literacy, *(N=18).*
Figure 12. Science Vocabulary Survey responses to survey item “I use context clues to figure out word meanings,” (N=18).

Another change in responses related to students finding the meaning of words they encounter that they do not know was on an item that inquired about their use of a dictionary or glossary. Initial responses to this statement included 82% of students choosing agree or tend to agree. This fell to only 32% on the post-treatment survey. Many of the students interviewed admitted that they do not think about the meaning of the words when they write them down from the glossary. Despite this admittance many cited this as their preferred method of learning new words.

The scores on the journal entries showed improvement from the pretreatment unit to the entries created during the treatment period. The average score on the journal entry made during the pretreatment plate tectonics unit was a 49% while the other two journal entries made during the treatment period resulted in class averages of 66% and 72%. The growth of one of the students is evident in the writing he did for these three journal entries. The first entry reads, “It is important to know the implications and processes of
plate tectonics because so that we know what is happening when we have an earthquake.
Also so we can better prepare for the damages that may occur. So that on the east coast
or in other countries they know the warning signs and can be prepared.” The final
journal entry was free from misconceptions and used much more appropriate vocabulary,
“Glaciers are an important part of the water cycle. They are fresh water reservoir and can
be alpine or continental. Glaciers are 70% of the fresh water content. They form when
snow buries snow and it moves under the force of gravity.”

Throughout my project I recorded personal observations of student progress in the
areas of comprehension and science literacy in a journal. In the beginning of the data
collection I noted a lack of use of relevant terms during group work discussions despite
the fact that the students had been introduced to the vocabulary. I also noted that when
students used terms during presentations on earthquakes they seemed unfamiliar with
them, like they were just reading them from the PowerPoint instead of using them to
explain a concept. As the treatment began I did not notice an improvement or increase in
the use of terminology immediately but by the end of the first unit I observed an ease or
comfort in the students while using terms while giving presentations on volcanoes. After
this I had several remarks indicating that the students were completing tasks that other
Science One classes had struggled with much more easily and with greater
understanding. One observation reads, “Students are asking good questions and putting
ideas together. I overheard a student ask another student ‘Are folded mountains
volcanic?’ and another ‘Do fault block mountains form from tension’ and ‘Are plateaus
created from upwarped mountains?’” I made a note that I was surprised that even after
using the context relationship procedure described in the methods sections students were
still confused by the definition of the scientific term reservoir versus the lay term. Another observation I made was that no one from this class was ineligible to participate in sports or school activities (had a D or F).

**INTERPRETATION AND CONCLUSION**

The research I have conducted provided some indication that increasing the opportunity for students to examine and compare vocabulary can increase their comprehension of the subject matter. This was evident with improved test scores and also an increase in student confidence in their abilities to perform unit objectives. The low average score on the summative assessment for the treatment unit on landforms was primarily due to the extremely low score of two students. Without these two students that average would have been 78%, which is higher than either of the pretreatment summative assessment averages. This increase in comprehension may stem from improvement in understanding word meanings which allowed them to get more from lectures, labs, and activities. Although the average score on the treatment units’ formative assessments were slightly higher the scores fluctuated throughout the duration of my research. I believe this was due to the variations in the difficulty of the assessments. Also, I am not sure why the final unit in the treatment period saw a decrease in students who were very confident in their ability to use the terms from the unit except maybe the increase in terms used when dealing with surface processes.

Adding all of the extra vocabulary work to the curriculum did put the treatment class behind by an entire unit so this would have to be taken into consideration and only
the most beneficial strategies employed. I would like to incorporate even more opportunities for the students to use the words in real speaking, reading and writing context.

Placing the students in an environment where vocabulary was emphasized lead to an improvement in student attitudes toward science literacy as evidenced by the Unit Attitude Surveys and the Science Vocabulary Questionnaire. Using a word wall along with vocabulary review games and other strategies seemed to make the terms more accessible to the students (Figure 13). Adding the introduction of prefixes and suffixes to the students increased their awareness of their use as a tool in finding word meaning. Student confidence in reading didn’t increase dramatically and I didn’t focus much attention on reading from science texts. I believe more work could be done in this area. I would also like to create more of a link between the words they use every day and the words used in science.

Figure 14. Word Wall.
I saw an improvement on student writing and projects during the treatment period. Students took more ownership over the terms as their confidence in their meanings and relationships improved. This allowed them to speak, write, and read more effectively about the topics that they were studying.

VALUE

My study of vocabulary and its importance for student comprehension has changed my teaching in several ways. First, I am now more aware of my assumptions of student understanding of terms. It wasn’t until I spent the time during my research studying vocabulary and how it impacts student learning that I realized how my science background had blinded me to the difficulties a student might have reading, writing and talking about science. Being aware of this I now spend more time on vocabulary and emphasize the importance of building and using appropriate vocabulary in class. Additionally, I search for rich contexts in which my students can use the terms. Gone are the days of long vocabulary lists and definitions copied from the text out of context.

Although I have improved on my vocabulary instruction my new focus is to increase student use of science words in real world applications. Having the students use the words in real conversations and original pieces of writing as well as read about them in contexts other than the textbook is very important. I believe this is the only way that these words will become a part of the student’s everyday vocabulary. This project brought me closer to achieving my goal of allowing my students to become informed scientifically literate decision makers it is my task to finish the job.
Finally, the project has made me aware of my need to reflect and evaluate my teaching practices as well as student learning. This awareness was brought about not only by studying and doing action research but by being surrounded by other professionals with a strong devotion to being reflective practitioners. I have other ideas that I would like to look into using action research including use of a class website to post assignments and discussions and more integration of Indian Education for All.
REFERENCES CITED


APPENDICES
APPENDIX A

VOCABULARY TERMS AND WORD PARTS USED IN TREATMENT
Volcano Unit

volcano         cinder cones
hot spot        magma
pyroclastic flow viscosity
lava            caldera
lahar           ash
pyroclastic material cinders
shield          blocks
composite

Earth’s Surface

fault block mountains fold
folded mountains fault
plains           tension
plateau          compression
upwarped mountains

Earth’s Water

reservoir        saturated zone
residence time   porosity
continental margin permeability
watershed        aquifer
water table

Surface Processes

weathering       erosion
floodplain       discharge
load  abrasion
mechanical weathering  mass movements
chemical weathering

**Prefixes, Suffixes and Root Words**

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>-able</td>
<td>-fer-</td>
</tr>
<tr>
<td>-aero</td>
<td>lith-</td>
</tr>
<tr>
<td>ambi</td>
<td>-logy</td>
</tr>
<tr>
<td>anti-</td>
<td>omni-</td>
</tr>
<tr>
<td>aqu-</td>
<td>paleo-</td>
</tr>
<tr>
<td>bath-</td>
<td>permea-</td>
</tr>
<tr>
<td>chlor-</td>
<td>por-</td>
</tr>
<tr>
<td>contra-</td>
<td>pter-</td>
</tr>
<tr>
<td>deca-</td>
<td>strat-</td>
</tr>
<tr>
<td>derm-</td>
<td>trans-</td>
</tr>
</tbody>
</table>
APPENDIX B

SCIENCE VOCABULARY QUESTIONNAIRE
Participation on this questionnaire is entirely optional and will not affect your grade.

Circle the answer that best describes your feeling toward the following statements. There is no right answer and your honest answers are the most useful.

1. It is important to build a scientific vocabulary.
   
   Agree    Tend to agree    Tend to disagree    Disagree

2. There are issues in the world and my community that require scientific vocabulary to understand.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

3. I can use the terms I learned in science to discuss current topics.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

4. I can use terms I learned in science to explain or defend an idea.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

5. I sometimes struggle with reading scientific information because of the terms.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

6. I use the dictionary or glossary to find the meaning of terms I don’t know.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

7. I can use terms from the unit to explain or summarize main ideas.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

8. Reading and writing the definition from the text is useful to me.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

9. Learning vocabulary is worthwhile.
   
   Agree    Tend to Agree    Tend to Disagree    Disagree

(These questions are a little different—they are asking how often you do the following things so pay attention to your answer!)

10. I use prefixes and suffixes to figure out word meanings.
    
    Often    Sometimes    Rarely    Never

11. I use root words to figure out word meanings.
    
    Often    Sometimes    Rarely    Never
12. I use context clues to figure out word meanings.

*Often  Sometimes  Rarely  Never*
APPENDIX C

UNIT ATTITUDE SURVEY EXAMPLE
Please carefully consider your ability to do the following tasks and then circle the appropriate choice below the statement. This will not be graded and your honest answers are what will be the most helpful.

1. I can use science terms to talk about plate tectonics.
   - very confident
   - somewhat confident
   - not at all confident

2. I describe the observations and evidence that led to the theory of plate tectonics.
   - very confident
   - somewhat confident
   - not at all confident

3. I can describe what causes plates to move.
   - very confident
   - somewhat confident
   - not at all confident

4. I can draw and label diagrams of the plate boundaries.
   - very confident
   - somewhat confident
   - not at all confident

5. I can list the features that form at the different plate boundaries.
   - very confident
   - somewhat confident
   - not at all confident
APPENDIX D

FORMATIVE ASSESSMENTS
List the pieces of evidence for plate tectonics.

What is the most interesting thing about earthquakes that you learned today?

List all the terms you know related to mountains, plains or plateaus.

Are most mountains formed at plate boundaries? Why or Why not? Give examples if you can.

List three ways that weathering, erosion, and deposition change Earth’s surface.
APPENDIX E

FORMATIVE ASSESSMENT SCORING RUBRIC
<table>
<thead>
<tr>
<th>Score</th>
<th>Numerical Value</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not adequate</td>
<td>Response contains some misconceptions or incomplete understandings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Few or no appropriate terms are used</td>
</tr>
<tr>
<td>1</td>
<td>Somewhat adequate</td>
<td>No misconceptions are present but the response does not point to a clear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>understanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some appropriate terms are used</td>
</tr>
<tr>
<td>2</td>
<td>Adequate</td>
<td>Student clearly understands the concept and uses many appropriate terms</td>
</tr>
<tr>
<td>3</td>
<td>More than adequate</td>
<td>Response shows advanced understanding of concepts and all necessary terms are used</td>
</tr>
</tbody>
</table>
APPENDIX F

JOURNAL PROMPTS
Why is it beneficial for society to know the processes and implications for plate tectonics?

A town that is home to a population of largely uneducated in the ways of science has been devastated by an earthquake. You have been asked to come to a town hall meeting to explain to them why and how earthquakes happen. What would you tell them?

Choose one reservoir in the water cycle and describe it.

You are hiking and come to the valley pictured above. Looking at this landscape you attempt to describe in detail what surface processes (weathering, erosion and deposition) have created the features to your companion. Detail what you would tell your friend and use evidence from the picture to support your claim.
APPENDIX F

SCIENCE LITERACY RUBRIC
## Science Literacy Rubric

<table>
<thead>
<tr>
<th>Skill</th>
<th>Behavior Absent</th>
<th>Behavior Emerging</th>
<th>Behavior Developing</th>
<th>Behavior Present</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use of Vocabulary Terms</strong></td>
<td>No Relevant terms are used or terms are used incorrectly</td>
<td>Some terms are used but many key terms are missing.</td>
<td>Many terms are used and they are used correctly.</td>
<td>All necessary terms are used and their use indicates a clear understanding.</td>
<td></td>
</tr>
<tr>
<td><strong>Misconceptions or Incomplete Understanding</strong></td>
<td>There are many misconceptions or incomplete understandings in the writing.</td>
<td>One or Two misconception of incomplete understandings.</td>
<td>No misconceptions are present but some of the writing points to incomplete understanding</td>
<td>The writing or project is free from misconceptions or incomplete understandings.</td>
<td></td>
</tr>
<tr>
<td><strong>Reading Procedures</strong></td>
<td>The procedure were clearly not followed or understood.</td>
<td>Some of the procedures were not followed or understood.</td>
<td>A mistake was made in following or understanding procedures.</td>
<td>Procedures were read and understood perfectly.</td>
<td></td>
</tr>
<tr>
<td><strong>Writing Procedures</strong></td>
<td>Procedures were poorly written.</td>
<td>Procedures are somewhat inaccurate or vague.</td>
<td>Procedure is written clearly enough to be reproducible.</td>
<td>Procedures are written clearly and contain scientific terminology.</td>
<td></td>
</tr>
<tr>
<td><strong>Concepts Expression</strong></td>
<td>No real understandings of the concepts are expressed.</td>
<td>Concepts are expressed with some accuracy.</td>
<td>Concepts are expressed fairly well.</td>
<td>Concepts are expressed clearly and indicate knowledge on the subject.</td>
<td></td>
</tr>
<tr>
<td><strong>Defend Scientific Argument</strong></td>
<td>Does not use facts to defend argument.</td>
<td>Some facts are used but the argument is largely based on opinion.</td>
<td>Student uses many valid facts but has trouble drawing conclusions from them.</td>
<td>Argument is well defended with ample scientific evidence.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX G

STUDENT INTERVIEW QUESTIONS
STUDENT INTERVIEW QUESTIONS

1. What was the last new word definition that you learned?
2. What school subject do you find the text book to be the most difficult to read and understand? Why?
3. Can you give me an example of a prefix or suffix in a word that helps you remember the meaning?
4. How do you study or memorize definitions if you have a test or quiz?
5. When you write the definitions from the book do you think about the meanings while you write them down?
6. Do you use your definitions list in your notebook to study for tests or quizzes?
7. Do you feel comfortable using science terms when talking to your classmates or teacher?
8. Is there any method of learning vocabulary that a teacher uses that works really well?
9. What do you do if you encounter a word in your science text that you don’t understand?
10. Do you feel that you can learn the meaning of science terms using context alone? For example using the following sentences could you come up with a definition for compounds? Tap water is a mixture containing mostly water but also many other compounds. Depending on your location, your water may contain compounds of calcium, magnesium, chlorine, fluorine, iron and potassium.
11. Is it important to know the appropriate vocabulary in a subject area? Why or Why not?
12. What does it mean to be scientifically literate?
13. Is there anything else you would like me to know?
APPENDIX H

EXEMPTION FOR IMPLIED CONSENT
Exemption Regarding Informed Consent

I, Rory Weishaar, Principal of Frenchtown High School, verify that the classroom research conducted by Katherine Aune is in accordance with established or commonly accepted educational settings involving normal educational practices. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Katherine Aune regarding informed consent.

(Signed Name)

(Rory A. Weishaar)

(Printed Name)

11-18-11

(Date)