Success in Science: The Power of Writing on Attitudes and Knowledge Acquisition in Middle School Science

Kelly A. Roberts

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Success in Science: the power of writing on attitudes and knowledge acquisition in middle school science

by

Kelly A. Roberts

A thesis submitted to the
Department of Education and Human Development of the
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Success in Science: the power of writing on attitudes and knowledge acquisition in middle school science

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Date: 7/22/07
Date: 7/23/07
This thesis is dedicated to:

My husband, Mark, for his patience and understanding throughout my educational pursuits. At last, we can eat at the dining room table again...

My mother and father for their encouragement and unwavering belief in my abilities.

My niece, Miranda, whose entrance to school spurred my return to college in pursuit of this degree.
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Chapter 1: Introduction

*Problem statement*

Science permeates many aspects of our daily lives from the mundane to the grandiose. The type of personal care products we use, the clothes we wear, the foods we eat, the cars we drive, the type of medical care we receive, and even our belief systems share science connections. In today’s advanced society, individuals face continual exposure to scientific and technological content through television, radio, newspapers, the internet, and even one’s daily conversations. In fact, much of an individual’s exposure to advances in science occurs outside of school through print and electronic media. Individuals must be able to use their knowledge and understanding of science to critically assess and react to science and societal issues.

In response to this need, science education reform has been geared toward the production of a scientifically literate society. However, despite agreement that the development of a scientifically literate population is paramount to maintaining current societal norms as well as promoting future advancements for the betterment of humankind, it is not clear which educational approaches may best serve this need. For various reasons, it would seem that many have abandoned the use of texts and other literacy-based instruction in favor of hands-on activities as a means of engaging students in learning science. Students need more than engagement of hands-on science, they must also talk and write about science in words. Students need to be able to read, write, draw, tabulate, graph, and communicate about science in all combinations. As such, educators must exploit the power of writing as a tool for the development of critical thinking skills and building of conceptual knowledge about science.
Significance of the problem

Recent studies have revealed a global deficit in the written skills of new graduates. Although written and oral communication skills fall into the top five criteria science-related industries consider in the hiring of new employees, recent studies have shown that few employers are finding these skills in the graduates they employ (Emerson, 2006).

Additionally, students and adults alike do not have a clear understanding as to what science is. Students do not generally view themselves as scientists and are often unable to incorporate their own being into a world of science. Instead, they view science as an independent entity that has little relevance to their lives. Furthermore, when asked to write in or about science, students hold a compartmentalized view of what scientific writing should look like. This view often incorporates negative connotations about scientific writing in regards to both level of difficulty and appeal.

Purpose

The New York State Intermediate Level Science Standards are shaped such that students should become scientifically literate as a result of their science instruction. In accordance with the intermediate level science standards, it is expected that students will be able to solve problems using their knowledge of science. Furthermore, it is expected that students will be able to share their knowledge in multiple formats including oral, written and graphic representations. This project sought to explore possible causes for the reported global communication deficits existing in science-related industries when the core educational framework is designed to promote these qualities. Specifically, are these deficits attributable to factors such as ability, lack of instruction, or possibly some other affective characteristic
that had not been considered. This study will explore the impact of incorporating literacy components such as children’s literature, poetry, nature journaling, and writing prompts on learning and attitudes in the middle school science classroom. The overarching objective of this project was to create a positive learning environment that simultaneously promoted literacy, scientific literacy, and positive attitudes toward learning science. In creating a literacy-based science curriculum, it was anticipated that students would develop greater conceptual knowledge, improve critical thinking skills, and express greater interest toward reading and writing in the sciences.

**Rationale**

In our science and technology dominated world, scientific discoveries are happening at astounding rates. Society needs to be able to interpret, evaluate, and assign importance to these discoveries in relation to their own lives. Minimally, this need requires that the general population be marginally knowledgeable in the areas of science and technology so that they are able to make informed decisions. The utilization of language in science instruction serves as a powerful means for helping students develop conceptual knowledge in science. Literacy is essentially a holistic approach to language. Thereby, formulating avenues to incorporate literacy into science instruction may positively influence our students and consequently society as a whole.

**Definition of terms.**

**Literacy:**

“Literacy is the ability to identify, understand, interpret, create, communicate and compute using printed and written materials associated with varying contexts. Literacy involves a continuum of learning to enable an individual to achieve his or her goals, to develop his or her
knowledge and potential, and to participate fully in the wider society“ (United Nations Educational, Scientific and Cultural Organization).

**Scientific Literacy:**

The knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity (National Science Education Standards, 1996).

**Summary**

Improved literacy, problem-solving skills and an understanding of the world around us are assets that will benefit students no matter what path they follow. Language is a powerful tool that can be utilized to help students develop conceptual knowledge in science. The research clearly shows that integrating literacy strategies into instruction may provide increased learning gains among students. However, it is not clear which literacy component (Cazden, 2001 in Rivard 2003; Keys, 2000; Klein, 1999; Lemke, 2002 in Rivard 2003; Mason & Boscolo, 2000; Prain & Hand, 1999; Rivard, 1994; Rowell, 1997) provides the greatest opportunity for meeting the educational goals of today’s classrooms. Additionally, the research also shows that reading and writing in the sciences is often underutilized as a means of developing knowledge in science and promoting the development of scientific literacy. The following literature review critically examines the role of literacy-based instruction in the middle school science classroom as an instrument for constructing meaning in science and toward the achievement of scientific literacy.

Chapter 2: Literature Review

**The Literacy-Science Connection**

The term literacy often conjures images of reading or writing, but literacy not only encompasses, but is also dependent on additional elements of language, including oral
communication, gesturing, and visual representations (Lemke, 1998; Yore, Bisanz, & Hand, 2003). A number of researchers have studied the use of language-based instructional activities as a means of developing understanding in science.

Proponents of the use of talk (Cazden, 2001 in Rivard 2003; Lemke, 2002 in Rivard 2003) contend that peer discussions serve as an intermediary stage between writing and thinking. These supporters view talk and writing as complimentary modalities in which talking helps students to shape their understanding providing the avenue for developing more descriptive written explanations of scientific phenomena.

A number of researchers have found that writing also serves a constructivist function in building conceptual knowledge in science (Keys, 2000; Klein, 1999; Prain & Hand, 1999; Rivard, 1994; Rowell, 1997). Writing for learning advocates assert that writing on a topic allows for clarification, organization of ideas, and reflection on the learning experience (Mason & Boscolo, 2000). Furthermore, while the format may vary, writing is considered to be an essential feature of all science-related endeavors.

Like writing, reading in the sciences is also an interactive-constructive process. Aggregate research on reading has shown that learning from text involves complex interactions between the reader and the text (Holliday, Yore, & Alvermann, 2004). Using the concept of biological literacy as an example, Uno and Bybee (1994) contend that the reading and comprehension of scientific texts is an important component in developing scientific literacy and should therefore be an educational goal. Furthermore they delineate understanding of biological science, a subset of
scientific literacy, as a lifelong process marked by hierarchial transitional periods in which one’s scientific schema evolves from one of naivity to one of mature understanding.

However, linguist Jay Lemke asserts that educators who limit literacy-related science instruction to reading, writing, and talking are missing a significant portion of science communication (Lemke in Saul, 2004). Paralleling this idea, Roth (2001) examined the role of gestures in the development of scientific literacy. Research in this area suggests that the use of gesturing is characteristic of problem solvers as they strive to make meaning of scientific phenomena (Crowder, 1996; Goldin-Meadow, 1997).

Moving beyond the language components, literacy also incorporates two distinct but related functionalities defined by Norris and Phillips (2003) as the fundamental and derived senses of literacy. Fundamental literacy is focused on reading and writing in the content area, whereas derived literacy is rooted in knowledge and understanding. Norris and Phillips (2003) contend that reading and writing transcend traditional connotations of methods for the storage and transmission of scientific content and are essential elements to the understanding of science.

**Gesture, Talk and the Derived Sense of Literacy**

At its core, the implicit purpose of communication is to convey information from one party to another. Before the advent of written communication methods, humans expertly displayed knowledge using both talk and gesturing. The emerging question then exists, in today’s advanced technological society, does gesturing, inextricably
linked to talk, play a contributory role in the development of scientific literacy while simultaneously providing valuable insight into how students learn. Gestures, characteristically distinguished from other hand movements, typically are classified into four categories including beats, deictic gestures, iconic gestures, and metaphoric gestures (Roth, 2001). Gestures follow a cyclic pattern starting and ending at a point of rest, moving through a preparatory, peak, and recovery phase. Beats, the simplest of the gestures serve an interactive, regulatory function such as coordinating speaking turns or acknowledging understanding (Bavelas in Roth, 2001). Deictic gestures used in concrete or abstract pointing can serve an important function in the classroom (Goldin-Meadow, 1999; Roth, 2001). Iconic gestures used in conjunction with concrete entities, and metaphoric gestures used to describe abstract concepts, are similar in that they are both representational gestures (Goldin-Meadow, 1999; Roth 2001).

While Piaget described the importance of gesturing in learning, development and communication in children (Piaget in Roth, 2001) almost fifty-years later little research exists exploring the connection between the role of gestures in teaching and learning particularly in math and science. The research of Susan Goldin-Meadow (1999), an authority on gesturing, suggests that gestures can reveal knowledge not expressed in speech and that gestures are indicative of emergent knowledge. Furthermore, Goldin-Meadow (1999) asserts that the mismatch between gestures and speech is indicative of a readiness to learn and that the relationship between speech and gestures is reflective of knowledge change.
The limited studies in this area suggest that understanding the correlation between gesturing and learning science provides an underutilized avenue for promoting the development of scientific literacy (Crowder, 1996; Goldin-Meadow, 1997; Roth, 2001). Crowder (1996) and Roth (2001) claim that gestures are frequently displayed as students attempt to explain phenomena extemporaneously and seemingly help students predict, revise, and coordinate elements in a model.

In response to emerging research suggestive that problem solvers incorporate gesturing into explanations of scientific phenomena, Crowder sought to understand the conditions in which sense-making discussions could be supported in the science classroom (Crowder, 1996). In evaluating the variance in types of science talk, Crowder (1996) divided science talk into two distinct subcategories, sense-making, and knowledge transmission. In her model, Crowder asserts that transmission views science as an object to be discussed, as opposed to sense-making, which views science as an action in which one seeks to coordinate theory and evidence. Despite this distinction, as Crowder’s model demonstrates, an area of overlap exists between the two modalities allowing students to integrate knowledge into their schema.

![Figure 1 - A model of two types of science talk (Crowder, 1996)](image-url)
Using sixth-grade classrooms located in areas of Boston and New York City, Crowder sought to describe the types of gesture and perspective taking associated with two of the many possible language activities in science talk (Crowder, 1996). Crowder looked at distinguishing descriptive from explanatory gesturing and the forms in which student perspective taking coincided with the acts of describing and explaining. The lessons used in this study focused on spatial related science concepts centered on seasonal changes and the formation of shadows. In these lessons, students either described or explained their ideas in response to questions posed by the teacher (Crowder, 1996).

Crowder (1996) found that distinct differences in gesturing exist in response to the task. Students using gestures to describe models showed alignment between gestures and speech patterns, with gestures being in time with stressed words or thoughts. Additionally, students using gesturing for descriptive purposes remained physically outside the gesture space. This gesturing pattern is in sharp contrast to the pattern that emerges when students explain in the moment. In spontaneous gesturing, students step into their gesture space developing a more intimate relationship with the material (Crowder, 1996).

Figure 2 - Inside Observer (Crowder, 1996)

Figure 3 - Outside Observer (Crowder, 1996)
The results of the Crowder study are in alignment with previous research into the use of gesturing and further suggest that gesturing provides a source of visual imagery for problem solving. Furthermore, Roth (in Saul, 2004) purports that it is important for teachers to be attuned to students' use of gesturing as it provides valuable insight as to how students learn and when it is necessary to intervene as a means of preventing the development of alternative conceptions.

While gesturing may have positive implications in the science classrooms, one must be wary of the limitations associated with gesturing. Gestures and body movements allow the teacher to convey more than their verbal explanation (Goldin-Meadow, 1997; Roth, 2001). This is an important phenomena to consider as students often show understanding in the classroom but subsequently are not able to make sense of their notes when reviewing the material. Gestures don't make it into the science notebook, thereby observant students are able to assimilate the information as opposed to those who only record the information verbalized by the teacher (Roth in Saul, 2004).

Another limitation is that gestures and speech don't always coordinate. At times both students and teachers may gesture one idea while verbalizing another which can adversely affect comprehension. Roth (in Saul, 2004) cites an example of an ecology professor whose gestures tuned students to the height of a curve whereas the discussion was focused on the width of the curve. Resultant from this gesture-speech mismatch, students expressed difficulties following the lecture and in understanding what the professor was talking about.
Despite these limitations, the use of gesturing as a means for promoting scientific literacy warrants further study to determine when and how it can be effectively integrated into the science classroom.

In exploring the use of talk from another perspective, it has been demonstrated that the majority of talk found within the classroom is triadic dialogue involving a three-part exchange between teacher and student. Typically the exchange is teacher initiated in the form of a question, followed by a student response, concluding with the teacher’s evaluation of the response (Chin, 2006; Dawes, 2004; Mason, 2001). While evidence exists supporting the importance of talk between teachers and learners, crucial aspects of collaborative talk in the science classroom have also been relatively well-defined (Dawes, 2004).

Rivard and Straw (2000) conducted an exploratory study to investigate the role of talk and writing on learning science. In their study, they explored the interconnectedness between talk and writing predicting that students who utilized both would show increased learning over students who used either modality exclusively (Rivard & Straw, 2000).

The Rivard and Straw (2000) study included 43 eighth-grade students from two Canadian classrooms. Students were randomly assigned to either the control group or one of the following three treatment groups, talk, talk and writing, or writing only. Students received the same whole-group instruction but branched off into their respective groups for each of five problem-solving sessions interspersed throughout
the unit (Rivard & Straw, 2000). Student learning was measured through multiple-choice tests, a test with short essay questions, and concept maps.

Students in the talk and writing treatment group exhibited extended retention of science knowledge. Additionally, the students using writing inclusively did not show increased learning of conceptual knowledge. This result suggests that peer discussion in combination with the interactive process of writing can positively influence science learning and retention (Rivard & Straw, 2000).

Following this initial study, Rivard (2004) conducted a similar study using a larger sample base of 154 eighth-grade students from four different schools. As seen in the original study, students were assigned to either one of three treatment groups or the control group. Paralleling the original study, treatment groups were designated as talk only, talk and writing, or writing only. In this study however, students were differentiated by ability with the research team looking to determine if treatment enhanced learning in low, average, and high achievers. The basic instruction in ecology was similar for all eight classrooms involved. Analogous to the original study, students were separated for each of the five problem-solving sessions included in the unit (Rivard, 2004). Results of this study suggest that higher achieving students benefit more from literacy tasks involving writing whereas lower achieving students demonstrated increased comprehension levels when used with talk.

Both of the Rivard studies demonstrate a link between the use of talk and the development of conceptual knowledge in the classroom. If this is the case, the question then exists whether a causal relationship exists between the type of talk and
positive learning outcomes. Dawes (2004) suggests that to be beneficial, talk must be structured within a guided framework. One such framework, Exploratory Talk, contains several essential skills that when properly used can support learning science through talk. Exploratory talk is defined as talk in which all relevant information is shared, all members of the group are encouraged to contribute without fear of reprisal, students provide evidence for their arguments, alternative views are explored, and the group seeks to reach a consensus before taking action (Mercer in Dawes, 2004).

A logical synthesis of these findings seemingly indicates that talk can positively influence learning in science, particularly when conducted within a framework where students can discuss ideas in a collaborative learning environment. The extent with which talk can contribute to creating a positive learning environment needs further exploration.

**Reading and Writing in the Science Classroom**

**Reading**

Knowledge of science text is important in the promotion of scientific literacy. Students need to be able to comprehend information from the text, interpret graphs and charts, and to read technical material. While the textbook is often the primary source of reading material in the science classroom, scientific literacy is partially dependent on exposure to multiple types of reading material. Students should be able to comprehend information found in laboratory manuals, science magazines, scientific journals, newspaper articles, and electronic media. Readers need to
recognize that scientific writing can be distorted and be able to use their understanding of science to differentiate between scientifically valid information from that which is unsubstantiated (Chiapetta & Koballa, 2006; Yore, 2000). Gooney & Long (2003) purport that the general understanding of science has been affected by our cultures’ conscience choice to read about science through popularizations, advertisements and other non-scientific textual mediums.

As mentioned previously, science education has experienced a paradigm shift moving from science as a body of knowledge to a way of knowing and explaining the world. Similarly, research on reading in the sciences has shifted also. The focus is no longer rooted in decoding and rote memorization but in the reader’s ability to interact with the text. Proponents of the reading-science, learning-writing connection believed this to be a pivotal advancement in the area of science reading (Holliday, Yore, & Alvermann in Yore, 2000). However, the language demands of middle school science texts can make this transition from “learning to read” to “reading to learn” difficult for many students, even those reading on grade level (Allington, 2002; Fang, 2006; Guthrie & Wigfield, 1999).

**Qualities of the Successful Science Reader**

A growing body of research suggests that strategic reading instruction among middle school students increases their comprehension of text. Effective readers share many common characteristics which include planning, monitoring, and checking for understanding throughout the reading process. These characteristics are not acquired, but learned behaviors. Successful readers of science text recognize that science
reading is an interactive-constructive process (Barton & Jordan, 2001). These readers self-regulate while reading, making adjustments when difficulties are perceived.

In addition to the qualities previously mentioned, the research base supports the following characteristics of successful science readers (Yore, 2000):

- Has the abilities, self-confidence, and self-efficacy necessary for science reading
- Recognize that science words are labels for ideas, and science text is stored descriptions and explanations of ideas, events, and patterns.
- Recognize that science text is not absolute truth but rather a form of interpretation of ideas resulting from the scientific enterprise
- Has the ability to evaluate science text for plausibility by assessing the logic and plausible reasoning of the text’s patterns of argumentation
- Uses specific knowledge-retrieval strategies to access prior knowledge
- Use specific knowledge-input strategies to access text-based information
- Use knowledge-construction strategies
- Applies critical thinking strategies to assess validity of the information

Textbooks, Motivation and Skills

The American Association for the Advancement of Science (AAAS) reported that science textbooks do a poor job of following standards based principles for concept learning (American Association for the Advancement of Science, 2002). Yet, according to the National Assessment of Educational Progress (2000), 80% of eighth grade teachers reported regular text usage.

Reading for comprehension in science, particularly textbooks can be challenging for students due to the content, readability, and organizational structure of the text. Adding to the challenge, the field of science is characterized by an expansive and
exacting vocabulary that students must be able to navigate through, associating these words with ideas. Further compounding the issue, research into science reading and science learning has revealed a number of student weaknesses in need of development if students are to develop conceptual knowledge through text. Students are not able to identify important ideas, are limited in their ability to address comprehension failure, and lack appropriate scientific knowledge to interpret both text and bilingual features of science text (Yore, 2000).

Research has shown that even students reading on grade level face difficulties in learning from textbooks. Students reading at their instructional reading level will misread or skip as many as five unfamiliar, content specific vocabulary words in every 100, or the equivalent of 10-25 words per page in a high school science text (Allington, 2002). The number of middle school students unable to read content area textbooks has reached epidemic proportions with some states, such as California, categorizing “struggling readers” as their own entity. Statistics suggest that it is commonplace to have classes in which 75%-80% of the students cannot successfully read their textbooks (Carnine & Carnine, 2004). Fostering motivation in this class of readers can be challenging with students facing wavering confidence issues and growing disinterest in the content area.

One may wonder then whether it is possible to utilize reading in the content area as a means of promoting scientific literacy when research demonstrates that large proportions of students are unable to read scientific text. A number of studies have examined the role of textbooks in student learning.
Using an analysis procedure developed and tested by Project 2061, Stern and Roseman (2004) examined nine middle school curriculum materials to determine if middle school science textbooks help students learn important ideas in science. The Project 2061 evaluation procedure examines alignment between the material’s content with key ideas and the extent to which instructional strategies in the student and teacher editions support students’ learning of the content (Stern & Roseman, 2004).

The Stern and Roseman study showed that while eight of the nine curriculum materials devoted a significant number of pages to the topic of “flow of matter and energy” the textbooks did not emphasize the key life science ideas at the core of the analysis. Additionally, despite multiple introductions, the key ideas were embedded in unrelated content making it difficult for students to focus on the main idea (Stern & Roseman, 2004).

The results of the Stern and Roseman study echoed findings of previous studies, in which content and comprehensibility issues were noted (Ambruster, 1996; Chambliss and Calfee, 1989; Sinatra & Dole, 1993). While the impact of texts on student learning has been examined, limited research exists demonstrating how textbooks are used in the classroom. This leads to a number of questions worthy of exploration, and as such has been an increased focus of study.

Driscoll, Moallem, Dick and Kirby (1994) examined the use of the textbook during a three week unit in an eighth grade science class. Their study sought to answer the question of how the textbook contributes to learning within the public
school environment. The Driscoll study took place within the context of one heterogeneous, eighth grade science classroom taught by an experienced teacher with more than 25 years of experience (Driscoll, Moallem, Dick, & Kirby, 1994). In terms of motivation and achievement, the students in the study were characterized as slightly below average.

Data collection for the Driscoll study took a number of forms including observations, surveys, interviews, document analysis, and student performance. The following listing outlines the focus questions utilized by the researchers to document the patterns of textbook usage within the classroom (Driscoll, Moallem, Dick, & Kirby, 1994):

- What does the teacher do to initiate text usage in class?
- What is the activity involving the textbook?
- What are the students doing with the text? Is everyone using the same thing?
- How do worksheets/overheads relate to the text?
- Do all students have a book? Who does and who does not?
- Where do the students appear to keep their books?
- What shape are the books in? Are they covered? Do the students write in them?
- What does the teacher say about the use of text outside the class? What directions/assignments does he/she give?
- What do the students say about their out-of-class text use?
- Does the physical environment of the classroom relate to text use, to facilitate or impede it?

Results of the study showed that textbook reference occurred during eight of thirteen instructional periods. Furthermore, this study of textbook usage revealed that the
textbook served as the basis of instruction for conveying information, and teaching vocabulary and study skills. It is important to note that this teacher employed other instructional methods for problem solving (Driscoll, Moallem, Dick, & Kirby, 1994). These findings are consistent with previous studies indicating that textbooks are the predominant influence on science instruction.

More importantly, the Driscoll study suggests that textbook usage by students is resultant from teacher initiated cueing. Students brought their books to class when prompted by their teacher to do so, and referred to them during class only when prompted by the teacher (Driscoll, Moallem, Dick, & Kirby, 1994). As expected, during student interviews some students reported difficulty in comprehending the text leading back to the content and comprehensibility issues mentioned previously.

Aggregate research has revealed that students who have difficulty reading and comprehending science content also possess limited proficiency in integrating the literacy skills of listening, speaking, reading, and writing (Casteel & Isom, 1994). Casteel and Isom (1994) assert that literacy-based instruction can support students' interest in science content while providing an avenue for extending scientific knowledge. In support of this claim, Casteel and Isom draw on the similarities between the parallel processes of science process skills and literacy process skills. Science process skills form the foundation for conducting science within a framework. Students engaged in scientific endeavors must make observations and predictions, organize ideas, draw conclusions, and communicate their ideas to others. Similarly, the literacy processes of purpose setting, predicting, organizing ideas, and
evaluation ultimately result in the comprehension and communication of ideas.

Incorporating literacy skills support the development of science process skills. Prior to making a hypothesis, one must have a purpose in mind for conducting the research. In this sense, the literacy process skill is necessary to complete the science process skill and therefore the two processes feed one another thereby improving understanding in both areas (Casteel & Isom, 1994).

While research suggests that the inclusion of reading strategies promotes increased comprehension, few teachers include reading instruction as part of their normal instructional routine (Pressley in Radcliffe, Caverly, Peterson, & Emmons, 2004). Additionally, little research exists supporting the effectiveness of the popular SQ3R study-reading strategy in comparison to traditional approaches (Haury in Radcliffe, Caverly, Peterson, & Emmons, 2004). However, a newer reading-study strategy called PLAN (acronym for Plan, Locate, Add, and Note) has been shown to be effective with middle school students. As such, Radcliffe, Caverly, Peterson and Emmons (2004) introduced the comprehension strategy into one of the researchers’ own middle school science classrooms.

Caverly, a teacher at a small rural middle school, used the fifteen students in his seventh grade class and the eighteen students in his eighth grade science class at the study participants. Reading comprehension tests, reading strategy checklists and student-created concept maps served as the data sources for this study. The study proceeded in phases, during which time the teacher prepared for the strategy, implemented the strategy in the classroom, and integrated the strategy as part of the
classroom routine (Radcliffe, Caverly, Peterson, & Emmons, 2004). A culture shift emerged because of this study. Following the study, students not only completed textbook assignments, but learned science content from the textbook as well. While the results seen in Caverly’s classrooms seem promising, there are a number of other findings of note. Implementing the PLAN strategy involved substantial time and effort on the part of the teacher. It was also documented that the learning benefits associated with the strategy took time to develop. Finally, the teacher in this study modified the strategy to fit his own instructional needs.

So the question remains, can textbooks effectively be used to develop conceptual understanding in science? It would seem that if we expect to use textbooks as a means for promoting the learning of science, then as an educational entity we must define the role and expectations of our text usage and align our educational goals accordingly.

**Multimodal Text and Alternative Reading**

By definition science textbooks are multimodal in the sense that the text incorporates both visual and graphic elements. Additionally, a number of science textbooks are also available in an audio format. Utilizing the additional element of sound may help students construct meaning by connecting what is seen to what is heard. The incorporation of sound may also have the effect of bringing the text to life thereby making it a topic viewed by the students as “real” and worthy of study.

One difficulty for students when reading scientific text is that they lack the prior knowledge needed to make connections within the text. Incorporating multiple levels
of instructional resources can provide a balanced curriculum in which students of all reading levels are provided the opportunity to achieve success. A combination of literature including tradebooks, children’s literature, primary source documents, webquests, news articles, and scientific magazines can all promote the development of scientific literacy, as they can provide the foundation from which to develop conceptual knowledge.

While some of these alternative literature sources could be viewed as optional, development of scientifically literate citizens would seem to suggest that news articles and science-based magazines should be included as part of the instructional curriculum. In response to the prevalence of scientific research reported in the media, researchers have begun to examine how individuals evaluate science news in the print media. Findings suggest that students lack the evaluation skills necessary to this form of scientific literacy (Kachan, Guilbert, & Bisanz, 2006).

Kachan, Guilbert and Bisanz (2006) sought to understand the current and potential uses of media reports in Canadian classrooms. Science education policy documents and provincial assessment materials were examined for references to the use of media reports. Additionally, interviews were conducted with secondary teachers to determine their practices and views on using media reports in their instruction (Kachan, Guilbert, & Bisanz, 2006).

Results of this study showed that while few references to media reports were noted within policy documents, 46% of exam items contained citations linked to four categories including popularizations, formal education and instruction, genres of
communication among scientists, and a category entitled other (Kachan, Guilbert, & Bisanz, 2006). As predicted, researchers found that classroom discussions reflected current topics in science news reports. Seventy-one percent of teachers interviewed reported using newspapers as source material, while fifty-eight percent reported using magazines. The internet, television, radio and professional journal articles were also cited as sources of media reports used within the classroom (Kachan, Guilbert, & Bisanz, 2006).

Developing student’s critical thinking skills is essential to the development of conceptual knowledge and promotion of scientific literacy. The majority of teachers involved in the Kachan study agreed that media reports could help students develop critical evaluation skills. Additionally, exposing students to multiple genres may act to increase motivation and interest in science related topics.

Writing

Writing in the science classroom is equally as important as reading in the science classroom. Not only must students read for comprehension, they must also be able to transform their own findings and ideas into written text. The value of writing-to-learn has been widely promoted by a number of researchers (Champagene & Kouba, 1999; Hand et al., 1999; Kelly & Chen, 1999 in Hand, 2002). Writing about science provides an arena for students to revise, reflect, and consolidate the scientific information obtained through laboratory activities, lectures, class discussions, reading assignments, and media sources (Prain & Hand, 1996; Yore, Hand, & Prain, 2002).
While many educators are supportive of the writing-to-learn movement, there are those who do not believe writing has the power to bring about conceptual change (Rowell, 1997). Moreover, even among supporters, much debate exists regarding the types of writing that will enable students to learn about science while simultaneously demonstrating understanding of scientific concepts. The modernist and postmodernist perspectives support the use of technical language and traditional writing forms and therefore do not embrace the potential of writing to learn strategies. Constructivist approaches view writing as an active process in which students are given multiple opportunities to articulate, defend, and explain their ideas within the context of the classroom (Prain & Hand, 1996).

**Student Perceptions and Quality of Writing**

While a number of studies have explored the link between student perceptions on the learning and understanding of science and scientific concepts, student perceptions on writing have been largely overlooked (Prain & Hand, 1999). As part of a long-term research project, Prain and Hand (1999) attempted to determine if students’ perceptions on writing for learning changed as a result of expanded usage of writing for learning in science. As part of the experimental framework students were exposed to a variety of diversified writing tasks, including the creation of brochures, letter writing, newspaper articles, posters, concept maps, and slide show presentations (Prain & Hand, 1999).

Through interviews and observation, it was shown that students reacted positively to the inclusion of these writing tasks. Additionally, student responses indicated that
students held negative attitudes toward the passive style writing tasks previously used within the classroom (Prain & Hand, 1999). Interestingly, students attributed the use of diversified writing tasks to increased learning and were able to identify the metacognitive aspects associated with these types of writing tasks. Furthermore, it was shown that students expressed increased ownership over their learning which in turn equated to positive attitudes toward learning. However, student responses as to the purpose of utilizing diversified writing revealed that students were not able to understand the broad scope of including writing to learn strategies. Students had given little, if any, thought as to the purpose of the activities yet they were able to clearly identify the learning gains experienced resulting from the tasks (Prain & Hand, 1999).

In another study focused on student perception, Levine and Geldman-Caspar (1996), examined writing preference and quality by gender in relation to five informal science related writing tasks. Previous research suggested a causative link between gender-related writing differences and gender differences in reading patterns (Levine & Geldman-Caspar, 1996). Furthermore, studies within the United States revealed differences in children’s literature preferences between boys and girls. As a result, examining the relationship between these changes and subsequent writing preference and performance seemed to be a natural extension of the existing research base.

The writing samples used in the Levine study were drawn from a sample of 374 seventh-grade boys and girls from two schools within the United States. Neither school in the study placed an emphasis on writing in the science classroom (Levine &
Geldman-Caspar, 1996). Students were asked to choose one of five defined writing tasks, each of which exemplified a different writing style including expressive writing, descriptive writing, narrative writing, dialogue, and free writing. Each of the tasks required students to express a personal viewpoint on a science related topic (Levine & Geldman-Caspar, 1996).

The Levine study (1996) revealed a number of differences between the writing preference and quality of writing exhibited between boys and girls. In terms of task preference, boys demonstrated a definite preference for informative style writing as opposed to girls whose choice selections did not indicate any particular preference. The science-related descriptions portrayed in the writing suggest that boys have a more imaginative perspective whereas girls writing tended to personify practicality. The data from this study also suggest that girls produced longer, more detailed, expressive writing than their male counterparts (Levine & Geldman-Caspar, 1996). Striking similarities were noted in this study as well. Overall, the quality of writing was considered to be relatively poor, receiving holistic ratings of low or intermediate. Additionally, with regard to science concepts, both boys and girls showed only superficial understanding of terminology rather than concept. It was noted that occasionally the writer expressed a sense of pride when describing personal science-related experience particularly when they were complimented by parents or friends (Levine & Geldman-Caspar, 1996).

Both the Prain and Hand (1999) and Levine and Geldman-Caspar (1996) studies suggest a need to incorporate non-traditional writing tasks into the curriculum. If our
goal is to promote scientific literacy and positive attitudes toward science then it makes sense to include opportunities for students to develop conceptual knowledge in an atmosphere they are comfortable with. These studies suggest that students need and are open to writing tasks that allow them to interact with the material.

Writing to Learn Strategies and Writing Heuristics

The writing to learn movement promotes the inclusion of informal writing tasks into all disciplines. Writing to learn strategies focus on the power of expressive writing to associate concepts with language. The role of writing in the development of conceptual knowledge has been the focus of many research studies in recent years (Hand, 1999; Hand & Prain, 2002; Keys, 1999; Mason & Boscolo, 2000). Research on writing to learn in science does not conclusively define the types of writing that should be emphasized, nor does it clearly indicate a superior instructional method as a means of promoting scientific literacy. However, if students are to expand their learning through writing, then teachers must coordinate purpose with strategies that enable students to meet the expected goals (Garaway in Hand & Prain, 2002).

Using past research into writing as a model, Hand and Prain (2002) devised a writing to learn framework to assist educators in planning writing to learn strategies. The five essential elements of their framework include methods of text production, audience, purpose, type, and topic, all of which provide a foundation for the writing demands associated with learning science through writing.

McNeill, Lizotte, Krajicik, and Marx (2006) looked at the effect of specific scaffolding techniques on the written explanations of seventh-grade students during a
project-based chemistry unit. The work of this research team was in response to claims that students have difficulties in explaining scientific phenomenon. Students have shown deficits in their abilities to provide evidence for claims. In addition, difficulties have also been noted in students’ ability to provide a rationale for their evidence (McNeill, Lizotte, Krajcik, & Marx, 2006). The research group devised an instructional model of claim, evidence, and reasoning targeted to middle-level science students.

As part of this scaffolding study, students were placed in one of two treatment groups, continuous scaffolding, or faded scaffolding. Both treatment groups were given written prompts at six points during the unit; however, students in the faded scaffolding group were given less detail in their prompts over time. The research team was looking to determine if the type of writing prompt had an effect on the construction of scientific explanations by the students. As a comparison, let us look at the stage three written prompts for both treatment groups (McNeill, Lizotte, Krajcik, & Marx, 2006). Students receiving continuous scaffolding were given the following prompt:

*Claim (Write a sentence that states whether mass stayed the same or changed.)*

*One piece of evidence (provide one piece of data that supports your claim whether mass stayed the same or changed.)*

*Evidence #1*

*Reasoning (Write a statement that connects your evidence to your claim whether mass stayed the same or changed).*
As opposed to the students in the faded scaffolding group who received this stage three prompt:

*Remember to include claim, evidence, and reasoning*

The results of the study demonstrated that students showed an increase in claim, evidence, and reasoning scores during in-class explanations regardless of the type of treatment they received. Examination of posttest explanations revealed students in the faded scaffolding group scored marginally higher than those students who had received continuous prompts throughout the investigation, thereby suggesting that faded scaffolding holds the potential to produce greater student gains in reasoning for items without scaffolds (McNeill, Lizotte, Krajcik, & Marx, 2006).

Resultant from this study on writing scaffolds, McNeill, Lizotte, Krajcik and Marx (2006) assert that providing written scaffolds results in stronger written scientific explanations. Moreover, the researchers’ purport that students are better equipped to write explanations when not provided support as a result of exposure to context-specific and generic fading prompts. A causal relationship between performance, content knowledge, and ability was also suggested as a result of the study (McNeill, Lizotte, Krajcik, & Marx, 2006).

In a parallel vein, Keys and Hand developed the science writing heuristic (SWH) as a means of helping both teachers and students develop conceptual knowledge through writing during laboratory investigations. The SWH is a dual writing framework that provides the teacher with a model for designing activities to promote
understanding through laboratory investigations and the student with a model to shape thinking during laboratory investigations (Keys, Hand, Prain, & Collins, 1999). Keys, Hand, Prain, and Collins (1999) sought to examine the extent with which using the SWH would change students conceptual knowledge about stream pollution based when faced with tests and evidence. Study participants were from two eighth-grade earth science classes in the same school, of which students were further divided into groups of four or five. To ensure a heterogeneous mixture within each group, the teacher performed the group selection (Keys, Hand, Prain, & Collins, 1999). Five interventions, including the creation of preliminary concept maps, journal entries, team discussions, report writing, and final concept maps were incorporated during the eight-week investigation. Prior to the report writing, the teacher issued explicit instructions and expectations for the student writing. Furthermore, the teacher modeled her expectations through representative writing samples to ensure the students were able to differentiate between strong and weak writing (Keys, Hand, Prain, & Collins, 1999).

While results of this study indicated students developed more detailed understandings, it was not shown that large conceptual changes about the nature of science had occurred because of the SWH. Furthermore, it was suggested that as the students gain experience using the SWH greater change might become evident (Keys, Hand, Prain, & Collins, 1999).

In a similar study, Hand, Wallace and Yang (2004) sought to correlate the effectiveness of using the SWH and a textbook writing activity to increased
conceptual understanding over students using traditional laboratory formats.

Additionally, the trio was interested in whether the additional textbook writing activity would further enhance learning (Hand, Wallace, & Yang, 2004). For this study, the group used 93 seventh-grade students enrolled in one of five class sections. In a quasi-experimental design, one class section served as the control group, two sections entitled the SG group and two sections labeled as the STG group. The primary mode of instruction was the same for all three groups; the variation came in the form of the writing activities completed by the students in response to three laboratory activities included as part of instruction. Students in the CG group completed traditional laboratory reports for each activity, whereas the SG and STG groups used the SWH for laboratory investigations. Additionally students in the SG completed a research paper summarizing the unit's practical activities, while the STG group completed a written summary in the form of a textbook explanation (Hand, Wallace, & Yang, 2004).

Results of this secondary study revealed that students in both the SG and STG groups outperformed the control group on multiple-choice questions, and one of three conceptual essay questions. These findings are suggestive that the SWH and textbook writing tasks are effective methods for increasing students' conceptual knowledge of the topic (Hand, Wallace, & Yang, 2004).

While this is not an exhaustive listing of the writing frameworks available, the results provided in the above examples would suggest that opportunity exists for
utilizing writing as a means of developing increased conceptual knowledge in science.

**Types of Genre Writing**

As mentioned previously, much debate exists regarding the types of writing that will enable students to learn about science while simultaneously demonstrating understanding of scientific concepts. At the center of this controversy is the use of creative writing in the science classroom. Some are of the belief that creative writing detracts from the development of conceptual knowledge and accentuates the premise that scientific writing is innately boring and incomprehensible to the masses (Keys, 1999). However, proponents of creative writing assert that creativity and imagination are integral aspects of science (Medewar in Massoudi, 2003), and that exposure to multiple writing genres can build conceptual knowledge in science.

Writing differs from other learning activities in that writing is an individualized reflection of who we are and what we believe. For students to engage in science, sustained interest and knowledge of the language of science are necessary. The language of science, taught through writing in science, is a precursor to learning and doing science (LaBonty & Danielson, 2005).

A number of creative formats are available that may promote increased understanding while simultaneously developing student interest in science. The following is a listing of possible formats and applications for use within the classroom (Prain & Hand, 1996).
Narratives provide students with the opportunity to demonstrate their understanding of procedural knowledge, to create stories outlining the interdependence between concepts, and to generate stories allowing them to demonstrate understanding from an alternative perspective or viewpoint.

Travelogues provide a creative method for allowing students to describe particular locations.

Instructional Manuals can take many formats. Students could be asked to write a manual outlining how to use a particular piece of laboratory equipment, such as the microscope, or perhaps rewrite portions of the text to clarify a topic for younger students.

Expository writing can take many forms including debates on controversial topics, skits describing a particular science process, or even role-playing scripts.

Concept Maps help students connect terms and ideas within the scope of the overarching topic.

Posters can help students express content knowledge on a particular topic while simultaneously teaching them how to select important ideas from subordinate material.

Scientific Reports fall under the traditional classification of writing in science, and provide an outlet for students to describe information from laboratory investigations, convey knowledge attained through research, and provide written explanations of scientific concepts.
Journal Writing provides an informal avenue for students to document predictions, observations or explanations of experiments. Furthermore, this type of writing provides for ongoing reaction to a topic, allowing the writer to connect personally with the material.

Letter writing provides an opportunity for the student to get personally involved with an issue relating to society.

Poetry provides students with an opportunity to document reaction to a scientific concept, refine conceptual knowledge of a process, and to reflect on their own role as a learner of science.

The connection between science and poetry has been documented within the research base. Poetry, by nature, assimilates a number of elements essential to science as a human endeavor. The development of figurative language, a precursor to abstract thinking, is enhanced through poetry. In alignment with the science process skills, writing poetry requires students to become careful observers (LaBonty & Danielson, 2005). Additionally, writing poetry helps students to develop the trait of voice within their writing.

While controversy may continue to exist as to the best formats for utilizing writing to learn strategies, Prain and Hand (1996) assert that if the purpose, audience, and genres are varied then student learning will be enhanced. Additionally, students must recognize that writing is a powerful medium for learning about science and can serve a range of purposes within the scientific community (Hand, Prain, Lawrence, & Yore, 2005).
1999). Rowell (1997) contends that science writing encompasses three overlapping dimensions, an exploratory function, a transformative function, and a discursive role.

**Reaction and Instructional Implications**

When a truly effective literacy-science connection is created in the classroom, both the literacy and the science work undertaken by students makes sense in terms of both disciplines (Saul, 2004), yet it would seem that accountability for writing has followed the same path as accountability for reading. Historically, a number of science teachers have made the claim that teaching reading is not an essential element of their jobs, nor do they have the time to incorporate reading instruction into an already overloaded curriculum. The same premise appears to be emerging in regards to writing, as it is often assumed that science literacy would be gained through language classes (Rowell, 1997).

In response to documented deficits in writing, the ability to communicate in science through writing has recently moved to the forefront of reform movements. As shown in the Prain and Hand study on student perceptions, "to enrich students’ understanding of the value and use of writing for learning in science, students will need to be given writing tasks that require them to explore and consolidate understandings, and also to reflect on their own learning from writing." (Prain & Hand, 1999)

If, as Hand and Prain suggest, students will need to communicate with numerous audiences and utilize various genres as professional scientists, doesn’t it seem that we should teach students to read and write in different genre and for different audiences?
Chapter 3: Application and Evaluation

Introduction

Research clearly shows that the integration of literacy strategies may provide increased learning gains among students. However, it is not clear which literacy component if any provides the greatest opportunity for meeting the educational goals of today’s classrooms. An action research plan exploring the efficacy of literacy strategies, particularly writing, was conducted throughout May and June of 2007 at a small suburban/rural, parochial school in Western New York.

The overarching objective of the project was to create a positive learning environment that simultaneously promoted literacy, scientific literacy, and positive attitudes toward learning science. Typically, as is the case in many middle school science classrooms, writing typically centers on lab reports or other research style written works. This project incorporated non-traditional literacy components including children’s literature, poetry, nature journaling, and creative writing prompts into the science curriculum as a means to develop a deeper understanding of the concepts under study.

Participants

The study participants included 65 seventh-grade students (25 boys and 40 girls) from three heterogeneous, life science classes in a parochial school in Western, NY. At parental request, two students were excluded from the study. The school is located along the Niagara escarpment, in the heart of Niagara County within a community of 22,279 inhabitants. The school is a regional school comprised of students from nine
neighboring districts covering three counties. The bulk of the student population resides in rural or semi-rural areas. The median family income differs marginally by county and ranges from $36,942 to $40,640 annually. On average, twelve-percent of the population residing in this area is at or below the state poverty level. Student attendance per family serves as the basis for tuition rates, with the single child rate being $3,336 annually.

**Procedures and Instruments of Study**

The research project took place within the unit on animals and animal behavior. Topics of study during the project included invertebrates, fish, amphibians, and reptiles. Typical instruction combines computer-enhanced lectures, guided note packets, student-centered activities, and laboratory experiences as a means of introducing and reinforcing the content. While these methods were still utilized throughout the research period, alternative literacy activities were embedded as a means of enhancing instruction. The students were introduced to invertebrates through children's literature, including Doreen Cronin's "Diary of a Worm" and "Diary of a Spider". Culminating activities for the unit included the creation of a children's book based on the invertebrate of their choice, and a writing portfolio that included the writing components completed throughout the unit.

**Quantitative**

Multiple methods were utilized to assess student understanding throughout the unit. Students completed pretests, posttests, laboratory reports, and a comprehensive writing portfolio highlighting the work completed throughout the research period.
Initial assessment information was compiled from student created KWL charts, and pretest results. Just prior to the instructional period, students completed a 25-item pretest consisting of multiple choice and short answer questions from the textbook question bank and online website. The test items correlated to the material taught throughout the research period and measured basic knowledge at the recall and comprehension levels. As a follow-up measure, students completed the same test one week after the conclusion of the research period. The posttest was administered with no advance notice to preclude the possible bias from students who would study in accordance with the pre-established routine for test preparation utilized throughout the year.

Through the course of the year, students wrote traditional laboratory reports as a means of summarizing the laboratory activities performed in class. Typically, formal labs were conducted biweekly though the frequency varied slightly over the course of the year. Prior to the instructional period students had completed 13 lab reports following the traditional format. Throughout the year, it was noted that many students found it difficult to draw connections between the activities and other phenomena occurring in their worlds. The conclusions were often skeletal-like with very little supporting information. For this unit, students completed three modified lab reports following the earthworm, frog, and owl pellet dissections incorporated into the unit. The modified laboratory reports focused on the development of the conclusion writing aspect of the lab report. Students were given a writing scaffold with guiding questions to organize the observations made during the lab. Key
categories of the writing scaffold included, "I observed", "I noticed", "It reminds me of", "This is so because", "I am curious about", "It surprised me that", and "I wonder what would happen if". Through this scaffolding, it was expected that the modified lab reports would provide more detailed insight into the students' thought processes as they engage in laboratory experiences.

The final quantitative assessment measure was the writing portfolio in which the students organized the writing elements completed throughout the unit. These writing pieces included nature journal entries, poems, a children's story based on an invertebrate of their choice, and three modified lab reports. Detailed instruction was provided for each of these major components, and student progress was monitored throughout the instructional period. Student portfolios were analyzed for content, idea development, and conceptual understanding.

**Qualitative**

In addition to the quantitative assessment, multiple measures were utilized to determine student attitudes and beliefs toward science. Prior to the instructional period, students completed a thirty-question summative survey assessing general attitudes toward science and the topics being studied. The survey examined student interest and attitudes about science, study habits, and student beliefs about writing. Student responses were rated on a Likert-style scale of 1-5 where students selected from the following responses, "strongly disagree", "disagree", "neutral", "agree", and "strongly agree". Additionally, seven students completed audiotaped interviews in which they shared their personal attitudes and beliefs about science. Students were
asked questions that sought to answer whether students integrated science into their everyday life or viewed science as an individual entity separate from them. Subsequently, student responses were transcribed so that item analysis could be performed.

Furthermore, as part of the portfolio process, students were required to include a reflection letter in which they provided an overview of the process, an assessment of the difficulty level in completing the writing components, as well as their overall attitudinal response to the project. It was explained to the students that the portfolio was a reflection of them, and that it provided a structured opportunity in which to share their creative talents. Additionally, teacher-created examples were provided to the students as models to stimulate thinking particularly for those students who have difficulty expressing their views in writing.

Chapter 4: Results

**KWL Charts**

Analysis of the KWL charts revealed that students held limited knowledge of invertebrates. Furthermore, in reviewing the information it was shown that students seemingly have difficulty articulating the information in their schema when asked to generalize within the format of the KWL. Additionally, student responses seemed to suggest little interest in the upcoming topic, as many students did not list any questions under the “what I want to know” column of the chart. Moreover, those students who did complete this section listed very superficial questions about invertebrates. On average, of those students completing the “W” section, only one
question was listed for that section. The most common response questioned why invertebrates are lacking a backbone. Only three students deviated from this thought pattern. Their questions included:

- “Can an animal ever turn from a vertebrate into an invertebrate?”
- “Can an invertebrate have a skull but no backbone?”
- “Do beetles mind being stepped on?”

It is unclear from these responses whether students lack interest in science, do not think about science, or merely have difficulty in deciding on questions they feel merit a response.

**Pretest and Posttest Results**

Seven students were excluded from the testing results due to absences on either the pretest or posttest dates. Overall, 95% of the students showed increases in test scores between the pretest and posttest. Five students showed an apparent decline in performance based on the testing results. In each of these cases, the incorrect responses were on the multiple-choice section of the test. Since it is not likely that the students would regress in terms of knowledge, these results suggest that the students may have correctly guessed at some questions on the pretest. Additionally, despite a decline in the performance on the multiple-choice section, all five students showed positive increases in the number of correct short answer responses. As shown in Graph 1, twenty-six percent of the students showed an 11-20% increase in performance following the instructional period. Performance gains were also noted in the 21-30% range, with twenty-three percent of the students falling into this group.
Statistical analysis of the test results yielded an increase in the number of correct responses to be 5.2 +/- 0.995. As shown in Graph 2, the largest increase in student learning was exhibited by those students classified as high ability students. Ability level was predetermined based on previous achievement in science. On average, students in this group answered an additional 7.2 questions correctly on the posttest. Individual results from this group ranged from 0-12, with two students showing a net increase of 12 correct responses between assessments. Students classified into the low ability group did show an increase in the number of questions answered correctly, however the net gain of 1.8 was much lower than that seen in the other two groups.

Graph 2. Learning gains between ability groups
Lab Reports

The conclusion section of the lab reports showed a slight increase in student connection and curiosity when using the writing scaffold. The majority of students expressed similar connections but displayed variety in terms of their curiosity. For the earthworm and frog dissections, a number of students reported that the dissections reminded them of being doctors and performing surgery or autopsies. Unexpectedly, student views of the owl pellet dissection were different with very few students referencing medical connections. For the owl pellet dissection, many students reported feeling like archaeologists as they picked through their pellets in search of bones. Many students also related the owl pellets to hairballs in cats.

Students expressed the most curiosity during the owl pellet dissection. The students were surprised by the number of bones found in a single owl pellet. As an extension of the lab, students were encouraged to create a model using the bones found within the owl pellet. Students used the charts from the lab activity to determine the type of creature discovered and the correct arrangement of bones. Approximately twenty-percent of the students completed the extension activity as shown in figure 4.
However, the overall quality of the modified laboratory reports was lower than previously shown in the traditional format. Using the modified format, students were able to draw connections but did not discuss those connections in detail. When using the traditional lab report format, students wrote conclusions in excess of 250 words. When using the writing scaffolds, students actually wrote less with many conclusions ranging between 75-100 words. Limited exposure to this type of format might explain the observed decrease in the quality. Using this scaffold over an extended period would likely result in improvement as students become accustomed to using the format.

**Writing Frames**

Opinion-based writing frames were utilized to help students develop written explanations linking cause and effect relationships. Additionally, the writing frames were employed as a means of measuring students' attitudes and beliefs toward science. Similar to the trend in the laboratory reports, students generally wrote less than was expected. As shown by the following writing frame excerpts, a number of students hold negative views about science. Often the students attributed negative beliefs to ability. When asked, “are you a scientist”, ten-percent of the students reported that they could not be scientists because science is too difficult for them.

“No. I do not like science. I hate doing dissections and lab reports. Science is too hard for me. Science is not my strong point.”

“I would say I am not a scientist. Even though I enjoy science, I am not always good at science. I try hard to do well but sometimes it is not good enough. I don’t think I am dedicated enough to become a scientist. Science is very interesting. I love doing the experiments, but not enough to become a scientist.”
“I don’t think I’m a scientist. I don’t really enjoy science that much; I find it kind of confusing. I never fully understood all the strange concepts in science to begin with. Sometimes science can be interesting, but all in all my opinion is that it is quite boring. I don’t think I was put on Earth to become a scientist. I’m positive about that.”

“I would not consider myself a scientist. In order to be a scientist you have to know a lot about science, which I don’t. Yes, I know some basic things about science, but not in depth. I don’t think I would be a good scientists, but I like a challenge so maybe someday I will be.”

“I’m not a scientist because I don’t like it that much and it is not best subject.”

“I am not a scientist. I can’t be a scientist because science is too complicated for me. Then again, you can probably be a scientist and not even know it. Since science is about what is around you, I must be a scientist once in awhile.”

Approximately forty-five percent of the students felt that they were scientists. In general, responses from this group of students were slightly more detailed than those who did not view themselves as scientists. As shown by the following excerpts, the written explanations by students in this group varied in format when compared to those students who did not view themselves as scientists. The students who viewed themselves as scientists stated a claim followed by supporting details. This is in contrast to the students who do not view themselves as scientists who offered attributions, such as difficulty level, as a rationale for the claim.

“Science is testing ideas through the process of experimentation. It has to do with finding the answer to a question in the world. I would have to say that everyone is a bit of a scientist, because at times we all try to find the answers we are looking for. It’s natural to be curious about things we don’t understand, and all science is the fulfillment of curiosity.”

“I think that everyone who practices science is a scientific person. Everyone practices science by living. So I am a scientific person. Scientists are people who practice science for a hobby that they do very often or their profession. So I am not a scientist, but someday I wouldn’t mind being one.”
"I think I am a scientist because when you study science you have some qualities of a real scientist. I study science everyday in school, so I get the basic knowledge of science that some famous scientists first learned. So in the end I do think I am a scientists. In reality, everyone is a scientist."

"I believe that everyone is a scientist. This because we are all curious about something sometime in our life. We all wonder about different things and try to find the answer. This is what all scientists do everyday. We watch new and exciting things happen all around us, such as a spider spinning a web, dew on the ground and other fascinating things to explore and learn about."

The remaining forty-five percent of students were either undecided or felt they were not scientists for some reason other than ability. In terms of detail, the responses to the other writing frames were similar to those seen here.

**Survey Results**

Due to student absences, only 61 students completed the anonymous questionnaire. Additionally, failure to correctly respond to the control question resulted in the exclusion of three surveys. Using a Likert-style scale of 1-5, students selected from the following responses, "strongly disagree", "disagree", "neutral", "agree", and "strongly agree". As shown in Graph 3, students selected neutral for more than ¾ of the questions asked on the survey. Of the three survey sections, students more frequently selected neutral to the questions in the attitude and writing sections of the survey. The second most frequent tendency was to agree with the question as posed.
While fifty-three percent of students responded that studying science changes their perception of how the world works (Graph 4), a large percentage of students do not hold an opinion either way.

Similarly, while forty-five percent of the students expressed the belief that science is related to their real-world experiences, twenty percent reported that science does not relate to their world and another thirty-four percent held no opinion (Graph 5).
These figures are quite disconcerting, considering the goal of science education is to promote scientific literacy.

The subject of science has little relation to what I experience in the real world.

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Strongly Agree</td>
<td>3.45%</td>
</tr>
<tr>
<td>Agree</td>
<td>17.24%</td>
</tr>
<tr>
<td>Neutral</td>
<td>34.48%</td>
</tr>
<tr>
<td>Disagree</td>
<td>31.03%</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>13.79%</td>
</tr>
</tbody>
</table>

Graph 5 – Relationship between science and real-world experiences

As shown in Graph 6, student responses show a high correlation between teacher effectiveness and student comprehension.

I cannot learn science does not explain thin

<table>
<thead>
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<th>Rating</th>
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<tbody>
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<td>5.17%</td>
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</table>

Graph 6 – Relationship between teacher effectiveness and student comprehension

Student Interviews

Seven students, four males and three females, participated in audiotaped interviews in which they expressed their attitudes and beliefs toward science. When asked, “Do you think about science experiences occurring in your everyday life, and
can you provide any examples", only three of the seven interviewees responded that they do in fact think about science in their everyday lives. In most cases, the examples provided dealt with the natural world. One student reported daily observations of a robin's nest outside a window in their home. Another student talked about plant growth. When asked whether they believe everyone is capable of understanding science, six of the seven students agreed that with work everyone is capable of understanding science.

All seven students responded positively when asked if anything they have learned in science has changed their ideas about how the world works. Several of the examples demonstrated dramatic shifts in thinking about their own personal relationship with the world around them. One student related a change in his appreciation of the world. The student talked about how previously he stomped on bird eggs, but now would probably just look at and admire them. Another student related how her increased knowledge of plants has led to more frequent observations of the plants she encounters. One student even shared that her eating habits have changed because of her scientific knowledge.

The students offered varying responses when asked, "Do you answer questions to the best of your ability when called on by the teacher?" In some cases the students did not answer as thoroughly as they could have for fear that their peers would deem them as science "geeks". In their minds, the desire to fit in with their peers tended to outweigh the fact that they liked science. On the opposite end of the spectrum, some students were more interested in impressing the teacher rather than their peers.
Additionally, despite their motivation for participating in the classroom, all seven students reported engaging in science activities at home. Activities included performing experiments, watching science-related television shows, and reading scientific literature.

**Children's Books**

One of the major writing pieces in the unit included the creation of a scientifically accurate children's story based on the invertebrate of their choosing. Students were provided systematic instruction in the area of writing a children's book. "Diary of a Worm" and "Diary of a Spider" by Doreen Cronin was provided as models of the expected format. Students were given the option to work alone or in small groups of up to three students. The finished stories were to be shared with the first-grade students in the school. Throughout the unit, student progress was monitored and feedback was given following each procedural step. Overall, the finished stories were of high quality. Illustrations were predominately hand drawn, though some students opted to utilize computer graphics programs (figure 5). In addition to

![Figure 5 - story illustrations](image-url)
meeting the assignment requirements for scientific information (figure 6), the students included elements from their own personal lives. In the example below (figure 7), the student talks about the upcoming end of the school year.

Figure 6 – Scientific Information

Figure 7 – Personal Connection

Some students incorporated cross-curricular historical perspectives, such as the story about Curtis the Clam set back in 1492 (figure 8). Additionally, while it was not a
requirement, almost every book wove a moral into the story. The examples below incorporated service and teamwork (figure 9) into the context of the stories.

Student comments on writing the children’s stories were very positive. The written responses indicated the students really enjoyed the process. They expressed both pride and excitement about their finished works. One student wrote, “The part I enjoyed most about the animal unit was writing the children’s book. I liked writing the story for the kids and did not think of the grade very much. I think the kids will enjoy it very much.” Another student who had written the book with a partner wrote, “I think I can speak for the both of us, especially me when I say it was fun to put this story together. I loved writing it!”

Figure 9 – Incorporation of morals
**Student thoughts on the portfolio process**

The culminating activity for the unit included the creation of a writing portfolio. Required portfolio elements included an introductory letter, lab reports for the three dissections, five weeks of natural journal entries, the children’s book, writing frames completed throughout the unit, and a closing letter of reflection. Creating the portfolios provided the students with the opportunity to be creative and infuse their own personality into their work. The portfolios showed that the students thought about the process as they put the portfolio together. Figure 10 shows the divider one student created to introduce the earthworm, frog and owl pellet dissections.

![Figure 10 - portfolio divider](image)

Some of the students wrote the introductory letter into a true letter format, including presentation in an envelope, as shown in figure 11.

![Figure 11 - introductory letter](image)
Figure 12 shows more examples of the types of dividers the students created to delineate the portfolio sections.

Based on student comments, the nature journal section of the portfolio seemed to have the biggest impact on the students. One student included the following as part of the reflection letter, "I especially liked doing the nature journals because it helped me get in touch with nature and notice all of the things around me. God created a beautiful place for us to live, and we just pollute it with harmful chemicals. After the nature journals, I realized how important everything around us is. I am determined to be kinder to Mother Earth now and not pollute or damage this wonderful world that we live in anymore. I love our world and want to keep loving it!" Another student expressed a similar awakening of the mind, "Before I did this portfolio I never actually thought about nature in the way that I do now. Doing this portfolio has changed my perspective on nature....I never used to like to go outside, but I encourage myself even more today to just sit there watching for whatever comes. I would definitely want to do another thing like this, not only in science but in anything...."
that would be possible. I truly think this portfolio has changed my perspective for life.”

Other students expressed similar sentiments indicating the process helped them to appreciate things they had not previously noticed. One student commented, “One of the things I really liked was doing the nature journals. I enjoyed sitting on my little patio chair and just watching all around me. It really gave me time to appreciate the world around me. I never knew we had a woodchuck living somewhere in our vicinity!” Similarly, another student shared the following, “One thing I liked about the portfolio was the nature journaling. It gave me a chance to observe blooming plants and trees and to see many different kinds of birds that I normally wouldn’t notice.” Another student wrote, “I think it was fun and good for me too, because I got to go outside and see nature up close. I also liked it because I never really thought about science this deeply and taken the time to “gather my thoughts”.

It was obvious that the students took the nature journaling seriously, as the entries were very thoughtful and personalized. In addition to the written documentation of their observations, students included drawing, poems, photographs, and even samples from the observation area. As shown in figure 13, one student collected a variety of samples from the observation area and presented them in a colorful, creative way.

![Figure 13 - Samples from Nature Journal](image)
In addition to commenting positively about the nature journals, students also expressed positive comments about the portfolio process as a whole. Many students commented they felt the process was difficult, but the difficulty level did not detract from the enjoyment they derived from the process. One student wrote, “Making this portfolio was one of the most fun projects I have done in awhile. It used my creativity and my brain to complete it and it was very easy for me to finish because I love science and I’m always trying to think in creative ways.” Another student expressed an increased like of science; “I really liked doing this portfolio. This section has really made me like science and understand it a lot more. So thank you for reading my portfolio and planting a seed of science knowledge into my brain.”

For other students, the process helped them to discover new things about themselves. One student wrote, “By finishing this animal portfolio I learned a little bit about myself. I never knew I could draw in so much detail, as I did in the lab reports because I had never been challenged to do so. I also learned that science is a very versatile study. You can do so many things with it and you can relate it to anything going on in our world right now. Although I already knew I enjoyed science, this year and this portfolio has really encouraged me to study science further and maybe do something with this knowledge when I am older.”

Perhaps one of the biggest gains from the project came in the pride and satisfaction the students felt after completing the project. Student comments included, “I am very proud of the finished portfolio and I hope you enjoyed reading it as much as I enjoyed making it”, “I think this portfolio was a fun but challenging
project. It was fun to do some of the sections and see how it all came together”, “When I was done with it I looked back and saw how much I had learned and how much science I enjoyed. Learning about the things in this portfolio was very interesting” and “My favorite part of making this portfolio was when I was finished. I had a feeling of accomplishment and pride and was quite happy with my work. I enjoyed this process and learned a lot.”

It was clear from reading the reflection letters that the writing portfolio positively influenced the students, and all but one student expressed a desire to do similar projects in the future. The desired expectation of having the students complete this project was captured in the concluding remarks of one student’s portfolio. The student had written the following, “When I was writing this portfolio, I often forgot the fact that I was learning new things as I did it.”

Chapter 5: Conclusions and Recommendations

Discussion

The foundational basis of the research sought to explore the efficacy of writing on learning and attitudes in the middle school classroom. Through the inclusion of literacy-based instruction, it was anticipated that students would develop greater conceptual knowledge, improve critical thinking skills, and express greater interest toward reading and writing in the sciences. While minimal information was revealed in regards to the measurement of conceptual knowledge, much knowledge was gained in terms of student attitudes and beliefs toward science.
Analysis of the pretest and posttest results showed learning gains for 95% of the students. On average, the students showed a 17% improvement on the multiple-choice section of the test as compared to a 38% gain on the short answer-section of the test. A number of students within the class employ memorization techniques as a method of test preparation. The impromptu issuing of the test did not allow the students a chance to utilize such techniques, which may have influenced their performance on the multiple-choice section of the test. Additionally, using a multiple-choice construct limits the students’ ability to demonstrate conceptual knowledge. Despite these limitations, the results of this testing are in agreement with previous research that suggests writing serves as a constructivist function in building conceptual knowledge (Keys, 2000; Klein, 1999; Prain & Hand, 1999; Rivard, 1994; Rowell, 1997).

McNeill, Lizotte, Krajick and Marx (2006) assert that providing students with writing scaffolds results in stronger written scientific explanations. Similarly, Key, Hand, Prain, and Collins (1999) also purport that using writing scaffolds promotes more detailed understandings of scientific phenomena. Based on the three laboratory activities completed in this unit, using a writing scaffold did not result in more descriptive written explanations by the students. While the inclusion of personal connections increased using the writing scaffold, in comparison to the traditional format used during the year, a decline in the quality and content of the lab reports was noted. Students’ lack of familiarity with this writing style may partially explain the noted decline in quality seen when using the writing scaffold. Extended usage of the
writing scaffold might yield different results than those seen here. More studies would need to be conducted to verify this.

As noted in the literature review, controversy has shrouded the use of creative writing in the science classroom. Proponents of creative writing assert that creativity and imagination are integral aspects of science (Medewar in Massoudi, 2003; Prain & Hand, 1996), while opponents (Keys, 1999) express the belief that creative writing detracts from the development of conceptual knowledge and accentuates popular belief that scientific writing is innately boring. Additionally, as previously mentioned, student perceptions on writing have also been studied extensively (Levine, 1996; Levine & Geldman-Caspar, 1996; Prain & Hand, 1999). The results of this study support the research base advocating the inclusion of creative writing in the science classroom.

While gender analysis of writing was not incorporated as part of the study, the writing of the students in this group was in contrast to the results of Levine and Goldman-Caspar (1996). The level of detail, length, and qualitative characteristics of the writing samples were similar among the boys and girls. However, as suggested by both Levin (1996) and Hand & Prain (1999) the results of this study support their assertions that it is necessary to include non-traditional writing tasks into the science classroom.

The positive student reaction to this unit is suggestive that students welcome diversity in the classroom. Additionally, the inclusion of extended writing tasks allowed the students to inflect their individualism into their work. The sense of
ownership and pride observed throughout the research period was much higher than had been seen in previous units throughout the year. These observations, combined with the student comments, support the inclusion of using non-traditional writing tasks in the science classroom.

A significant outcome from this study centered on the attitudinal mindset of the students. It was both unexpected and encouraging to witness the transformative power of writing on the students’ attitudes and beliefs toward science. Many students went from observing science as an independent entity to becoming a part of that entity. Even more powerful, was the fact that some students were able to recognize this transformation in themselves. The students who expressed that the project changed their perspective on nature, and now hold a greater appreciation of the world around them demonstrate that middle school students are capable of self-reflection. As we promote stewardship of the Earth, it is important that our youth recognize and appreciate the world around them. Through this appreciation, the alliance of people dedicated to the preservation of the Earth and the betterment of humankind grows.

The student who wrote, “When I was writing this portfolio, I often forgot the fact that I was learning new things as I did it”, embodied the essence of this project.” Learning science should not be difficult; it should be a fun, natural extension of one’s innate curiosities. While the research did not follow the anticipated path, understanding student beliefs provides valuable insight into designing classroom instruction.
Recommendations

While the results of this study support the use of non-traditional writing elements in the science classroom, further research is necessary to validate the outcomes shown here. Since this study was conducted at the conclusion of the 2006-2007 school year when motivation typically wanes, providing a fresh instructional style may have resulted in elevated interest thereby influencing the obtained results. Moreover, research has shown that subject-specific motivational declines are greatest between sixth and seventh grade (Anderman & Maehr, 1994). Providing students with a series of projects that allowed the infusion of personal interest and choice within the confines of a structured assignment may also have contributed to the increase in motivation and student effort observed during this study.

As a validation measure, instructional methods similar to those used in the study will be utilized with this same group of students as they move into eighth-grade science. Quality of writing, perceptions, and student attitudes will be monitored throughout the year to determine if multiple exposures to this mode of instruction continues to yield positive benefits. Additionally, the writing project used for the current research will be used with the incoming seventh-grade class and the results will be compared between the two groups.

In the coming school year, further studies expanding the use of creative writing will be implemented and assessed for attitudinal impact and the efficacy of developing conceptual knowledge. Possible creative writing tasks will include song writing, poetry, plays, advertisements, travel brochures, riddles, epitaphs, and bumper
sticker slogans. The rationale for including these types of tasks is to promote critical thinking about scientific topics by providing students with alternative avenues for learning complex concepts. If the students deem the tasks as fun, they will become more involved in the learning process and less likely to succumb to the negative attributions typically associated with studying science.

If the goal of science education is to promote scientific literacy and positive attitudes toward science, then the inclusion of instructional methods that promote ownership and interest need to be considered when designing the curriculum. Incorporating literacy strategies that provide students with choice and preference may provide the needed balance to sustain motivation and interest in the sciences.

References


