Advances in Social Sciences Research Journal – Vol.1, No.3
Publication Date: May 15, 2014
DOI: 10.14738/assrj.13.121
Brown, P. L., & Concannon, J. P. (2014). Investigating student perceptions of vocabulary and learning in middle school science. *Advances in Social Sciences Research Journal, 1*(3), 196-206

Investigating Student Perceptions of Vocabulary and Learning in Middle School Science

Patrick L. Brown
Ft. Zumwalt School District, St. Louis, Missouri

James P. Concannon
Assistant Professor of Education, Westminster College, Fulton, Missouri

ABSTRACT
Science courses are all too often taught as a litany of facts leading many students to focus on rote memorization of terminologies instead of developing deep conceptual understanding (Groves, 1995). The frequent use of a textbook can contribute to the problem. The purpose of this teacher classroom research study was to investigate the vocabulary demands and students' perceptions of instructional strategies in an 8th grade physical science class. The findings indicate that 21 formal science vocabulary terms were presented for 17 relevant pages of the textbook. Students' perceived "expanding vocabulary" and discussing examples of items as the most helpful instructional strategies for developing understanding. Students believed the pre-test of vocabulary content and reading and discussing vocabulary passages from the textbook at the onset of instruction were the least helpful instructional strategies. The results of this study provide a better understanding of the types of instructional strategies that students' believe encourage vocabulary learning.

Key Words: Vocabulary Teaching, Action Research, Middle School Science

INTRODUCTION

Learning vocabulary is an instructional goal in all content areas in middle school (Harmon, Wood, & Kiser, 2009). Academic vocabulary, in science, is essential to discipline- specific learning (Fisher & Blachowicz, 2013). Vocabulary instruction is a building process where students make connections between new words and old terms, firsthand experiences, and the context of the subject they are studying (Snow, Griffin, & Burns, 2005). Vocabulary instruction in science education is important for students' success in the course, future courses, and overall science literacy. In the USA, new standards called the Common Core State Standards (CCSS) include a focus on language and vocabulary focus in science education and technical subjects throughout K-12 education (National Governors Association Center for Best Practices [NGA] & Council of Chief State School Officers [CCSSO], 2010). The CCSS emphasizes that students learn both domain-specific terminology and general academic words that can be applied across content areas. In addition, In the USA the Next Generation Science Standards (NGSS), include a language and vocabulary focus so students can successfully contribute to science dialogue involving disciplinary core content in meaningful ways using domain-specific terminologies and essential science practice skills (National Research Council [NRC], 2011). However, in science education, vocabulary teaching and learning can be difficult due to the overabundance content-specific terminologies (Groves, 1995; Harmon & Hedrick, 2005). The purpose of this study is to investigate content-specific vocabulary teaching and learning in a middle school science classroom.

LITERATURE REVIEW

The ultimate goal of science education is that students gain a deep understanding and knowledge so that they are scientifically literature. However, science courses are all too often taught as a litany of facts leading many students to focus on rote memorization of terminologies instead of developing deep conceptual understanding (Groves, 1995). For example, in a study of the vocabulary demands of secondary science textbooks, Yager (1983) found the number of new terms was higher than recommended for high school foreign language classes. Groves (1995) built on Yeager's work and preformed an analysis of secondary textbooks. His findings reiterate Yeager's work and found a heavy emphasis on formal science terminology. Groves argued that in order to learn formal science terminology, many students resort to rote memorization instead of developing deep conceptual understanding. A number of studies show that vocabulary is challenging for students learning science.

Science teachers, particularly in upper elementary, often do not consider the vocabulary demands students face in science (Rupley & Slough, 2010). However, vocabulary comprehension is vital for literate discourse and aids in performance of science activities (Moje, Collazo, Carrillo, & Marx, 2001). The underpinnings of vocabulary mastery and literate discourse are students' cognitive development and the frequency of opportunities to learn vocabulary in multiple contexts. In effect, these underpins support the student's vocabulary comprehension and how precise he or she understanding vocabulary (Rupley & Slough, 2010). Therefore, it is essential for students to learn and use an array of vocabulary. The depth of a student's vocabulary has direct implications for academic progress; despairingly, a minimal amount time out of the school day is actually spent learning new vocabulary (Scott, Jamieson-Noel, & Asselin, 2003; Gregg & Sekers, 2006). It is paramount for teachers, teacher educators, and researchers to consider the best means to introduce and teach vocabulary to students (Baumann & Kame'enui, 1991; Beck and McKeown, 1991; Gregg & Sekeres, 2006; Nagy & Scott, 2000).

Gregg and Sekeres (2006) examined inner-city third graders' vocabulary acquisition from a geography unit. The unit focused on the weathering and erosion of mountains through mechanical action, and likewise rounding and fracturing of stone into sediment. In the unit, the teacher provided several hands-on, engaging activities which provided a context for students to discuss. The teacher brought in rounded stones, jagged stones, gravel, and sediment. During their discussion, students were sorting, and learning targeted vocabulary words in the correct context. "In these discussions, they grappled with the vocabulary that allowed them to share their own observations of and ideas about the stones and how they got the way there were" (p. 54). When the teacher could not bring in the materials, she brought in pictures. For example, the teacher brought in pictures of the upper, middle, and lower reaches and had students sort them into categories. In this process, students were engaged while acquiring and using targeted vocabulary. The context, in this study, proved to be the key when it comes to young students acquiring new vocabulary. Conversely, other studies have shown that having students memorize vocabulary words is ineffective (Anderson & Nagy, 1991; McKeown, 1993).

Yates, Cuthrell, and Rose (2011) examined the use of word walls at the middle school level with 524 students in Southeast United States. Word wall, as described by Yates et al., "are collections of words that are developmentally appropriate… and words selected for specific instructional purposes" (p. 31). Students use the word walls when "analyzing unknown words, to spell unfamiliar words, or defining new vocabulary" (p. 31). In this study, there consisted one large word wall in the hallway spanning multiple content areas; science being one area. The content areas were colored coded. The science words consisted of terms such as exposure, chemical, and toxicology. The color coded words in the hall were duplicated in the respective content classrooms. For example, the science words in the hall were duplicated in the science classroom. The word walls were "cumulative" and provided a "conversational scaffold" (p. 31).

After the year the word walls were created in the hall and classroom, there was a significant increase in the percentage of eighth grade students scoring at the proficient level in science. It is likely the success of the word wall was attributed to the high frequency students were exposed to new terms, and by how teachers in the study referred to these words. This resulted in, as reported by the teachers in the study, an increased frequency of the words in discourse.

Although studies seem to indicate that vocabulary can be overwhelming for students, in a review of the literature, Harmon and Hedrick (2005) identified instructional strategies that help students learn science vocabulary. They reported that pre-reading strategies, engaging students in active learning and using discussions are beneficial for helping students learn science vocabulary. In fact, a number of authors (e.g., Blachowicz & Fisher, 2011; Gilles et al., 1988; Seaver, 1991; Stahl & Kapinus, 1991) provide research-based instructional practices for teaching vocabulary in science classes. However, no study identifies students' views of the effectiveness of different instructional strategies on their learning and their perceptions of science terminology in a middle school science classroom. To address these gaps in the literature, this study focuses on three important components of learning science terminology-students' perceptions of vocabulary, students' perceptions of instructional strategies used to learn vocabulary, and students' content knowledge gains

Research Questions

This study focuses on three broad research questions with sub-questions all aimed at specific science content-- "properties of light:"

- What are students' perceptions of specific science vocabulary? Are there statistically significant differences in students' pre and post conceptions of specific science vocabulary? Are there statistically significant differences in females' versus males' perceptions of specific science vocabulary?
- What are students' perceptions of instructional strategies designed to learn formal science vocabulary? Are there statistically significant differences in females' versus males' perceptions of instructional strategies designed to learn formal science vocabulary?
- Does vocabulary specific instruction result in content knowledge gains?

METHODS

The participants included students (n=35-38) enrolled in 2 different 8th grade physical science at a middle school that is part of a large school district in the central United States. In the middle school curriculum, students take Earth and Space Science in 6th grade, Life Science in 7th Grade, and Physical Science in 8th Grade. At the time of the study, students had learned about scientific inquiry, energy and energy transformations, forces of motion, and the electromagnetic spectrum. The content, "properties of light," builds on the unit regarding the electromagnetic spectrum and was taught 3 weeks into the second semester. "Properties of light" is emphasized in the district curriculum based on state (Department of Elementary and Secondary Education [DESE], 2008) and National Science Education Standards (National Research Council [NRC], 1996). Multiple instructional strategies were used to help students learn the intended content. These strategies and the order they were used during instruction are summarized in Table 1 on the next page.

Table 1. Instructional strategies used to teach properties of light.

Instructional Strategy	Description
Pretest	Questions probing students' perception of knowledge of formal science vocabulary used in "properties of light chapter."
Textbook read out loud	Teacher read introduction paragraphs from chapter to students that included "formal science terminology" for the section. Students used context clues to describe formal science terminology.
Demonstration	Demonstration and discussion to illustrate formal science terminology (see Author).
Expanding Vocabulary Activity	Students used textbooks to: (1) define "formal science terminology" in their own words, (2) provide 3 examples of each term, and (3) make a connection between each term and their everyday lives.
Whole class discussion	Students identify materials and properties of different items in the classroom that illustrate "formal science terminology."
Read and Review	Students identify main point for each sub-section of the textbook reading
Guided Reading and Study	Textbook worksheet
Posttest	Questions probing (1) students' perception of knowledge of formal science vocabulary, (2) students' perceptions of activities used to learn formal science terminology, (3) students' abilities to correctly identified formal terminology when provided with a description of the new term.
Delayed Posttest (2 weeks after unit)	Questions probing (1) students' perception of knowledge of formal science vocabulary, (2) students' perceptions of activities used to learn formal science terminology

Students participated in a pre, post, and delayed posttest over multiple days that occurred during instruction; thus, the number of participants in the study fluctuated if students missed a portion of, or entire, class session. Pre, post, and delayed posttests about students' perceptions of knowledge, learning, and content were embedded in the lessons and seamless from normal instruction that had been used with students frequently during the course and prior to the study. The questions on the pre, post, and delayed posttests promote metacognition meaning that they prompted students thinking about what they already know, what they will learn, and what they have learned. In this regard, the questions have an educational value and could contribute to students' developing understanding. Because all data collection strategies are considered typical instructional approaches used in the course aimed at enhancing understanding, all students participated; however, students could choose to skip or not answer any item. To maintain student confidentially and protect student identity, any identifiers were removed prior to analysis. In addition, all results of the questionnaires about students' perceptions and content achievement tests were analyzed and reported in aggregate form. Descriptive statistics were used to indicate the percentage and number of responses. Inferential statistics were used to determine whether differences in perceptions and knowledge (from pre to posttest) were statistically significant.

FINDINGS

In this section, findings are presented for research questions pertaining to: (1) students perceptions' of vocabulary learning; and (2) students' perceptions of activities used to learn vocabulary, and (3) content knowledge gains.

Students Perceptions of Vocabulary Learning

Students were asked about their beliefs about learning terminology, whether they believed they will know terminology outside of class and after the test, and if they use terminology in their everyday life with their family and friends. As shown in Table 2 below, there were not considerable differences between many of student's pre and posttest views. On both the pre and posttest, more than half of the students agreed that learning terminology was interesting (59% and 61%, respectively). In addition, on both the pre and posttest tests, after learning new terminology, most students thought they would know the terms outside of class (81% and 83%, respectively) and after the test (67% and 77%, respectively). On both the pre and posttests, few students thought they would use terminology in their everyday lives (88% and 77%, respectively).

The instruction was effective at increasing students, particularly females', perceptions of their understanding the terms. Using an analysis of variance (ANOVA), a statistically significant difference was found among pretest survey questions between males and females. Prior to instruction, males were significantly more confident than females that they could remember the meanings of the terminology after the final lesson [$F(1, 32) = 4.58$, $p<.05$]. This difference between males and females was not present in the posttest [$F(1, 32) = 1.11$, $p>.05$]. After instruction, females were as confident as males in remembering the terminology after taking the test.

The students' responses on the delayed posttest indicate considerable shifts for two different categories. First, 84% of students believed "learning terminology was interesting" on the delayed posttest compared to only 59% on the pretest and 61% on the posttest. Second, 79% of students believed they would use terms in everyday life compared to only 12% on the pretest and 23% on the posttest. Finally, one-third of the students reported having shared terminology with either a family member of friend on the delayed posttest.

Table 2. Students' pre, post, and delayed-posttest perceptions and knowledge of formal science terminology used in science

	Pretest		Posttest		Delayed Posttest	
	Disagree	Agree	Disagree	Agree	Disagree	Agree
Terminology is interesting	41%	59%	39%	61%	16%	84%
Know "words" outside class	19%	81%	17%	83%	16%	84%
Know "words" after test	33%	67%	23%	77%	20%	80%
Use "words" in everyday life	88%	12%	77%	23%	21%	79%
Shared "words" with family /friends	X[1]	X	X	X	67%	33%

Note. Question not present on test

Students' Perceptions of Instructional Strategies used to Promote Vocabulary Learning

Students' perceptions of vocabulary activities were divided between 2 different categories of instructional strategies: written and discussion. As shown in table 3, of the written instructional strategies, students believed that the most helpful for their learning was the expanding vocabulary activities (43%), followed by the book worksheet (30%). Students thought that the pretest and essential questions were least helpful (11% and 16%, respectively) for their learning.

There was no statistically significant difference between the number of males and females who preferred various writing activities (X_2=4.83, $p>.05$); however, more females than males thought completing a science pretest was useful for learning new science vocabulary.

Table 3. Students' perceptions of written instructional strategies helpful for their learning of new science vocabulary (N=37)

Written instructional strategies	Perceived helpfulness for learning
Pretest	11%
Expanding vocabulary	43%
Essential questions	16%
Book Worksheet	30%

Table 4 below reports students' perceptions of the discussion strategies believed to be helpful for their vocabulary learning. Of the three different types of discussions, more than half of the students (58%) thought discussing objects that illustrated the properties of light (e.g., window glass is transparent, solid blue coffee mug is opaque, etc…) in class was most helpful for their vocabulary learning. Approximately one-third (32%) believed discussing the demonstration was helpful. Only 10% of students found reading the textbook passage and describing terms based on context clues to be the most helpful discussion activity for learning new vocabulary.

There was no statistically significant difference between the number of males and females who preferred various discussion activities (X_2=.43, p>.05). The majority of both males and females preferred discussing examples of new terms over the other discussion strategies implemented; however, more females than males believed whole class discussions were helpful in learning new terms.

Table 4. Students' perception of discussion strategies helpful for learning of new science vocabulary

Discussion Activities	Perceived helpfulness for learning (N=38)
Textbook Passage	10%
Examples	58%
Demonstrations	32%

Perceptions of Content Knowledge

Most students believed they either "understood" or thought they "understood and could explain" the following terms: "reflected" (94%), "absorbed" (100%), "transparent" (80%), and "refracted" (76%). Most students believed they did not understand the terms "translucent" (83%) and "opaque" (94%) (See Table 5 below). Students' perceptions of their vocabulary knowledge were also assessed after instruction. Most students believed they knew a definition (92%-100%) and could provide an example (92-97%) for the following terms: "opaque," "translucent," "transparent," and "reflection." In the posttest, students were less confident in their knowledge of "absorption" (14% believed they did not know a definition and 16% believed they could not give an example of "absorption").

Statistically significant differences were found when comparing means from pretest to posttest using paired sample t-tests of students' perceptions of understanding. There was a statistically significant increase in students' perceptions of understanding the terms "opaque" [t(32) = 10.00, p<.001] and "translucent" [t(32) = 9.26, p<.001]. On the other hand, there was a statistically significant decrease in students' perceptions of understanding "absorption" [t(32) = 3.97, p<.001] and "transparency" [t(32) = 9.29, p<.001]. In other words, students' perceptions of their knowledge of the terms "opaque" and "translucent" increased and students' perceptions of their knowledge of the terms "absorption" and "transparency" decreased from pretest to posttest.

Table 5. *Students' preconceptions of vocabulary content*

	Pretest				Posttest				
	"Do not understand"[1]	"Understand"[2]	"Can explain"[3]	N=	"Know"[4]	"Do Not Know"[5]	"Give Examples"[6]	"Cannot Give Examples"[7]	N
Reflection	6%	68%	26%	35	95%	5%	97%	3%	37
Absorption	0%	43%	57%	35	86%	14%	84%	16%	37
Translucent	83%	14%	3%	35	95%	5%	92%	8%	37
Transparent	20%	46%	34%	35	100%	0%	97%	3%	37
Opaque	94%	0%	6%	35	92%	8%	95%	5%	38
Refraction	24%	62%	14%	37	38%	62%	32%	68%	37

1. Note. I do not understand the term
2. Note. I understand the term
3. Note. I understand the term an could explain the term to someone using my own words
4. Note. "Know" =I know one or more definitions for the term.
5. Note. "Do not Know" =I do not know the definition for the term
6. Note. "Give Examples" =I can provide an example of the term.
7. Note. "Cannot Give Examples" =I cannot provide an example of the term.

Most students (62%) did not believe they knew the definition or could provide an example (68%) of "refraction" after instruction (versus only 24% not understanding the term "refraction" before instruction). There was a statistically significant negative correlation of students' perceptions of understanding "refraction" ($r_{(p)} = -.45$, $p<.01$). Thus, students who were confident that they understood the word "refraction" were significantly less confident in the posttest.

Content Achievement

The results of the content achievement test were mixed. Most students held accurate knowledge of the term "translucent" (95%). However, approximately three-fourths of the students answered the question concerning "opaque" materials correctly and only 69% of the students answered the question on "reflection" correctly. Students' knowledge of "refraction" was related to the question. For example, more students (84%) knew that "refraction" is a property used to explain that light changes speed as it enters new mediums than knew that a property that explains that light changes direction when it enters a new medium (only 69%).

DISCUSSION

The purpose of this study was to investigate students' perceptions of vocabulary and learning. Research identifies best practices for teaching science vocabulary (Harmon & Hedrick, 2005). This study is the first to begin to identify the types of discussion and written instructional strategies that students' perceived as helpful for their vocabulary learning. One important finding is students' perceived "expanding vocabulary" and "discussing objects" in class as the most helpful instructional strategies in their vocabulary learning. Students believed the pretest of vocabulary content and reading and discussing vocabulary passages from the textbook at the onset of instruction were the least helpful instructional strategies for developing understanding.

Another significant finding is related to the analysis of student's perceptions of knowledge of specific terms before and after instruction. In many ways the vocabulary instruction had a positive influence on students' knowledge. First, for some terms (e.g., "opaque," "translucent," "transparency," and "absorption"), instruction had an impact on their developing understanding. In other words, after instruction students were more confident that they knew the terms "opaque," "translucent," "transparency," and "absorption." Secondly, for the term, students realized that in spite of instruction they still were not confident in their knowledge of the meaning or examples of this word. For the term "refraction," students recognized that in the context of studying the properties of light the meaning of this word is more difficult to explain or give an example of than they first thought. The gender analysis indicated that female students gain more confidence in their knowledge of terminology than males as a result of the vocabulary instruction used in this study.

This study also found a mismatch between students' perceptions of their knowledge of the some terms and their content knowledge gains. While many students believed they did not know (62%) or could provide an example (68%) for the term refraction, 84% correctly answered the question about refraction explaining the property of light changing speeds when it enters a new medium and 69% correctly identified refraction as a property of light bending when it enters a new medium. Similarly students were over confident in their knowledge of the term opaque. While most students thought they knew the term (92%) and could give an explanation (95%), only 75% correctly answered the question concerning opaque materials correctly. Thus, students' perceptions of knowledge did not truly reflective their actual content knowledge gains. As a result, these findings present a number of implications for research and teaching.

IMPLICATIONS AND CONCLUSIONS

The findings of this study indicate that science teachers must acknowledge student's learning preferences and plan so that students have a variety of experiences learning content. By incorporating multiple vocabulary strategies, teachers can better accommodate students' diverse learning preferences and needs. In addition, making student's learning preferences explicit has the added benefit of promoting more self-sufficient learning. For example, if a student knows the strategies that help them understand science terms and concepts, they can use approaches to develop deeper conceptual knowledge when they encounter new and different topics. In addition, both teachers and students benefit from knowing the terms and concepts that students still have difficulty understanding after instruction. Teachers must implement a variety of strategies with their learners and use frequent formative feedback to identify approaches that are beneficial for the class as well as individual students.

The findings also present implications of school administration and the development of cross-curricular pedagogical strategies. In the USA the CCSS place high standards for what students should know, learn, and be able to do as a result of reading and vocabulary instruction. Viewing reading and vocabulary instruction as a shared responsibility across academic disciplines (English Language Arts, Social Studies, Mathematics, and Science) could better help students transfer vocabulary strategies across content areas. Both students and teachers benefit from having vocabulary strategies that help students use domain-specific and general academic terminologies in meaningful and purposeful ways. School administration can support cross-curricular vocabulary strategies by explicitly outlining reading and vocabulary objectives in policy documents, providing time for professional development and common lesson planning, and helping teachers set vocabulary teaching and learning goals in their professional teaching growth and development plans.

The findings of this study present implications for future research. This study investigated a specific science topic (properties of light) over a short amount of time (2 days, with the delayed posttest occurring 2 weeks after instruction). More research is needed that investigates the vocabulary strategies in this study, and others, for a range of science topics over time. Investigating a range of vocabulary strategies over time would provide a more clear understanding of the types of strategies that students believe consistently help them develop knowledge. In addition, qualitative research that uses interview techniques may provide researchers with a more nuanced understanding of the factors that facilitate and constrain student vocabulary learning. Studies are needed that examine the interrelationships among students' perception of knowledge, students' beliefs about vocabulary strategies used to learn, and students content knowledge gains. These studies could better clarify the relationship between students' perceptions of their understanding, the ways that students' best learn vocabulary, and content knowledge gains. Finally, research is needed that investigates students' content knowledge gains in a range of applications. In this study, the content knowledge test focused on students' ability to define science terminology. More authentic content knowledge assessments that require students to justify their thinking and explain how vocabulary strategies helped them develop ideas would begin to explore the relationship between content knowledge gains and learning from vocabulary strategies.

In conclusion, researching students' perceptions and vocabulary learning has the potential to inform the design of middle school science curriculum and activities. This research contributes to the existing body of literature by being the first study to document the types of vocabulary instruction that students believe are helpful for their learning. The results of this study provide a better understanding of the types of instructional strategies that students' believe encourage vocabulary learning. To provide quality science learning, classroom teachers must understand the vocabulary demands placed on students and students' beliefs about teaching and learning that are important for their development of knowledge. Teacher-researchers play a powerful role in educational reform and can promote effective learning environments by using empirical support for best teaching and learning practices.

References:

Anderson, R.C., & Nagy, W.E. (1996/1991). Word Meanings. In *Handbook of Reading Research*, *Vol. II*, ed. By Flood, J., Lapp, D., Squire, J.R. & Jensen, J.M. pp. 690-709. Mahwah, NJ: Erlbaum Associates.

Author (2013). *Science Scope.*

Baumann, J.F. & Kame'enui, E.J. (1996/1991). Research on Vocabulary Instruction: Ode to Voltaire. In *Handbook of Research on Teaching the English Language Arts*, *Vol. II*, ed. By Flood, J., Lapp, D., Squire, J.R. & Jensen, J.M. pp. 604-632. New York: Macmillan Publishing Company.

Beck, I. L. & McKeown, M.G. (1996/1991). Conditions of Vocabulary Acquisition In *Handbook of Reading Research*, *Vol. II*, ed. By Flood, J., Lapp, D., Squire, J.R. & Jensen, J.M. pp. 789-814. Mahwah, MJ: Erlbaum Associates.

Blachowicz, C. L. Z. & Fisher, P. (2011). Best practices in teaching vocabulary revisited. In L. Morrow & L. Gambrell (Eds.), Best practices in literacy instruction (4th ed., pp. 224-249). New York: Guilford, 224-249.

Department of Elementary and Secondary Education [DESE], (2008). Science Grade Level

Expectations: A Framework for Instruction and Assessment. Published online: http://dese.mo.gov/divimprove/curriculum/GLE/SCgle.html

Fisher, P.J., & Blachowicz, C. L. Z. (2013). A few words about math and science. *Educational Leadership, 71*(3), 46-51.

Gilles, C., Bixby, M., Crowley, P., Crenshaw, S. R., Henrichs, M., Reynolds, F. E., & Pyle, D. (1988). *Whole language strategies for secondary students*. New York: Richard C. Owen Publishers, Inc.

Gregg, M., & Sekers, D. (2006). My word! Vocabulary and geography learning. *Journal of Geography, 105,* 53-58.

Groves, F. H. (1995). Science vocabulary load of selected secondary science textbooks. *School Science and Mathematics, 95*(5), 231–235.

Harmon, J. M., Wood, K. D., & Kiser, K. (2009). Promoting vocabulary learning with the interactive word wall. *Middle School Journal, 40* (3), 58–63.

Harmon, J.M. & Hedrick, W.B. (2005). Research on vocabulary instruction in the content areas: Implications for struggling readers. *Reading & Writing Quarterly, 21*: 261–280

Hubbard, R. S., & Power, B. M. (1999). *Living the Questions: A Guide for Teacher-Researchers.* Portland, OR: Stenhouse Publishers.

Hubbard, R. S., & Power, B. M. (2003). The *art of classroom inquiry: A handbook for teacher-researchers* (Rev. Ed.). Portsmouth, NH: Heinemann.

McKeown, M.G. (1993). Creating definitions for young word learners. *Reading Research Quarterly, 28,* 208-224.

Moje, E.B., Collazo, T. Carrillo, R., & Marx, R. W. (2001). "Maestro, what is 'quality'?": Language, literacy, and discourse in project-based science. *Journal of Research in Science Teaching, 38, 469-498.*

Nagy, W.E. & Scott, J.A. (2000). Vocabulary process. In *Handbook of Reading Research, Vol. III*, ed. By Kamil, M.L., Barr, R., Pearson, P.D., & Mosenthal, P.B., pp. 269-284. Mahway, NJ: Erlbaum Association.

National Governors Association Center for Best Practices [NGA] &Council of Chief State School Officers [CCSSO]. (2010). *Common Core State Standards (English Language Arts)*. Washington, DC: National Governors Association Center for Best Practices, Council of Chief State School Officers.

National Research Council (NRC). (2011). *A framework for K-12 science education: Practices,*

crosscutting concepts, and core ideas.. Washington, DC: National Academic Press.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Rupley, W. H. & Slough, S. (2010). Building prior knowledge and vocabulary in science in the intermediate grades: Creating hooks for learning. *Literacy Research and Instruction, 49, 99-112.*

Scott, J.A., Jamieson-Noel, D., & Asselin, M. (2003). Vocabulary instruction throughout the day in twenty-three Canadian upper-elementary classrooms. *The Elementary School Journal, 103,* 281-286*.*

Seaver, J. (1991). The effect of pre-reading vocabulary development strategies on sixth grade science text results. Eric No. ED 329 952.

Snow, C. E., Griffin, P., & Burns, M. S. (2005). *Knowledge to support the teaching of reading: Preparing teachers for a changing world.* San Francisco, CA: Jossey-Bass.

Stahl, S. A. & Kapinus, B. A. (1991). Possible sentences: Predicting word meanings to teach content area vocabulary. The Reading Teacher, 45(1), 36–43.

Wysession, M., Frank, D., & Yancopoulos, S. (2009). *Physical science: Concepts in action*. Needham, MA: Pearson Prentice Hall.

Yager, R.E. (1983). The importance of terminology in teaching K-12 science. *Journal of Research in Science Teaching, 20*, 577-588.

Yates, P.H., Cuthrell, K. & Rose, M. (2011). Out of the room and into the hall: Making content word walls work. *Clearing House, 84, 31-36*