Articulate Your Learning
Integrating Science Content and Writers Workshop in a 4th Grade Classroom

by

Aijeron Simmons

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School of Education
Mills College

Abstract

This study is a case of teacher action research in the context of a fourth grade classroom in an urban school serving minority students of low socio-economic status, the majority of who are English learners. Carried out from the perspective of a teacher researcher utilizing methods of curriculum integration and documenting how student responses to the methods can inform further curriculum integration. It examines the effectiveness of integrating content specific knowledge and explicit writing instruction. I implemented the integration of the explicit teaching of writing through writers workshop and hands-on science experiences to answer the question how will integrating explicit writing instruction into a hands-on science curriculum effect students development of science content knowledge and writing. The data presents how students' vocabulary, writing, and science content knowledge grows throughout the action cycles. It also explores the importance of strategic planning and time that goes into curriculum integration.

Beginning the Journey

I grew up in the city of Oakland attending school in the Oakland public school system for part of my elementary schooling and all of my high school years. Between those periods I was taught in a private Christian School opened by my African American Grandparents also in Oakland, California. Being in those two environments were startlingly different. Although both schools supposedly offered the same curriculum, the private family school offered a wealth of learning opportunities outside the classroom. We traveled all over the Bay Area on fieldtrips to exciting places, meeting people in the neighborhood, seeing, and experiencing first hand the topics that were written about in our text books. When I began to do my student teaching in an Oakland public school I was stunned to find that in a first grade class room students spent the greater part of the day reading and re-reading an anthology full of short stories. A small part of the day was dedicated to math and the remaining part to English language development. I spent every day waiting and searching for the moment when I would see the students studying any of the sciences. After much waiting and questioning, I was told that the focus of the school was on raising reading scores and the other curriculum had to be down sized in order for the teaching of reading to be done more successfully.

Immediately I was startled and in some way haunted by the blatant inequity staring me in the face. No matter what the reason being given me I could not understand how students were being denied these rich experiences. In my mind it was obvious that constant remediation in certain subject could by no means be the answer to creating more equitable outcomes for the students in the low income communities immediately effected by this lack of curricular diversity. Even with the potential of raising reading and math scores, these students were in my mind and heart being made subject to a great injustice.

I could remember leaving my Oakland public high school after senior year bright eyed and headed to U.C. Berkeley ready to begin my career as a computer scientist. I loaded my schedule up with science courses and felt so proud of getting the opportunity to receive such a high quality education. I remember like yesterday going to my first chemistry class and having the separate lab and thinking how unprepared I was because

so much of what was being said and done was over my head. It was then that I realized as I spoke with other freshman that although I had the grades to get me into Cal I had no where near the understanding it was going to take to get me through a basic introductory science course with a passing grade. My heart was broken. I had done everything in my power to be successful but because of the inequity in resources and curriculum in the school district where I lived I was unprepared for success. It was there on that campus that I realized something about equity that I have never forgotten and can never forget. As I teacher I ponder how many ways this same inequity affects students today in urban areas like the one I grew up in.

With this question in my mind constantly other things began to stand out to me as I encountered them. I saw a newspaper article written about students in high school with low test scores spending blocks of their day only studying reading, writing, and math. I vowed to myself that in my own classroom I would make sure that students were able to study all subject matters and that I would provide for students time in the day to experience hands on learning.

Eyes on My Own Practice

As I began my first year in a public school classroom, determined to find a way to teach all subjects well, I made time in my schedule to teach science and social studies each once a week in two hour blocks. Because reading scores are so essential to funding and state testing I received no support for the teaching of the sciences. However week after week my students would ask, "when are we doing science." They longed for the days when the books would be put away and we would grab our science notebooks and do some inquiry. Many days we would not have time to finish experiments, or something would come up and our afternoon science would have to be the first thing to be rescheduled if we needed to make up time in our anthology. Weeks when there was what seemed to be endless testing, science and social studies were always the first to be sacrificed because they were not on our immediate grade level state test. Every week that science or social studies was slighted I would be disappointed and so would my students. This led to my constant wondering how science and social studies, which are rich in

reading and writing, are not considered part of a good literacy program. I wonder how I can present scientific inquiry in an elementary school classroom in a way that would make it legitimately part of the literacy program.

If educators continue to separate the subject matter and deem one more relevant than the other something is bound to get pushed to the side. Teachers never have enough time to cover everything and if we continue to exclude science and social studies to further jam the comprehension steps into our students they never experience the excitement of science and social studies. Subjects that are the essence of why we want comprehend what we read. We want to know about other people and we want to know about our world. I believe when we give students experiences they will desire the language and the ability to tell about what they have done. They will have the context and the concrete to give life to the abstract words they are reading. If more children are experiencing curriculum relevant to living it may foster increases of interest in the science and mathematics fields. Finding that students are able to articulate scientific experiences in a variety of genres could revive the idea that curriculum does not have to be divided out into blocks of subjects as we are mandated to do by our districts. Teachers could begin integrating curriculum through thematic inquiries that involve all the subject matters and are more relevant to students' lives. Teachers wouldn't be so fearful of doing something that goes against the status quo if we were able to bring back the idea of inquiry and a more qualitative approach to teaching and learning.

Currently in education we are in a scramble to raise test scores, identify best practices, and give students marketable skills. We are trying to teach English learners and native English speakers the use of academic English and the ability to read at grade level. We are experiencing a decline in the number of American students who are entering into the mathematics and science fields (Dorph, Goldstein, Lee, Lepori, Schneider, & Venkatsean, 2007). We are faced with increased violence and social rebellion in low-income communities. We are contending with the notion that we can purchase a curriculum and enforce it so strictly that all students will be able to read by the end of third grade, no matter their background. Many districts in America have chosen to

increase the amount of time students spend engaged in reading and mathematics and decrease their time engaged in the sciences (McMurrer, 2007). This approach, which focuses heavily on intervention and explicit teaching of the skills it takes to read and write, does not incorporate how to teach students to read and write through the use of academic subject areas such as science and social studies. This approach has taken precedence in the school district in which I teach. The day to day implementation of teaching these reading and writing skills, constant testing, and modification of curricular practices has been limiting or causing elimination of the teaching of other subject areas(McMurrer, 2007). In my particular school site many teachers have chosen not to place any emphasis on science instruction.

I believe one way to approach integration effectively is to begin with the presentation of the district mandated science curriculum and extend each of the investigations to include explicit writing instruction. Through these methods I predict students will develop a greater understanding of science content and a strengthened ability to write. As students participate in this lesson design, it is essential to examine the nature of the teacher's role in making the connection between content and expression, and the impact these connections students' learning. . This research will focus on answering the question **how will integrating explicit writing instruction into a hands-on science curriculum affect students development of science content knowledge and writing.** By answering these questions from the perspective of a practicing teacher in a low income urban setting I would like this research to encourage teachers to do more strategic teaching of the sciences in settings like mine.

In the Context of the Field

The trend in science education since the late 1950's has been to integrate hands on investigations into science lessons, so students get more opportunities to engage in true scientific inquiry (Pine & Aschbacher, 2006). This was a counter to heavy text book use that did not give students opportunities to truly engage in inquiry. However, research has shown that although inquiry based science is necessary to giving students true science content knowledge, teachers must also modify lessons beyond hands on investigation for

students to truly learn the concepts (Pine & Aschbacher, 2007; Von Secker, 2002). In addition to investigations and inquiry students need strong literacy instruction to support the vocabulary and language needed to engage in all parts of the scientific process. It is suggested that for inquiry science to facilitate gains in literacy teachers must include vocabulary instruction, reading strategies, discussion, and make explicit connection to the world students live in through scientific inquiry (Wise, 1996).

There are many approaches that encourage the integration of curriculum These approaches allow students to learn the skills of reading, writing, and arithmetic by participating in hands on inquiry science and project based learning within the sciences and other curricular areas (Hapgood & Palincsar, 2007). Much of the literature relating to integrating curriculum explains to teachers the places in science curriculum where writing is used and what type of writing assignments should be placed into science activities. Many of these approaches to integration in elementary science do not stress the necessity for students to write in proper form when writing in science. Also these explanations of a particular approach to teaching curriculum were not written specifically to address the pressures of NCLB legislation concerning literacy. The most prevalent way to handle the pressures of No Child Left Behind, as stated above has been to decrease the amount of time spent teaching science. With the increased pressure from this legislation on literacy it is essential to examine ways to help students develop as fluent writers with proper form, grammar, style, and voice within particular content areas. Carolyn Keys examined the idea of writing in science in an article published in 1998. She ends her discourse with several questions. One of those questions is "What types of explicit writing instruction foster students' understanding of scientific writing". Another is "How does writing in scientific genres foster conceptual knowledge development". These two questions are at the center of my research. I think they are the perfect place to begin an examination of effective curricular integration in the current educational climate.

One essential component that must be addressed in order to bridge the connection between science inquiry and writing in scientific genres is the development of a scientific vocabulary. This is particularly important in urban schools where many students lack extensive vocabularies. Students must have explicit vocabulary instruction to enhance their comprehension of science learning (Konopak, 1991). Inquiry science provides for

students a context with which to link to vocabulary to facilitate a deeper understanding of the words. Students "may have problems learning the technical words if they lack the related experiences and understandings from which meanings are derived" (Konopak, 1991, p. 135).

In "Learning through Writing" published by Santa and Havens it is stated that "writing encourages active involvement in learning...writing forces organization…we cannot write about something if we don't understand it." (Santa and Havens, 1991, p. 123). There are several skills needed to become good writers that are often used in science. Some of those have been identified as purpose setting, predicting, organizing ideas, constructing, composing, drawing conclusions, evaluating, revising, comprehending, and communicating (Casteel & Isom, 1994). Another component of effective communication through writing is the understanding that there are different parts of the writing process. This process based approach to writing has had significant impact on the teaching of writing in the United States (Unger & Fleischman, 2004). Students have been encouraged to go through the process of prewriting, drafting, revising, editing, and publishing as they produce finalized papers. These processes parallel many of the processes scientists go through in search of findings and producing conclusions. The following diagram outlines the components I have identified as essential to connecting science and writing.

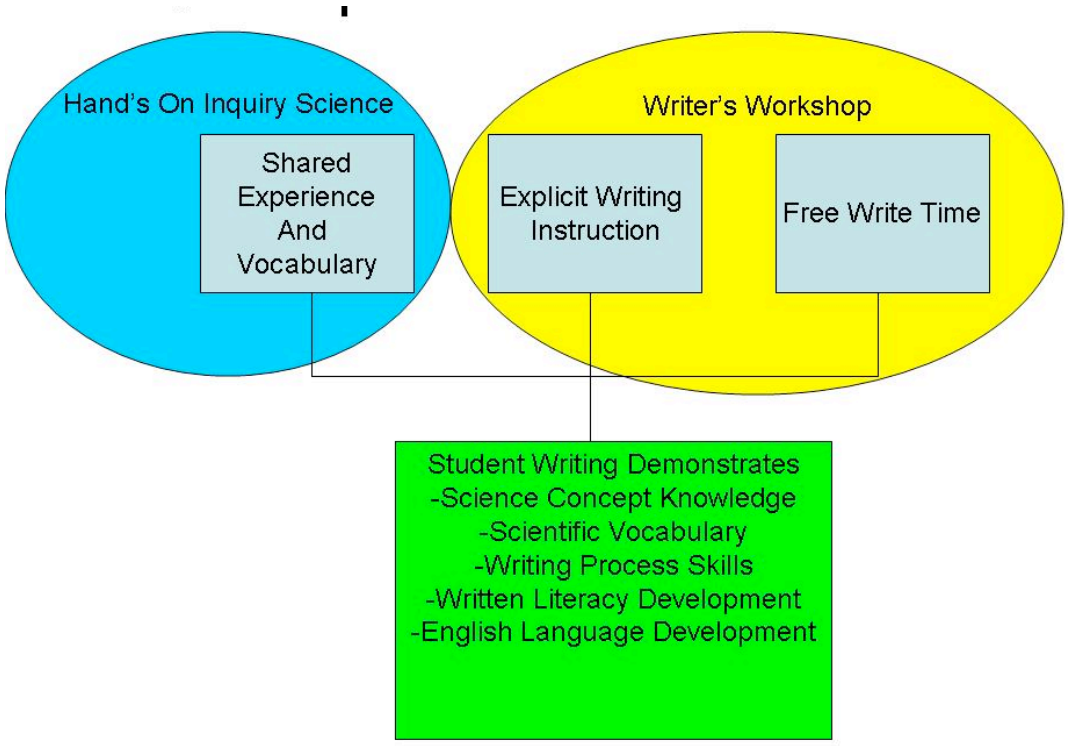

Diagram of Conceptual Framework **figure 1**

Going About the Business of Research

The Methodology

The school I teach in is an urban public elementary school that has been reconstituted under No Child Left Behind legislation and is in year 2 as a new small arts integrated school. 92 percent of our students qualify for free or reduced price lunch. The student body is 69 percent Latino, 30 percent African American, and 1 percent Asian Pacific Islander. This study takes place in my 4th grade classroom. I teach 27 students ranging in age from 9 to 11 years. 22 students are English learners of Latino descent. Of the 22, 15 received bilingual instruction from kindergarten to 3rd grade. The remaining students are African American.

Data for this study was drawn from a focal group of seven students, chosen by assigning each returned permission slip a number and pulling seven numbers. However the number of focal students I will be reporting data on is only six. In the process of the research one of my students transferred schools unexpectedly. The six focal students range in ability from proficient to far below basic according to our district benchmark exams. Three of the students are girls and three are boys. All of the students are Latino and at one point were labeled as English learners. One tested as proficient in English and is no longer labeled an English learner. The African American student included in the original sample transferred. Only one other African American student returned the permission slip. Due to the late transferring of the first student there was not enough data to retroactively include that student in this study. Finally all of these students qualify for free or reduce priced lunch.

The first source of data collected was through interviews with each of the focal students. Each student was asked a series of questions to gather information about what science background knowledge students could share and what students understood about the connections between writing and science. The questions for this interview can be found in Appendix A. To analyze this data I took some notes after each interview recording my thoughts about what students said and connections to things we had done in the classroom. I also looked for some trends and surprises in student answers. These data were also analyzed by my colleagues in Mills MEET program for examples of science content, vocabulary, and understanding of the role of writing in science.

After the initial interview we began the magnetism and electricity unit of the FOSS curriculum used by my district to teach science. The unit takes place of over one trimester. Prior to teaching the unit I identified the most important vocabulary and my second source of data is vocabulary pre and post tests. The first test was conducted prior to any teaching of the science unit. The last test was conducted after the final lesson and review session. These data were analyzed into four categories: Incorrect/No Answer, Non Scientific, Related Concept, and Clear Scientific definition. I also conducted a comparative analysis across students to see if there were any trends.

Progressing through the cycles

I gathered data on the incorporation of each writing activity and the investigation at the end of each cycle. These action research cycles are a modified version of Kemmis and Mctaggart's action research spiral (Kemmis & Mctaggart, 1988). For this study I utilized the plan, act, reflect, modify portion of their spiral. Each action in the spiral included an investigation from the FOSS unit and a complete writing cycle. Writing cycles consisted of prewriting, drafting, revising, and publishing. After each cycle I did a brief analysis of student writing to plan for the next cycle. Three cycles were completed over the course of the unit, each cycle taking about two weeks to complete.

After completing the initial data collection mentioned above I implemented the first action research cycle. This cycle began with an activity around exploring magnets and magnetic poles. Vocabulary cards were created by each student during the exploration and discussion as words were needed to describe the phenomenon students were trying to explain. Once the exploration of the magnets was complete students began preparing for the writing task. For this first cycle I gave no pre introduction for their writing. I asked them to first talk to a neighbor about what they had noticed. After about 5 minutes of conversation I asked the students to write a one paragraph summary of what they had done. Upon the completion of this activity I reflected on the process and student writing to plan an action for the next cycle. Intensive analysis and coding of the data was not completed until the end of all the cycles.

As a modified plan entering into the second cycle I added the requirement that a graphic organizer be completed during the investigation (Appendix B). I introduced the graphic organizer at the onset of the investigation as opposed to the beginning of the writing. However I did explain that the organizer would be used later to write about what they learned at the conclusion of the investigation. For this cycle students were to write a two paragraph report explaining their procedures during the investigation and discoveries concluding the investigation. Students shared with one another after writing the report

and prior to the editing session in which they were asked to add details and proofread their science report. This report concluded a lesson on the force of attraction between two doughnut magnets.

After reflecting and analyzing the second data cycle I wanted to facilitate the inclusion of more evidence into their writing. By observing students conversations I could hear students using vocabulary correctly and I wanted to facilitate that in their writing. I introduced a graphic organizer that included a section for vocabulary from each investigation that students could choose to put in their final report (Appendix C). I also encouraged students to use labeled diagrams in their final writing piece. During this cycle students shared their reports with partners and were asked to carefully edit and neatly complete the final report. This report was from the electricity unit and students were asked to explain electricity and the different types of circuits in this report.

At the end of all three cycles I analyzed each piece of student writing for: Findings, Evidence, Organization, and Clarity. These categories are drawn from Keys (1998) article mentioned in the background for the research. Keys states that knowledge telling processes include stating findings, citing evidence, and describing observations. For the purpose of this research I am including any observations as citations of evidence She also includes that part of the thinking involved in the writing involves making language choices. For this study I am analyzing language choices according to organization of ideas and clarity of words.

The final source of data was a post questionnaire students completed at the end of the entire unit. This questionnaire (Appendix D) asks students to reflect on the learning process and share what they felt they understood from the unit. With these data I looked to see if students made an explicit connection between writing and their own learning. Student's reflections of their own learning were compared to the writing students had done to see if there was cohesion or contradiction in what I determined as student "knowledge telling" and what students understand that they have come to know (Keys, 1998, p. 121).

Articulating My Own Learning

My teaching of vocabulary was much more strategic with the knowledge that students would need the vocabulary in order to record for their graphic organizers and write the science report. As this study began my focus was to successfully integrate writing into the science curriculum. I knew that I would need to make sure students were able to understand the vocabulary to successfully write about the activities we had completed. However, in my mind vocabulary was just going to be a tool to help students feel more successful at the writing process. It was very apparent at the completion of the study that vocabulary development was much more meaningful for students than I realized it would be. It was also clear to me that deeply imbedded in students understanding of science is their ability to use scientific terms to discuss the world around them.

Students have many encounters with the world around them that don't feel like science learning. In their article "Reciprocal processes in science literacy and learning" Casteel and Isom quote a 1986 article by Moore, Moore, Cunningham and Cunningham, that states "Biology is not plants and animals, it is language about plants and animals" (Casteel and Isom, 1994, pg 540). My students began to develop this understanding as they discussed and wrote about investigations we completed. It is the understanding of the meticulous processes and the specific vocabulary words that make students feel like they are learning science. One student stated in the post interview questionnaire that "vocabulary helped me the most because I needed to remember the meaning to help me do the science". Another student stated "I discovered from reading my words I knew more science". When answering the question what did you discovered about your learning from reading your reports, students often stated I discovered I learned a lot of science.

I began with the belief that tracking student's vocabulary use would be an indicator that students had grasped the science content. I found that it was indeed a useful tool in tracking student content knowledge growth. **What was particularly significant**

was how learning the vocabulary was what the students felt was the most important content in the lesson. At the end of the entire unit on Magnetism I gave students a questionnaire asking several questions about what students felt they learned. One of the questions asked students to identify the most helpful parts of the science activity, other that the actual hands-on part of the investigation. Students chose between 4 parts of the activity. The following is a graph of student responses. This graph demonstrates that most of the focal students in this study felt having vocabulary cards to reference throughout the unit was a very important part of their learning. The table reflects that one student chose writing the report a favorite part, however upon looking at her reason why she stated that writing the report helped her to learn her vocabulary words in her graphic organizer. Her choices are recorded twice in the chart. This student seemed to have made the connection that the vocabulary was essential to organizing and writing her science report. Another student commented that the vocabulary assisted them in learning the meanings of the words when they were writing their report.

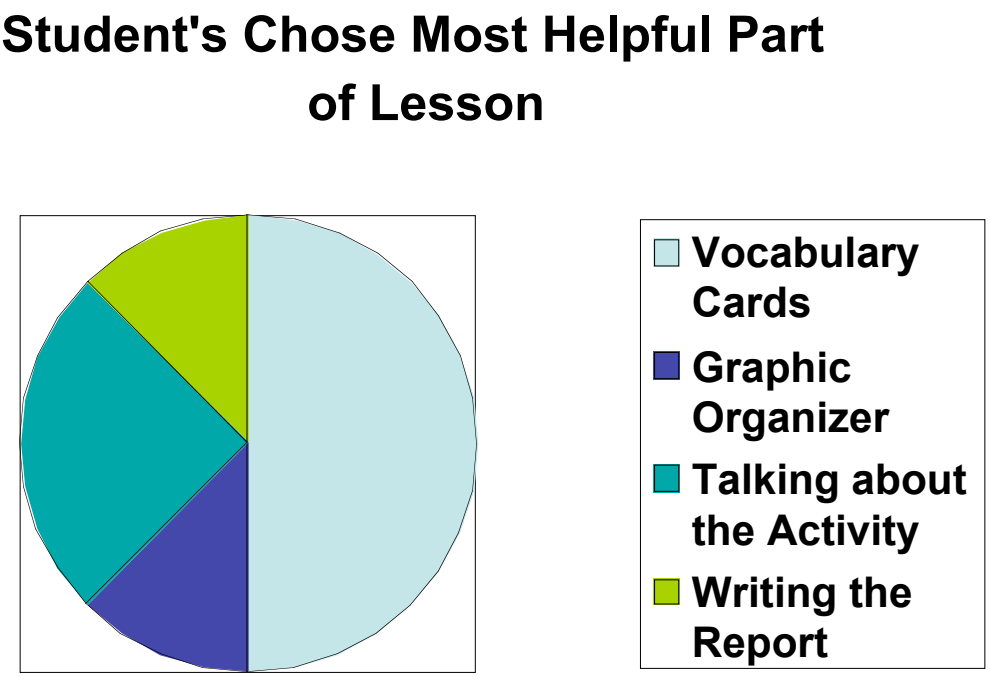

figure 2

Writing the science report gave student another opportunity to utilize the vocabulary they learned during the activity in an authentic way. It also made a space for them to think about the concepts and utilize the vocabulary many more times than would have been required if we had just done the hands-on investigation. This is clear because in the initial interview given to my students only 1 of them made reference to any science we had done in the previous unit. However at the end of this cycle five of the six students that completed the questionnaire made reference to specific scientific terms in their answers. One student made no reference to any specific vocabulary learned, however that student did choose vocabulary as the most helpful part of the lesson. Two students chose talking about the activity as the most helpful part. This directly connects to vocabulary development as well. Talking about the science activity also provided an authentic opportunity for students to utilize the vocabulary needed to scientifically discuss what they did in the investigation. To conclude I found that students must understand scientific vocabulary to grasp content. Writing and reporting provides students the authentic opportunities needed to engage with the concepts learned and connect them to the appropriate vocabulary and articulate their learning in a scientific way.

This directly connects to another finding regarding students understanding of science concepts. I chose the concepts I felt were most important for students to understand at the onset of this project. Many of these words had several meanings related to things students encountered all the time. However, those many may or may not be science related. Students completed vocabulary pre and post tests at the beginning and end of the science unit. **From this data I began to see that students developed an understanding that meanings of words can be content specific**. It was clear from these two tests that student clearly understood the non-scientific meanings they had for the words were not correct meanings as they wrote the science reports and completed the vocabulary post tests. The following is a graph of students pre and post test data. Each test was analyzed for vocabulary that was correct and scientific, incorrect but science related, non scientific, or completely incorrect or unanswered. The following is a graph of pre test data. Students wrote meanings for vocabulary words they knew that were scientific and non scientific. They wrote whatever they knew about the words.

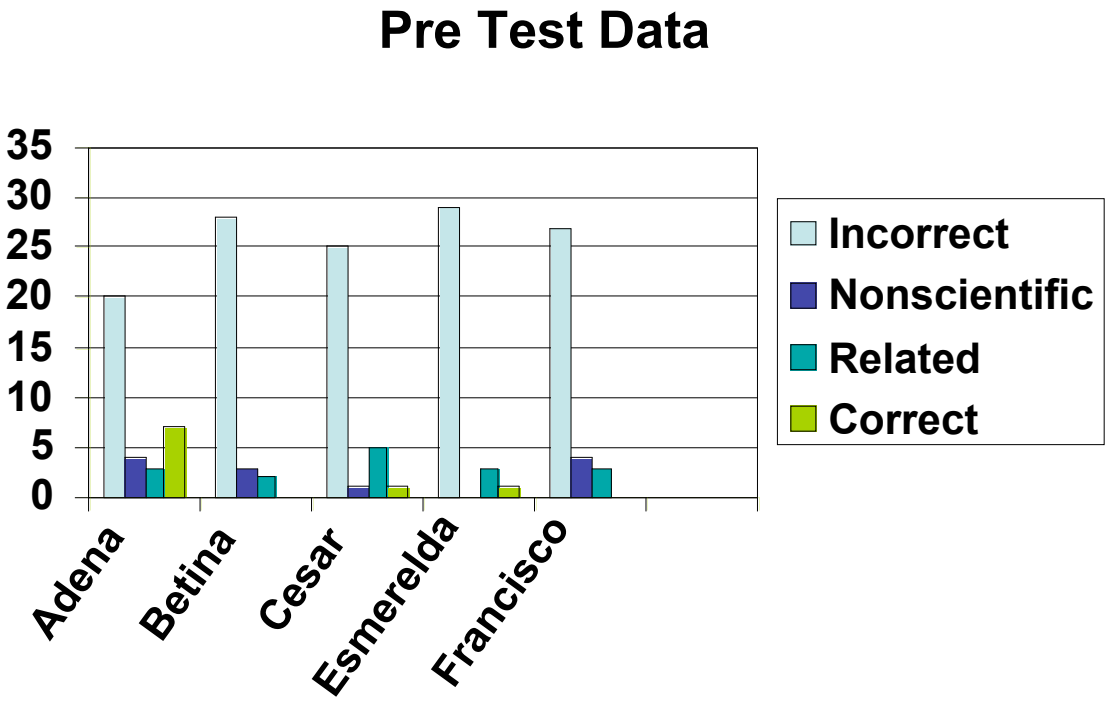

figure 3

The next graph shows the difference in student answers from the pre test to the post test. The number of correct answers increased as I anticipated. However, I did not expect to see such a drastic change in the nonscientific or related categories. After analyzing the data it was clear that students understood that there was a correct scientific answer. Students drastically answered as blank, scientific and incorrect, related and scientific, or correct answers. There was only one non scientific definition in the post test data.

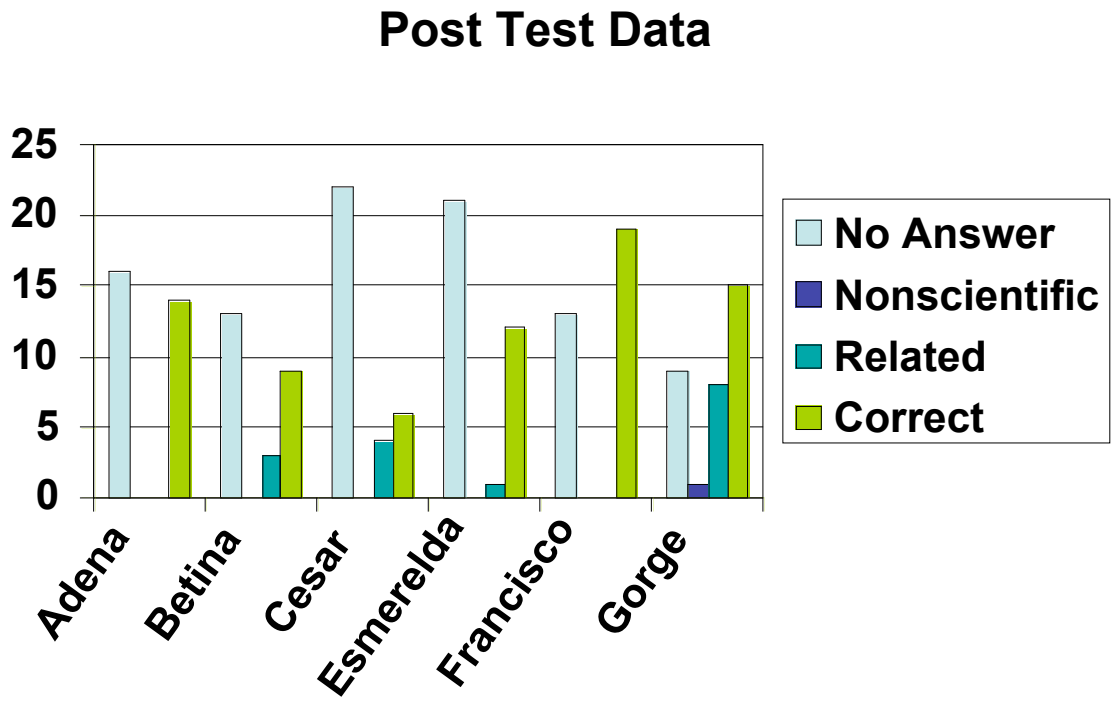

figure 4

Konopak discusses a continuum of development of scientific vocabulary for students (Konopak, 1991). I would argue based on these data that part of that continuum of understanding is the realization that when discussing words in a scientific way the common understandings students had associated with the words did not pertain to scientific meanings in some cases. I also looked at students writing for examples of pre test usage of science words in their writing reports. However, I noticed one usage of a non scientific concept in a report. One student referred to the metal washers we used in an activity as dish washers. Although "washers" was not a vocabulary word, the student had a concept of a washer as it related to dishes and placed that into the science report. With this knowledge of the role of vocabulary and concept schema I have been reviewing Konopak's article (1991) to enhance my students' understanding of the concepts along the vocabulary continuum.

I analyzed students writing in four categories; findings, evidence, organization, and clarity. Each student made the connection that the science report was to write about things they learned in through the activity and they understood they needed to use the vocabulary. Several students made references to activities being fun and interesting as if

they were writing a narrative about the activity. There were only a few examples from focal students where they made a clear connection in the writing between the evidence we used to get to a finding and the finding. **I believe students need much more practice being able to articulate how the outcomes of an activity provide the evidence for their conclusions.** In one report the student was able to tell how many washers it took to break the force attracting two donut magnets. However she did not include with any clarity that the conclusion of the test was as the magnets were moved further apart it took less washers to break the force. Students need more explicit teaching in how to get evidence from the activity and use it to make a distinct conclusion.

In terms of organization students were able to separate and clearly distinguish paragraphs as they related to concepts. **Utilizing the graphic organizer provided students a clear was to organize and represent related concepts and meanings into distinct paragraphs.** Students were also able to develop interesting opening sentences, transitional words for topic sentences within the writing, and some students including a concluding sentence. Writing in the scientific genre helped to reinforce the 4^{th} grade writing standards for organization. Movement through activities and their distinct places within the graphic organizer students were able to utilize their knowledge of writing and transitional phrases to add cohesion to their writing. One student understood that each section required its own paragraph and she separated them out with new titles. She did not make the connection that she could include transitional phrases and keep the paragraphs flowing as one piece of writing.

Finally each piece of writing was analyzed for the writer's clarity of ideas and communication. It was clear in each piece what scientific concepts students were discussing. The overall organization of each paper was also clear. However, the details within each sentence did not always connect. Students still wrote incomplete sentences or used phrases that did not make sense. **This writing project seemed to have absolutely no influence on students' ability to formulate a good sentence with the proper tense and structure.** The element of grammar in students' writing would probably involve much more explicit structure and opportunities to edit for specific things. Given the time constraints in which I work their was just not enough time in my two hours science block to give to extended editing sessions.

Integrating science and writing had positive effects on student learning in both areas. Students engaged with the science content and completed investigations. Upon completion of those investigations writing helped students process the content in the investigations and solidify what things they had learned. In the activity where students wrote about their discoveries, one student asked me "is learning a new word a discovery". Having to write down what he had learned made him question where his understanding had grown. It also gave students an opportunity to see which science concepts that had not fully come to understand. During the writing many students would ask me clarifying questions about portions of the science activity. These processes brought on through the writing supported the development of science content. Graphic organizers, discussion, and having a common discourse all helped students write more. I noticed a drastic increase in the amount students were writing. The shared discourse that was able to take place made the peer sharing and editing processes of writing a lot more productive for students. Because of the success I felt from this integration, I plan to continue to implement writing workshop into my science curriculum.

Implementing Discoveries

Vocabulary Development

This research has lead me to see how important it is for students to be receiving explicit vocabulary instruction across the subject matter areas. Prior to this study I introduced important words and concepts to students during science lessons. However I spent no time making sure students were being given authentic opportunities to engage in discourse or writing using content area vocabulary. My vocabulary instruction was confined to the language arts block of the school day. I now believe students need vocabulary development and strategies for developing meaning across all subject areas. Students need opportunities to use those words in authentic discourse, to read the words in context, to write the words in their own writing, and to make cross curricular connections with vocabulary. I can see for my low level English speakers how important it is for them to receive opportunities to expand their English vocabulary in all subjects so they will be able to perform in subject matter content in later grades. With the emphasis I

now place on explicit vocabulary instruction and authentic opportunities for vocabulary use, it is necessary that I enhance my teaching toolkit. I must learn more strategies that will facilitate cross disciplinary understanding and layers of meaning that different words have.

As I think deeply about the implications of not helping students develop more complex vocabulary I'm reminded that part of the achievement gap is essentially a gap in the amount of words students are exposed to. Many students don't have the vocabulary needed to perform well on mandated, standardized tests. Vocabulary development is an essential component to addressing the equity issue that grounds the purpose for this research. If all subjects are not presented students have no reason to conceptualize the vocabulary words that are essential to understanding different disciplines. This limit of teaching language arts and math also limits a teacher to teaching vocabulary relevant to the stories students are reading. This means the rich vocabulary that can be learned through science, social studies, math, physical education, art and music are left untapped. Subject matter areas facilitate multiple opportunities for students to engage in authentic activities that involve written and oral literacy skills. Not to mention the richness in literature that accompanies all the subject areas as well. As a result of this study I plan to increase my implementation of vocabulary use across all areas of my classroom curriculum.

Curriculum Integration

Asking students to write reports about what they came to understand in the science activity gave me an opportunity to see in a new way what students were coming to understand about the science, and how well they were able to articulate it. Writing provides a mechanism for shared reflection of processes and thinking. It also facilitates a teaching style that must take into account that students are going to be asked to write about what they know. With this is mind I was able to more carefully craft lessons that could lead to students being able to articulate conceptual understanding. The science lesson came to be about must more that just completing one investigation. Thinking about

facilitating articulation and understanding I saw in myself more intentional planning of lessons, use of charts and graphs, purposeful language, and intentional questions in my teaching. I needed to expand all these areas if I was to ask students to articulate their learning. For me that means that integration of the subject matter and writing development lead to more purposeful teaching on my part.

Writing across the curriculum also provides students with the opportunity to be more reflective about the learning process. At the end of this research one of my students concluded that the writing helped them to "remember what they already knew." Giving this student the opportunity to reread the science pieces that she had written helped her to realize what she already knew. Another student concluded that he "realized he didn't know much science last year." For him rereading his writing exposed how far he had come in science understanding from one year to the next. I would like to give students more opportunities to be able to produce something they can reflect upon and see the development of their understanding. When subject matter meets literacy skills students can synthesize and effectively use all the skills we teach in English language arts sessions and they can begin to implement the higher level thinking skills that are missing from completing ditto sheets and filling up practice book pages.

A component to writing that was missing from this study was the importance of audience. After completing cycle 3, I began thinking about how students writing would grow and develop if they were told ahead of time that they would be sharing their written findings with someone else. I emphasized to students at several places in the writers workshop that scientists are asked to share their findings in detailed ways. However, I did not incorporate that sharing into any of the research cycles. If given he opportunity to expand on this research in a larger more long term project I would ask student to prepare to report their written findings to an audience. This way the report could take on an even more authentic purpose.

Successful integration of subject matter and literacy involves planning and time. Going into this research I believed we would be able to complete 5 cycles of

investigation and writing. However, due to time constraints and planning limitations we were only able to complete 3 cycles. I was also only planning the integration of writing and science. I did not strategically incorporate any reading strategies or incorporate literacy development in other subject areas. I wonder how much more time it would take to do this across multiple areas. I am left wondering what effect this planned strategic integration would have on my students' development of concepts across subject matter.

Importance of Evidence

Analyzing the data for "telling of knowledge" exposed the importance of students' ability to produce evidence for their thinking. As I presently teach students test taking strategies, we are emphasizing the importance of locating supporting ideas for answers to multiple choice questions within the texts provided. Mathematically we discuss producing the thinking that lead to the conclusion or answer in a math problem. When making predictions, drawing conclusions, and giving opinions on a story, we ask students to base it on evidence located in the text. In science activities we ask students to conduct a test that should provide evidence for a certain conclusion. Facilitating students understanding of the different sources of evidence and how to verbalize where they located their evidence is another activity that can be enforced across subject matter. The more opportunities students have to engage with a certain type of thinking the more they are likely to internalize those ways of thinking and learning. Locating and reporting sources of evidence is another one of those linking concepts that can tie multiple subjects together.

Continued Inquiry

This research leaves me with several questions I feel are worthy of further research. What is the role of evidence in student understanding? How do students view what they have learned from a reflective writing piece? Does extended vocabulary development in subject areas directly affect reading comprehension? What are the implications of strategic vocabulary development across subject matter? These questions stand out to me most as I continue my journey towards a more equitable teaching practice that can lead to more equitable outcomes for all students

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Appendix A: Interview protocol for pre interview of focal students

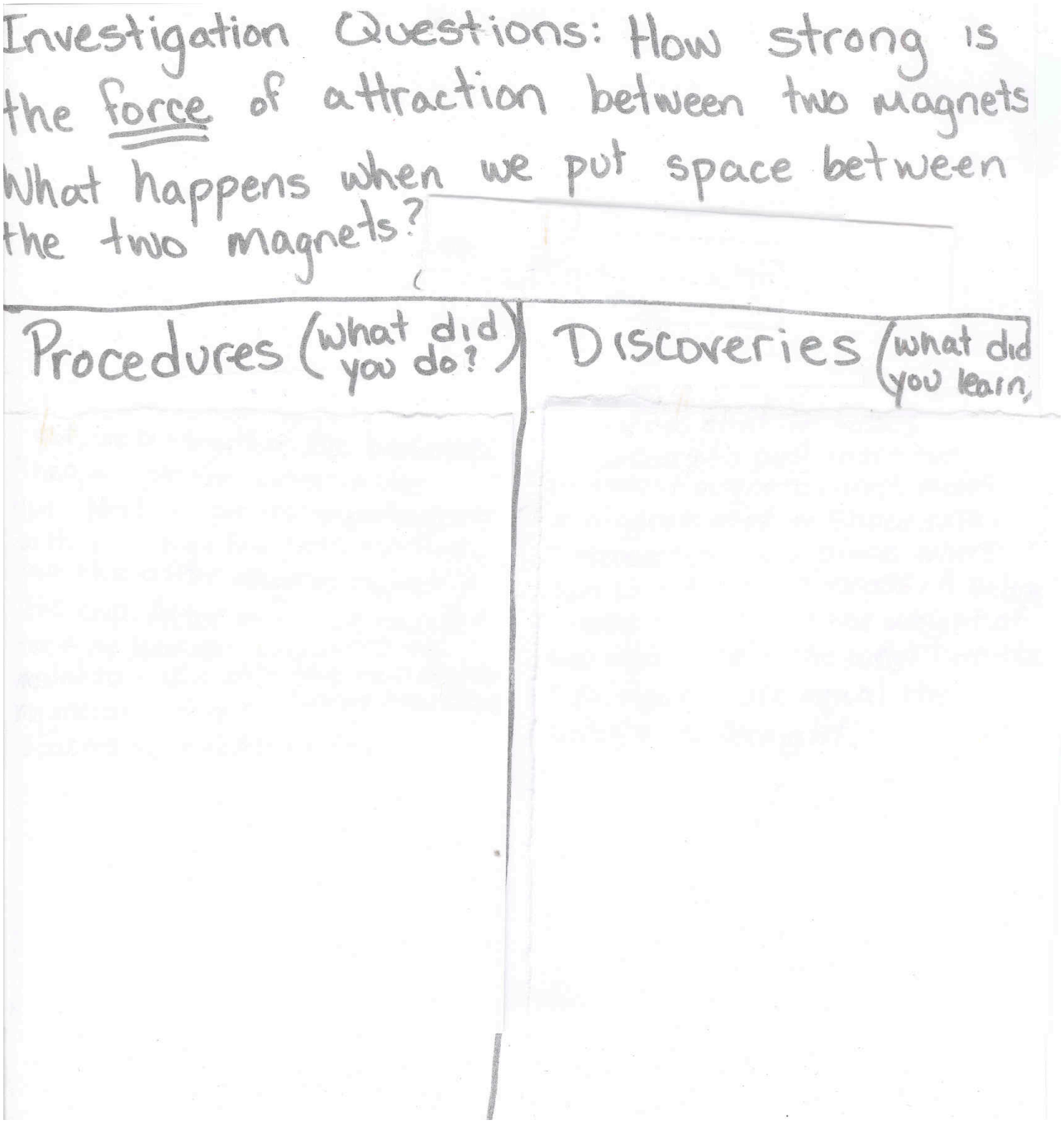
I am learning about how students learn science and writing. I want to ask you some questions about writing and science at school. Please just tell me how you feel honestly. It will help me to teach science and writing better.

1. What things have you learned about science this year?
2. What things have you learned about writing this year?
3. How do you use writing when we do science?
4. Do you ever use things we learned in science when you are writing?
5. Which subjects do you use when you are writing? How?
6. Do you talk about science ideas outside of class? Where? With who?
7. What is your favorite thing to write about?

Appendix B: Graphic Organizer for Electricity Report in Cycle 3

VOCABULARY	INVESTIGATION NOTES

Appendix C: Graphic Organizer Used in Action Cycle 2



Appendix D: Final Questionnaire Given to Focal Students

SCIENCE AND WRITING QUESTIONAIRE

1. Why do you think it is important for a scientist to write?
2. Have you discovered anything about your learning when you were writing your science report?
3. Do you think you can share a report to your parents about a lesson we did? Which one would you share? Why?

4. Circle which one of these parts help you learn the most. Then write why it helps?

Vocabulary cards Writing the Science Report Graphic Organizer Talking about the Activity