Sponsoring Committee: Dr. Joseph Shosh, Moravian College
Mrs. Rosalie Mancino, Moravian College
Mrs. Kathy Maziarz, Notre Dame of Bethlehem

TO INQUIRE OR NOT TO INQUIRE?

THAT IS NO LONGER THE QUESTION.

Paula Watkins Karabasz

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Tell me I forget.
Teach me and I remember.
Involve me and I learn.

Ben Franklin

ABSTRACT

This qualitative study explored the experiences of using the inquiry method in a 6^{th} grade science classroom. Forty-six students in grade six participated in the study conducted in a suburban eastern Pennsylvania private elementary school containing approximately 400 students. Methods used to gather data include teacher observation, student surveys, and student work. Methods of analysis included coding of researcher field log based on student observation, creating of theme statements and review of student work. The students participated in inquiry-based science activities and inquiry-based scientific problem solving.

Findings suggest that using inquiry-based learning improves student motivation and engagement and has the ability to develop, improve and enhance scientific skills. Furthermore, most students are likely to improve the science content knowledge and understanding through use of hands-on inquiry-based activities. The majority of the students preferred using the inquiry method and felt they had gleaned a benefit in scientific skill and scientific knowledge when using the inquiry method.

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Being a DaVinci Fellow this past summer has helped me immeasurably with learning what it means to teach with inquiry. I admire the DaVinci Science Center's mission and dedication to improving science education. Without this valuable professional development opportunity I would have been ill prepared to undertake my study. The training I received from the center, has transformed my

teaching of science. Inquiry will continue to be the central focus in my classroom.

Finally, I would like to thank my family for putting up with me. You supported the many times I had to sacrifice on family time. I appreciate the help with the laundry, cleaning, shopping, etc. You are my angels. Never once did you complain, but rather continued to support my efforts and spurred me on. Special thanks to my husband, Jim of 25 years. My mother and my aunt have always been guiding lights in my path. I thank you for your love and support no matter what venture I have pursued. I especially want to thank my daughter Kelsey and my son Cheyne whose vision and promise helped to carry me through. For both of them, and for all my students, I hope that I can help to lead them to pursue their own inquiries and fuel their passion for learning.

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RESEARCHER STANCE

"To Inquire or not to Inquire? That is no longer the question."

I have always been fascinated by science, which is all about inquiry, curiosity and wonder. It is all around us; it helps us to explain our world and the natural phenomena that occur. On the first day of science class every year for the past seven years, I have begun by admitting to students that science is my passion, or, as I like to tell them, "Science Rocks." Of course I have a tendency to get a little carried away as I tell my stories of Ben Franklin, Leonardo DaVinci and others. I usually end by insisting they follow my lead. "I'll say 'Science.' You'll say 'Rocks!' Are you ready?"

"Science! Rocks!"

"Science! Rocks!"

Needless to say my classroom can become a bit noisy at times.

As a science student in elementary school over 35 years ago, I don't ever remember participating in any science lab experiments or being involved in any hands-on science activities as part of the classroom experience.   As a result, I really don't think I obtained a lot of long lasting science knowledge at this point in my educational career. There was no real application for the science knowledge we were forced to memorize. I seem to remember that I was successful on tests, but long term retention just didn't occur. My science knowledge, conceptual understanding, and application to authentic experiences were lacking.

In high school I was placed in Honors Biology I and II, Chemistry, and Physics, and here my love of science began. We experienced real labs. I remember beginning to make some connections to the world around me that I had never made before. I'll never forget my high school science experiences. Sister Mary Clair actually led us through a cat dissection. From that moment on, I was hooked. I actually made it all the way to the State Regional finals of the Junior Academy of Science with my project on photographic resolution.

But in the end, something was still missing from the classroom experience. Applying what I now know about learning to my own science education experiences, I don't think there was enough emphasis on actually developing scientific thinking and scientific skills or allowing students to construct their own meaning of the scientific knowledge being presented. Our natural curiosity was unfortunately not fostered. We were not really learning how to make sense of the scientific phenomena all around us. Instead, science instruction was still mainly memorizing facts for a test with a few lab experiences thrown in.

Much later in college as I was pursuing my elementary education certification, I enrolled in a required Science course for prospective classroom teachers; it opened up my eyes to a whole new way of teaching and learning science. I felt a renewed passion for science and knew that I wanted to develop an excellent science curriculum. As I watched my son experience elementary science, he, too, was unfortunately not being exposed to teaching and learning methods that would ultimately help him to understand the world around him and apply that real world knowledge. I was now more convinced than ever that the curriculum needed to change to meet the needs of our students.

Fortuitously, a science teaching position became available at my son's school, and I felt the need to see if I really could realize my passion and inspire students to develop that same level of appreciation and passion for science that I had acquired.

As a new teacher in 2002, I began to learn the 6th grace science curriculum at my school. I find that I need to continually adapt it to include more hands-on experiences, including labs, activities, and projects that have the effect of helping students develop those scientific skills I never developed until much later in college.

I continue to try to improve, rewrite, rework, and adapt my curriculum every year to create more authentic science experiences for my students. I was fortunate to attend a Teacher's Workshop at the Diocesan Convention for Catholic School Teachers conducted by Dr. David Smith, the Director of the Da Vinci Center for Science and Technology. In response to his presentation on inquiry learning, I began to look at what I was doing my classroom in a whole new light. This presentation, I felt, could help me understand how to create more powerful and effective learning experiences for my students. I began to wonder how I could transform my students and my classroom by using this method. I was eager to begin anew and incorporate inquiry-based learning into my teaching.

As an educator who wants to do the very best for my students, I want more for them. I don't want just memorization for the test. I not only want to increase students' knowledge, but also enhance their motivation for science and teach them to learn how to think scientifically and to develop those higher order thinking skills such as analysis and synthesis.

This summer I had an amazing opportunity to realize my potential as the "Science Nerd," a term my students often use to refer to my passion for science. I was accepted as a Teaching Fellow in the DaVinci Science Center Program.

For two weeks from 8 am to 3 pm every day, I was immersed in science and engaged in the use of the inquiry method of teaching and learning science. By becoming part of this program and its relation to progressive science education, I have learned more about inquiry than I ever would have by studying and reading about it alone. I actually saw and experienced teachers using it, and I as a science student, learned through my inquiry.

While I have always used a lot of hands-on exploration and lab experiences in my teaching of science, I knew that something was still missing. Only a portion of my students each year were able to really apply the content knowledge gained and use it to explain real world phenomena or create their own explanations and connections. For instance, after all my blood, sweat and tears on the States of Matter Continuum, I was shocked than many of the students could not explain real world phenomena. The classic example I use on tests goes something like this: “It is a hot day and there is a glass of lemonade on the table with ice in it. You begin to notice there is water on the outside of the glass and underneath the bottom of the glass when you pick it up. Is the glass leaking? Please explain using scientific reasoning.”

Typically half of the class says the glass is leaking. The other half realizes that it is, in fact, not leaking at all and explains the theory of condensation. Why can’t more students understand and apply such scientific concepts? All students should be able to apply scientific understanding to the world around them to construct explanations for natural phenomena. I'm convinced that teaching with Inquiry might ultimately solve the puzzle and lead me to the Oz I have been seeking. Can I transform my teaching and my students' learning to lead my students to higher levels of scientific thinking and problem solving?

To inquire or not to Inquire? That is no longer the question.

To Inquire or Not to Inquire, That is No Longer the Question.

LITERATURE REVIEW

Introduction

By using inquiry based learning, the science classroom can be transformed from a place where teachers are filling students' heads with countless number of science facts, science vocabulary, and theories to a place where students are actively engaged in experiencing and creating a real understanding of science for themselves. The use of active learning strategies in the classroom such as inquiry learning has been linked to increasing science knowledge and improving attitudes towards science (Fisher, Geres, Logue, Smith & Zimmerman, 1998). Research also indicates that an inquiry approach within the science classroom has been shown to increase student motivation for the learning of science (Carroll & Leander, 2001). This kind of teaching according to the National Research Council (2000) gives all students the "problem solving, communication, and thinking skills that they will need to be effective workers and citizens in the 21st century" (p. xii).

Where We Have Come From

In 1957 with the launching of Sputnik, America experienced a crisis in science education in the U.S. The push for improving science education had begun in light of the Russian advancement. Poor U.S. performance on international science assessments continues to be and has been a concern for the past 50 years (Smith, Desimore, Zeidner, et al., 2007). The ideas of John Dewey in the early part of the 20th century and Joseph Schwab in the 1960's shaped and laid the groundwork that science should be taught as inquiry (National Research Council, 2000). Before 1990 many science educators continued to use direct instruction in the classroom without including an inquiry component. Student directed inquiry learning was reported to be a rare occurrence (National Research Council, 2000). The recent push for improvement in modern Science Education came in 1991 when the National Science Teachers Association in coordination with the National Research Council drafted Standards for U.S. Science Education. "A prominent feature of the standards is a focus on inquiry" (National Research

Council, p. xv). The fact that No Child Left Behind Legislation (NCLB 2001) now includes science standards and science assessments continues to push and refocus attention on the teaching and learning of science (Smith, Desimone, Zeidner, et al., 2007).

Theoretical Perspectives

Constructivism is a modern educational theory developed and promoted by some of the great educational theorists of our time. The theory of constructivism calls for construction of knowledge. Students seek their own understandings in which they make sense of the knowledge as it fits to prior knowledge and in the larger world around them (Tobin, 1993).

Tobin (1993) indicates that the constructivist epistemology is an “active process in which learners construct knowledge in a way that makes personal sense. And it is a subjective process, as learners draw on their own background experiences to make sense” (p. 223). Utilizing this theory enables teachers to address the issue of how students learn best and how, in turn, teachers should design instruction (Tobin, 1993). Inquiry learning fits within the constructivist model as students are engaged in constructing their own science knowledge through the use of inquiry.

Using practices that are in alignment with constructivist learning theory allows students the opportunity to arrive at deeper understandings of the knowledge at hand and its connection to the real world. Students today don't always experience connecting "the information they receive in school to interpretations of the world around them" (Brooks & Brooks, 1993, p. 8). Katz and Chard (1986) emphasize that focusing on performance or achievement alone usually results in diminished retention in the long run, but focusing on the type of learning that is active and authentic creates understanding and long-term retention.

Another educational theorist whose work influences this study is Benjamin Bloom. When we push our students to think at higher cognitive levels, levels beyond simple recall of information, we are stimulating their thinking processes (Bloom et al., 1956). When we encourage students to think at higher levels, we are encouraging meaningful learning to take place (Mysliewic, Dunbar, & Shibley, 2005). Bloom's taxonomy explains the cognitive value of moving students from the lowest level or knowledge, through the higher phases of analysis, synthesis and evaluation.

Teachers are the vehicles through which students are able to make successful interactions with content material. The primary issue of an education that is founded on experience is to choose the kind of experiences or activities that are productive and lead to future fulfilling experiences (Dewey 1938). Inquiry Learning can provide those experiences.

Teaching with Inquiry

It is critical for science teachers using inquiry in the classroom to develop the ability not only to involve their students in an inquiry activity but also to promote the understanding of inquiry to support student construction of scientific knowledge (National Research Council, 2000). Newman, Abel & Hubbard (2004) explain that “When students are engaged in inquiry, they describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge and communicate their ideas to others. They identify their assumptions, use critical and logical thinking and consider alternative explanations” (p. 258). Haranda and Yoshina (2004) describe inquiry learning as having the ability to promote deeper levels of thinking and improve students' motivation for the learning of science.

Teaching science using inquiry learning involves designing or using a learning activity that allows for the promotion of student inquiry and is collaborative, student driven and open ended. When students are involved in an inquiry activity they are following their own line of questioning to solve a problem and arrive at a solution. In the process they will have utilized higher order thinking, problem solving, collaboration, communication and literacy skills and scientific process skills. According to the National Research Council and National Science Teachers Association, the steps for conducting an Inquiry Learning Activity are first to introduce the scientific concept and build on students' prior knowledge, helping students to define the question or problem, gather the data and evidence needed to create a solution to the inquiry, consider and analyze the data, and arrive at a conclusion based upon their data collection and analysis (National Research Council, 2000). Students are encouraged to create new inquiries during the activity that will lead them to further develop their knowledge concerning the particular topic being investigated.

Hofstein, Shore and Kipnis (2004) in their research report go on to conclude that "inquiry-centered laboratories have the potential to enhance students' meaningful learning, conceptual understanding and their understanding of the nature of science" (p. 1). The curiosity and wonder of the student leads to powerful and meaningful learning (Harada & Yoshina, 2004).

Best Practices in Teaching Science using Inquiry

Teaching with inquiry includes the following classroom best practices in the teaching of science inquiry: stimulating higher order thinking skills, developing scientific inquiry skills, utilizing collaborative scientific learning, scientific literacy including scientific discourse, reading across the content area and scientific writing, promoting active science learning and student centered learning, and finally engendering students' motivation for the learning of science.

Teaching Higher Order Thinking in the Realm of Science

Teaching students how to use higher order thinking skills is an important part of an inquiry activity and process. The use of inquiry learning should include higher level thinking skills in the process (Zohar & Dori, 2003). When students learn how to apply systematic problem solving skills they are able to devise solutions and create alternative solutions (Harada & Yoshina, 2004).

Higher order thinking as defined in Bloom's taxonomy involves application, analysis, synthesis and evaluation (Bloom, 1956). Application is where the student can apply the knowledge gained which should be implicit in the design of an inquiry activity. Analysis creates an understanding of the parts and how those pieces of information fit with the whole. Synthesis combines separate pieces of knowledge and involves putting those pieces together to create a new whole. Evaluation, the highest level of Bloom's taxonomy, looks for judgment or the value of something. An inquiry activity should be designed with these higher order thinking skills in mind.

Dean and Kuhn (1999) emphasize that we cannot teach higher order thinking skills if we do not understand what those skills are. Students need to be taught how to formulate higher level questions. Low level or "unproductive" questions lead to dead end inquiries. They might include asking for a fact, date or definition. Such questions, while often important to answer in their own right, simply are not likely to lead to a higher level of thinking and understanding

(Winokur & Worth, 2006). Deeper level questions or “productive” questions are open-ended. They lead to further discourse and further inquiry to allow for deeper understandings (Winkokur & Worth, 2006). Some of the elements of higher order thinking can be found when developing thinking patterns to solve problems (Zohar, 2006). Specific thinking strategies can be employed in a lesson to allow for practice of thinking patterns, and the repetition of thinking patterns is the key to the assimilation of the process of higher order thinking. “Articulating the cognitive activity” (Zohar, p. 340) or rather thinking-aloud may produce important connections between the concrete and the abstract in science.

Scientific Inquiry Skills

The foundation of every scientific investigation is the use and knowledge of the scientific method, which provides a framework for solving a scientific problem (Appleton, 2006). Identifying a problem, developing a hypothesis, designing a procedure to test the hypothesis, running the experiment, collecting data, analyzing data, forming conclusions and theories, communicating and reflecting are all essential steps in the use of the scientific inquiry (Harwood, 2004).

Cuevas, Lee, Hart and Deaktor (2005) suggest that using inquiry as an intervention in the classroom has a positive impact on the development of students’ inquiry abilities. Their study asks whether science inquiry skills can be improved for diverse students when inquiry teaching and learning is employed in the classroom. They attempted to improve inquiry skills among 25 linguistically and culturally diverse third and fourth grade science students enrolled within six elementary schools over a two year time span. There were 25 students total who participated in the study divided among six different elementary schools with six different teachers. The intervention was used in each of the six classrooms studied with all the students; however, only data on the 25 participants were collected and analyzed. The intervention not only included using instructional units based on inquiry, but also introduced inquiry based teacher workshops and inquiry based classroom practices. All six teachers were equally prepared in terms of professional development workshop participation and access to inquiry instructional units. The introduction of lessons which taught inquiry and promoted inquiry learning provided the intervention in the six classrooms studied.

Data collection involved student pre and post-study elicitation sessions that were conducted one-on-one with researchers, scored using rubrics, and videotaped, audio taped and transcribed. The elicitation involved introducing a scientific inquiry problem in the form of a passage read to the students and asking the students to create an inquiry investigation using a prescribed format to assess how well they were able to demonstrate their mastery of inquiry skills. Part of the task involved asking or designing inquiry questions based upon the scientific problem given. Students were then scored on their oral and written responses demonstrating their mastery of inquiry skills using a scoring rubric. The scores were compiled and compared for score gains in inquiry skill regarding pre and post-study elicitation sessions for each participant in the study.

This quantitative study suggested that there were significant gains in diverse learners' inquiry skills when comparing pre-elicitation and post-elicitation assessments. The study suggested that there were statistically significant changes in inquiry ability in the third and fourth grade students studied based on the increase in pre and post elicitation scores. While students' ability to develop procedures for solving problems appeared to improve significantly, students' ability to formulate a problem statement did not improve significantly. The overall mean scores between pre and post elicitation sessions showed significant increases in students' ability to conduct an inquiry investigation. The mean scores for the entire sample of 25 students increased from 8.04 during the pre-elicitation to 12.16 during the post-study elicitations, with 16.00 representing a perfect score for the elicitation session. The majority of the students showed tremendous gains in science inquiry skills as measured from pre-inquiry elicitation compared to post-inquiry instruction elicitation.

Collaborative Scientific Learning

Manlove, Lazander and de Jong (2006) note that the NRC recommends that science educators assist students in building their scientific understanding though the use of interactive processes like collaboration. Tobin (2005) points out that collaboration involves successful social interactions among students discussing and sharing ideas and information that “generates positive emotional energy and solidarity among group members” (p. 308). Collaboration may consist of a group of students working together to solve a scientific inquiry involving communication among group members as a vehicle to share ideas, concepts, and theories, as well as to analyze data and ultimately to arrive at a conclusion.

It is critical that teachers model scientific collaboration in the classroom before students are expected to engage in it on their own. Students need to learn how to regulate their own learning in a self-directed collaborative setting and this is a skill that needs to be taught rather than assumed. Students need to monitor their 2 understandings, their inquiry process and the knowledge they have gained (Manlove, Lazander & de Jong, 2006). Engaging in collaborative work helps students to discover creative and meaningful solutions to difficult problems and to develop a respect for diversity of opinion (Harada & Yoshina, 2004). Michael and Modell (2003) note that there has been overwhelming evidence from multiple studies that collaborative learning is an effective learning tool.

These writers refer to Lunetta (1990) when stating that students who learn within a collaborative setting learn more than students who work as learners working individually.

Science Literacy

Dyasi (2006) in Linking Science & Literacy discusses science inquiry as a "collaborative activity and as such involves teams of students in discussing, planning, and conducting investigations together and sharing responsibilities for 3 involves all the elements of literacy (p. 12). Students use the elements of literacy to create meaning and scientific understanding.

The development of students' ability to perform scientific inquiry depends on the development of oral and written skill (Dyasi, 2006). The collaborative communication and the sharing of ideas is an essential element in the inquiry investigation. For teachers, it is important to promote and teach science literacy in order to ultimately promote the advancement of science education (Dyasi, 2006). The National Science Education Standards include the objective of scientific literacy at various grade levels.

Scientific Discourse

Discourse in the science classroom is absolutely necessary for making meaning of scientific concepts applying new understandings to real world knowledge. As Cazden (2001) points out talk allows us to process the learning and leads to understanding. Oral communication plays a large role in the learning of science. Winokur and Worth (2006) say that, "Talk plays a critical role in such science learning, not only because of the importance in science of communicating data, analyses and ideas, but also because it is fundamental to the development of scientific reasoning skills and the construction of theory and explanations" (p. 44).

Scientific Writing

Writing also helps us come to terms with what we know and aids us in the creation of meaning. Hand (2006) describes writing as a process of negotiation which is important to build understanding. The nature of science is complex and writing explanations may help the student construct knowledge about the science topic at hand.

Scientific writing assists students to think more deeply about science concepts and to communicate their understanding (Sutherland, McNeill, Krajcik, 2006).

“Writing improves learning in all areas. When students increase their writing abilities they increase their ability to think and learn” (Kotelmann, et al., 2006, p.149). Writing opportunities in the science classroom should be designed to enhance and develop scientific understanding and ultimately scientific knowledge. Scientific writing is important to help support the students in developing scientific explanations (Sutherland, et al., 2006). Writing in science follows a nonfiction writing model, though, which is not natural to most students (Kotelmann, et al., 2006).

Writing in science can take several forms such as science journals or notebooks, lab reports, lab explanations, problem solving activities, and projects, to name a few. “A science notebook [and other forms of science writing] provides students a place to record their thinking and their learning before, during and after a science investigation” (Kotelmann, et.al., 2006, p. 151).

Reading Across the Content Area

Reading a non-fiction textbook is not only difficult, given the readability of most texts, but in general is not an enjoyable activity for many students (Allen, 2000). Content area reading instruction is important to help students explore the world of science and begin to understand it. Just as there are reading strategies employed in the reading classroom, students need to be taught how to read a science text or science materials. Activating prior knowledge is part of this process of teaching content area reading, and this helps to prepare students to draw connections and applications to the real world (Cervetti & Pearson, 2006). Students need to establish a purpose for reading and make predictions. Teachers need to lead students to draw inferences and make both conclusions and connections while also building relationships between ideas and concepts (Cervetti & Pearson, 2006).

Active Learning

Inquiry learning is a form of active learning**.** “Teachers who use active learning say that students learn more material, understand more ideas and enjoy school more” (Delisle, p. 8). Learning should not be a passive activity, but rather is an active process involving the pursuit of knowledge. When students are active learners, teachers are promoting engagement and motivation to learn (Caroll & Leander, 2001). Active science learning activities revolve around using knowledge acquired, scientific process and reasoning skills, communication skills and science literacy skills to solve a problem (Delisle,1997). Wilson (1996) conducted a study which inventoried students’ learning styles and concluded that the majority of students prefer active types of learning. When they are engaged in hands-on, inquiry activities students create the circumstances for real learning to take place (Harada & Yoshina, 2004).

Student Centered Learning

Inquiry learning incorporates the idea of learning being student centered rather than teacher directed. Students follow an inquiry to construct their own solution to a scientific inquiry problem. When students help to shape the direction of their learning, they are empowered and learning may be taken to a whole new level. Student centered learning is determined by what the student does to facilitate his or her own learning (Michael & Modell, 2003). Students take ownership for their own learning which results in more effective learning (Brown, 2008). Student centered learning can involve several different approaches including cooperative learning or collaborative learning. This approach creates a new role for the teacher as guide rather than director. Through student centered learning students become "self-sufficient, creative thinkers and people who appreciate the value of being taught" (Brown, 2008, p. 33).

With teacher as facilitator students are at the center of their learning, with teacher facilitators providing help and guidance only as needed. "It takes a lot of skill for a teacher to become hands-off and allow his or her students to control their own learning" (Shull, 2006, p. 79). As Dewey (1938) wrote "…..Teachers are the organs through which pupils are brought into effective connection with the material" (p. 18).

Motivation

Angelo Collins, Executive Director of the Knowles Science Teaching Foundation, asked a group of 75 middle school science teachers to explain how 29 their students learn science, and many responded by stating the importance of motivation" (Collins, 2002).

Motivation is viewed by constructivists to be internal to the child but responsive to the external environment (Wadsworth, 1996). If teachers are able to incite interest in the child, the circumstances for motivation to learn are also created. To promote achievement, motivation must be the initial objective (Stipek, 1998). Using motivation to promote academic achievement in the science classroom becomes the ultimate goal.

Intrinsic motivation refers to a student's willingness, and it "seeks to increase the factors that move a student toward becoming more involved in the class and classroom strategies need to be pursued to enhance and facilitate motivation for the learner (Bomia, Beluzo, Demeester, Elander, et al 1997).

Incorporating active learning like inquiry learning influences student motivation positively (Carroll & Leander, 2001). A study from Fisher, Gerdes, Logue, Smith & Zimmerman (1998) found that an increase in motivation for science was achieved through the use of hands-on inquiry based learning in the science classroom. This study concluded that using active learning strategies in the science classroom promotes not only improvement of science knowledge, development of higher order thinking skills, but also improves student attitude and motivation toward the learning of science (Fisher, et al., 1998). The study included students in the first, third and fourth grades in a single school district. The average class size was 22 students. Data were collected using teacher observation, test scores, anecdotal records, and student surveys. The intervention included implementing active learning strategies in the form of hands-on-science lessons.

Researches indicated that students gained a “more positive attitude toward science because of our intervention” (Fisher, et al., 1998, p. 43) based on observations of attitude through written and oral data. The study noted a significant “change in attitude, increase in confidence, and heightened enthusiasm, in the classroom” (Fisher, et al., 1998, p. 44).

Another study conducted in 2001 by Carroll & Leander sought to examine the effects of attempts to increase motivation in a fifth-grade social studies class by using active learning strategies. Students' motivation for the learning of social studies was measured before and after the intervention by student survey, observation checklist, teacher observations and academic achievement. By introducing active learning strategies in the social studies classroom, "students indicated that they had increased confidence and they were more excited about learning" (p. 42). An analysis of post intervention data concluded that students had increased motivation. Students not only showed improvement in motivation but also in their academic achievement.

Dilemmas in the Teaching of Inquiry

Utilizing inquiry as a teaching and learning method may pose several problems. First, many teachers have limited experience with using inquiry activities in their classrooms (Newman, et al., 2004). Professional development has been deficient in this area. Many elementary teachers lack the understanding of how to effectively teach with inquiry (Newman, et al., 2004). "Good inquiry-oriented teachers listen well and ask appropriate questions, assisting individuals in organizing their thoughts and gaining insights. Inquiry-oriented teachers seldom tell but often question" (Trowbridge & Bybee, 1996, p. 156).

Another issue is that teachers need to be knowledgeable in their content area in order to teach with inquiry. Teachers may lack the understanding of the nature of science and may be weak in content area knowledge (Newman et al., 2004; Frierichson & Meis, 2006).

Yet another issue is that students need both modeling in advance of and support while engaging in inquiry learning (Friedrichson & Meis, 2006). Students need to be taught how to conduct an inquiry activity, how to develop higher order thinking, and how to put the inquiry skills into practice.

Another dilemma is limited resources. Finding the time to teach using this method, which generally tends to be more time consuming than traditional methods, may be a problem. Teachers must find a way to allocate the time to teach using this method, as well as, fitting in standard curriculum and assessments (Newman et al., 2004). Instructional resources may not be readily available, funds for laboratory supplies may be insufficient or lacking; and there may be a lack of teacher preparation time to adequately prepare for teaching the inquiry lesson.

A final challenge may be the definition of inquiry learning itself. Various versions of inquiry learning exist. The key is to use an active inquiry activity that results in the development of higher level cognitive processes, content knowledge, involves scientific literacy skills and develops scientific inquiry skills in the process (Newman et al., 2004).

Conclusion

Regardless of the difficulties noted in teaching with inquiry, inquiry focused learning has been shown to produce higher levels of science knowledge (Fisher, Gerdes, Logue, et al., 1998), improvement of scientific inquiry skills (Cuevas, Lee, & Hart, 2005), improvement in motivation and attitude (Bomia, Beluzo, Demeester, et al., 1997), (Fisher, et al., 1998) and development of higher order thinking skills (Zohar & Dori, 2003). Inquiry learning helps to promote students' science knowledge, student motivation, and the development of higher order thinking skills, while improving and furthering development of science inquiry skills. Through the use of collaboration and student directed learning, science students may lead an inquiry investigation using scientific processes that allow them to make real world connections. As Dewey said, “Everything depends upon the quality of the experience had” (p. 27). Inquiry learning can create an environment that empowers the learner to reach new heights of scientific achievement. “Effective science teachers …through the use of inquiry can have a powerful influence on their students’ science learning” (National Research Council, 2000, p. 128).

METHODOLOGY

Research Goals

I began my study with the goal of transforming my classroom from a place where there was just transmission of knowledge, to a place where students truly learn to interact with the content, learn how to think about it in a whole new way and connect those thoughts to the natural world. By studying the effects of using the inquiry method in my classroom, I hoped to see my goal fulfilled. I hoped to see my students developing their scientific thinking, their scientific skills and their scientific problem solving.

With this goal in mind, I began to redesign my classroom lab experiences and activities to include an inquiry component. I tossed out the old labs with the “cookbook mentality.” In the future my students would have to think for themselves, they would no longer just passively follow along and hope the concepts would miraculously sink in. I hoped that by becoming active participants in the process and leading their own inquiries, my students could create the change that would make the difference in their learning.

The types of inquiry-based activities that my study included were problem-solving activities, laboratory activities and group activities. I not only made observations of collaborative behavior but also captured and graded the problem solving and lab activities to assess students' scientific thinking and problem solving. There were eleven different activities; two were problem solving projects and nine involved lab activities.

Setting

The study took place in a medium sized private elementary school in a suburban setting. Students are fairly homogenous in regards to ethnicity and socio-economic status, but are a bit more diverse in terms of their academic ability and achievement. Approximately 400 students attend this school in grades ranging from pre-school to eighth grade. My classroom has a total of six grouped seating areas, including four students at each grouped area. The laboratory that I also use contains six lab stations with four lab stools where students sit when they work on the inquiry labs and problem solving. The teacher demonstration area is located at the front of the room.

Participants

The students who were part of my study were enrolled in my sixth grade science class. All 46 of my 6th grade students elected to participate in my study. The classes are completely heterogeneous. There are 23 students in each class, with a nearly even mix of boys and girls. Each class meets four times a week for 40 minute periods. Nine of the students or 20% have been identified as having learning or emotional/social disabilities. Eleven of the students or 24% have been identified as gifted.

I had taught most of these students 5th grade science. Most of them appeared to be motivated for science and displayed positive attitudes. Unfortunately, I don't think I had tapped their potential for scientific thinking. I had not previously challenged them enough to think for themselves. I hoped that by introducing inquiry into their learning that their view of science would be transformed from merely one of many school subjects to something that surrounds them every waking minute and helps them to understand the context of the world around them.

Procedures

Before my study began I explained the project not only to my students but also to their parents at Back to School Night in early September, including the importance of the Informed Consent Form (see Appendix B) Throughout my study I observed, analyzed and assessed 11 activities, and also administered three surveys, and several tests.

I assessed group activities through of use of lab worksheets prepared by students and monitored the students by teacher observation checklists (see Appendix H). In addition I administered the aforementioned three surveys (see Appendix E, L and Q) to assess the feelings and reactions to science in general and more specifically the collaborative inquiry activities the students completed as part of their introductory study of Chemistry.

I also collected observational data from by teacher field log, which I maintained throughout the study. In this way, the data I gathered from student work, field logs, tests, and surveys helped me achieve triangulation to support valid conclusions. Hendricks (2006) suggests that by using at least three methods of data collection such as student work, observation and survey or interview data, triangulation can be accomplished.

Surveys

I administered surveys to assess student opinions and attitudes and elicit other types of feedback from study participants. “A survey or questionnaire gives you a broad base for understanding your students’ ideas in regard to your research question” (Maclean and Mohr, p. 41). At the beginning of the study, I administered an initial survey to learn more about student motivation and attitudes towards science. The mid-study survey included more specific questions that measured responses on a rating scale of: 1 – never, 2-seldom, 3-sometimes, 4-

usually and 5-always. (See Appendix L). I wanted to determine if their attitudes toward science had changed and how they felt about using the inquiry method in science class.

At the end of the study, I surveyed students to assess how they felt about science (see Appendix Q) and to determine if they felt that inquiry learning had helped them become better science students and improve their science skills. The assessment of these student opinions allowed me to learn more about the challenges presented by using the inquiry method both from a student's perspective and to compare this to my own. It also allowed me to assess the overall benefits or pitfalls as identified by my students.

Student Work

Throughout the study I collected student work. Students prepared lab worksheets for every lab activity. I also assessed their collaborative activity with the use of a checklist.

During problem solving sessions students submitted their completed worksheets. I also used quiz and test information to assess the impact of the use of the inquiry method. Reviewing the student work allowed me to develop insights into the development of student scientific thinking and scientific skills. Maclean and Mohr (1999) suggest collecting multiple samples of student work over a period of time and can be used as an example for study. The Problem-Solving activities were graded based on a grading rubric (see Appendix P). Cooperative activities were graded several times to assess the effectiveness of the cooperation and collaborations of the group.

Field Log

I recorded observations in my field log after every activity. In my log I recorded teacher reflection, observations and student reactions. I observed students as they worked through the many inquiry activities. These observations allowed me to gain insights into the students' thinking and reactions to the use of inquiry. Ely, Vinz, Downing and Anzul (1997) indicate the "Fieldnotes are the written record of the data as shaped through the researcher's eyes….." (p. 17). Through my field log I was able to capture a number of important snapshots that enabled me to see how inquiry was shaping the actions and attitudes of my students over time.

Within the inquiry-based classroom it is critical for the teacher to try to maintain the role as facilitator and allow the students to guide their own inquiry and seek to improve their own knowledge. I was able to note and record in my log those experiences that I perceived as being both positive and negative at time.

When students were working in their groups on various inquiry activities and problem solving activities, I circulated among the groups facilitating and offering minor assistance when needed. Sometimes I would guide students toward an area of exploration they had not yet considered. I would also question groups to assess their level of understanding and skill and do my best to record examples of student discourse, knowing that the ability of students to explain what they are doing are most important in the promotion of science literacy. As soon as possible after each lesson, I would gather my thoughts and type up a formal version of my notes, adding my own reflections and interpretations of events.

Activities

The students worked in cooperative/collaborative lab groups of mixed ability and gender for all activities. Collaborative groups' behavior was assessed and monitored for effectiveness. The following inquiry activities were created and implemented as part of the study: (see Appendixes E – 0)

1. Discrepant Event – Raw Egg Inquiry
2. Skittles Lab
3. Buidling Molecules
4. Observation Skills – Inquiry
5. Problem Solving – Static Electricity

6. Solids, Liquids, Gases - Inquiry Investigation
7. Mixed Up Lab – Mixtures, Solutions, Colloids and Suspension
8. Slime Lab
9. Chemical Change Lab
10. Oxidation Lab
11. Problem Solving – Physical & Chemical Change

Researcher Trustworthiness

I began my process of research by explaining my study to my sixth grade students and their parents at Back to School Night. The next day I handed out participation consent forms to students for their parents to sign. I safeguarded all data and kept all records confidential and private. I maintained the anonymity of all of my students participating in the study. The use of pseudonyms helped to protect student identities.

Students had the ability to opt not to participate in the study and it did not affect their grade. All students received the same instruction whether they were participating in the study or not. I reminded students that they were allowed to withdraw from the study at any time without penalty. If the student wished to withdraw, notice was accepted from the parent or the student themselves. If a student decided to withdraw, I did not use any of his or her information in the study.

I do believe that coming to terms with my biases helped me become a better teacher of science. I anticipated that by using the inquiry method, all students would become more motivated for learning science. I was also biased in that I thoroughly expected that by using inquiry, I will be able to develop higher order thinking processes and promote better scientific problem solving ability in my students. I monitored all support data, making sure that I was reporting valid observations working to maintain objectivity at all times. Throughout this process, I discussed the project with various peers and my principal, as well as, professors and my teacher support group. I believe they were able to give me insights I would not have gained without their help and guidance.

The belief that all genuine education
Comes about through experience does
Not mean that all experiences are
Genuinely or equally educative.

John Dewey

My Story

And So, It Begins?

I'm nervous. Would they buy into my plan? Could I count on them? I was going to be asking them to do something they had not done before in science class – inquire.

They stared at me. What was she talking about? What ***IS*** *the inquiry method?*

- Researcher Field Log, 9/2/08

I introduced my study by explaining that I wanted more for my sixth graders as students of science. I wanted them to know that science isn't just what takes place within the classroom walls, but it is what goes on out there in the real world. I told them that by using the inquiry method they could learn how to think about science in a whole new way, which would allow them to use real scientific thinking, not just memorize facts for a test.

They seemed interested. They were listening. Maybe they, too, sensed something was missing in their science instruction all along.

- Researcher Field Log, 9/2/08

I handed out the consent form (Appendix B) and discussed just what it meant. To my surprise, the students responded positively and enthusiastically to the idea of my study. They all wanted to become subjects in the "experiment." In fact, I was originally only going to include one sixth grade class of 23 students in my study, but because the other class also wanted to participate, I ended up with a participant pool of 46 students. As I mentioned earlier, most of my students were already motivated students of science, and we had developed a strong working relationship during their fifth grade year. Even there, I had used a hands-on and multi-media approach to the teaching of science to which students responded positively. Of course, I wondered if my students would continue to respond positively when I introduced the inquiry method, and if they would feel they are indeed benefiting from its use.

Can a Raw Egg be Crushed in the Hand?

I conducted my first inquiry lesson on September 4th. I used a discrepant event that I had used in the past, but this time I incorporated the elements of inquiry. The problem: Can a raw egg be crushed in the human hand when equal pressure is applied? I prefaced the lesson by teaching the students the 5 E's of the inquiry lesson (Llewellyn, 2007). The first E is for **Engage**. It is important to set the tone for student engagement no matter what the activity. I asked my students questions about what they already knew about a chicken egg, and they jotted down their ideas on the Lab Activity Sheet. The second E in the inquiry lesson is for **Exploration.** I set up the activity with participants who have an opportunity to see if they could crush the chicken egg in their hand. Before the test, we predicted whether indeed it could be done or not. 95% of the students agreed the egg could be crushed in the human hand and recorded their prediction. After testing the egg and realizing that it could not be broken when equal pressure was applied, I then asked the students to explain why they thought the egg could not be crushed. **Explanation** is the third step in the Inquiry Lesson. Through student discourse, students eventually “discovered” that a pressure point has to be introduced before the egg can be broken. They recorded this idea under explanation on their lab sheets. The students were smarter than I had given them credit for in the past. Students actually constructed their own exploration of a pressure point without my help. Imagine that. The students clearly seemed more engaged and more empowered directing their own inquiry than they would have been listening to me explain the concept to them. The excitement in the room was electrifying. What a lesson I learned. Here, all these years I had thought that spoon-feeding kids was the answer, assuming they were incapable of constructing explorations on their own. Clearly, I had been mistaken. I then asked the students to **Elaborate** their explanations, and I also asked them to **Extend** their thinking for further explanation. Students seemed to struggle with this. No one had ever asked them to design their own exploration before or to elaborate on a written answer so that it mirrored scientific writing. Was I actually asking them to think for themselves? Could I get them to become more comfortable with these final aspects of the inquiry lesson?

To Survey or Not to Survey? Pre-Study Study.

In my pre-intervention survey, 44 out of 46 students indicated that they like science and are motivated to study it. But when I asked them what areas of science they are most interested in, responses included animals, the human body, and the solar system. I wondered if they would have the same level of motivation for the study of chemistry, which students tend to find a little more difficult. Only half of the students commented that they were looking forward to studying chemistry this year. The majority of the students said that they enjoyed the our initial lab experiences. I hoped that as the study progressed, the half of the class who said they were looking forward to it would enjoy it, and the other half would become interested as a result of their inquiry.

Forcing Students to Think. What do Skittles have to do with it?

Today we'll be conducting a Skittles Lab. Skittles are more scientific than you may think. I wonder if we can discover their secrets? What do you know about Skittles?

-Researcher Field Log, 9/16/08

At first I got the blank stares. No one wanted to venture into uncharted waters during whole class instruction. Teaching them to think for themselves was clearly not going to be as easy as I had first imagined. I had to jump start those neurons. I prompted students again, encouraging them to brainstorm in their lab groups. As

I moved from group to group offering encouragement, I started to relax; yes, they were getting it. One student offered that he knows that skittles come in different colors and flavors. Another student suggested they are made with an "S" imprinted on the candy. Another student explained that Skittles are bite-sized sweet tasting candies containing a lot of sugar. They kept volunteering, and I knew that the "engage" part was working. They were fueling each other as they shared their observations. I then asked them to explore. What did they want to know about Skittles and how could we test it? I still got the feeling, though, that not all students were comfortable yet with directing their own inquiry. I knew I would have to push them further outside of their own comfort level. About half of the students were able to come up with an inquiry that they could pursue. The other half, though, didn't yet see what I wanted them to be able to do. For them, this new approach seemed too new, too foreign, too uncertain. As I took stock of where we were, I realized that some students are really comfortable with allowing the teacher to do all the thinking for them rather than thinking for themselves. I knew that those students would need more modeling and more support to help them feel comfortable with inquiry learning.

One group suggested we test the melt rate of various colors of Skittles. Another group offered that we could test which Skittle's flavor was the most popular. Yet another group shared that we could examine a Skittle's ingredients and investigate how it is made. The responses were exciting, and I felt as if I was really making progress in developing students' ability to pose questions for scientific problem solving. Having the students design their own lab experiences seemed to be so much more motivating than having their teacher dictate a procedure, a method, and results. Student reactions to the new approach and their engagement told me I was on the right track.

For those groups who struggled with the idea of directing their own inquiry, I circulated among groups and offered support and guided them by asking questions that would help define their own line of inquiry without giving them the answer. That is the critical component. It is important to be able to guide the students through the inquiry without simply giving the answer away.

Students learned to think about the material rather than just accept a given line of pre-determined inquiry. My observations suggested that allowing students to direct their inquiry process encouraged them to become more engaged in the experience and more connected in the process.

What Are We Going to Do With That Quarter?

I had never done an activity before where I tried to teach and develop observation and inquiry skills. I had, unfortunately, just assumed that all students already knew how to observe and inquire. I didn't feel the need to teach them. The skittles activity had taught me that students were only beginning to understand what scientific observation involved, so I now asked them to really "look" at a quarter dollar as though they were viewing it for the first time. We discussed what observation meant. We constructed a definition as a class that included looking at something carefully in great detail. I then challenged each group to see if they could come up with 20 observations about their quarters. At first they were incredulous. I noticed the looks. "She must be crazy," I heard them thinking. "How can we possibly come up with 20 observations of a dumb quarter?" It was slow going at first. I suggested that students use the magnifying lenses I had supplied as well as the rulers. Slowly, they started looking more carefully. I rotated among each group, offering encouragement but being careful to try to maintain the guide on the side stance, not the sage on the stage presence I had persisted in using in the past. I was determined to let them struggle through this, and I was not about to provide any group with the "answers," regardless of how much they begged me to do so.

After a few strained minutes, groups slowly began to record observations. At first it was basic. I heard, "It's round." from a group. George Washington is on the front, added another. After a few more minutes, I heard students discussing the fact that the quarter was made of metal and wondering what kind.

Another group counted the ridges in the beveled edge. Another group noted the discoloration on the beveled edge and wondered if this had been caused by oxidation. Another group decided to measure the diameter. One boy noted that he remembered how he found a quarter once on the ground and when he picked it up it was hot. He said that metal absorbs heat. Even after getting off to a slow start, every group was able to make at least 20 scientific observations. Here students began to learn for themselves what scientific observation involves. Looking very carefully in a detailed way is more work that it might initially seem. The information that can be gleaned from "observing" is extremely informative. As I listened to their observations, I knew that connecting their observations to their own experiences would likely promote new understandings and lead to new inquiries.

Do We Get to Eat the Marshmallows?

Problem: Can sixth grade science students figure out how to build models of molecules using marshmallows and toothpicks?

Hypothesis: sixth grade students will eventually discover that they can envision and build a 3-D molecule using the materials at hand.

Data: Every group is capable of following the line of inquiry and developing an atomic model that represents the chemical formula of the given compound. Not only are they capable, they are motivated to build more molecules outside of the one noted on the lab data sheet. I see engagement. I see learning.

Conclusion: This hands-on inquiry activity helped students understand the concepts of basic units of a compound. What I found most interesting about this activity is that when tested, the students had 100% accuracy on this part of the test. In previous years, without the use of this activity, only a little over half of the class had been able to identify the basic atoms of a molecule on the test. I am convinced that this inquiry activity provided students the opportunity to not only learn but understand the concept.

What does Collaborative Problem Solving Look Like?

I took a risk and tried something I had never done before in the science classroom – problem solving. Students worked together in collaborative groups to solve a real world scientific problem. Here I could really test their thinking, but could they do it? Would they do it?

The task involved a problem involving dislodged atoms producing static electricity:

Mrs. Karabasz sent Jack and Jill on an errand to the office in November. There was a new wool rug in front of the office door and the students wiped their feet on it before touching the metal doorknob. They both received a shock. Why? Please explain in as much scientific detail as possible. As a second part of the question – In May, Jack and Jill were sent to the office again and followed the same procedure, but this time they did not receive a shock. Why?

It was interesting to watch the students approach to this problem. Everyone seemed quite uncomfortable at first, and there was a collective sigh of relief when I told them they could rely on their additional resources if they needed to do so. A cacophony of voices rang out. “Mrs. Karabasz, we need help.” “What do you mean, use our resources?” “What does the different time of year have to do with it?” “I don’t get it!” A leader emerged in every group. Between the two classes, there were twelve groups in all, and most were able to develop a solution. It took much longer than I thought and many groups appeared to struggle. I did, however, constantly monitor

the quality of the scientific writing and scientific explanation on their lab data sheets.

There was a recurring theme in the requests for teacher assistance. They were unsure of themselves, not knowing where to begin or how to develop their answer. But the fact that they were asking questions told me that they were motivated and attempting to meet the challenge.

Figure 1 juxtaposes Kait's journey into problem solving with my own.

Kait's Story

Kait

I don't get this. What does she mean problem solving. She didn't teach us how to do this and it's graded?

Teacher

I know they can do this. They need to think and use their resources and communicate to one another. Each group represents a mixture of student ability. I know they can work together to develop an answer. I have to give them more support.

Kait

Alright. Using the resources help, but this problem is different than what we talked about in class. But how is it the same? I know I've gotten shocked before when I have touched a doorknob. What can it mean?

Teacher

Some groups are starting to come together and get it. They are talking about atoms being disturbed and losing electrons causing some objects to become either positively or negatively charged. They are relating it to the balloon activity we did in class demonstrating static electricity. It's starting to come together.

Kait

I got it. When they rubbed their shoes on the mat they disturbed atoms causing the electrons to jump from one atom to another either positively or negatively charged. The metal doorknob is a good conductor of heat and electricity so when they rub their feet on the mat they created static electricity which caused the shock when they touched the doorknob.

Students learned how to work together to collaboratively solve a scientific problem. They were beginning to understand how to “grapple” with content to arrive at a solution and to rely on each other as they worked to construct an answer.

What is a State of Matter Anyway?

Rather than dictating the definitions of solid, liquid and gas as I had done in the past, I decided to see if I could push my students to develop their own definitions. I provided lab data sheets, quarters, erasers, paper, baggie, water, straw and plastic containers and let them loose. I told them that I wanted them to develop their own definitions of the states of matter in their lab groups. Students were to begin with solids. They needed to examine the “solid” objects on the lab table and determine and discuss what properties they had in common and record those properties on the data sheet. Once they had concluded the properties or characteristics of the particular state of matter, they were to construct a definition. They then moved on to liquids and then gases, repeating the same procedure. They seemed to really enjoy being given the opportunity to “play” with the objects.

Mada observed, “I think the baggie is a solid.”

Jaro added, “But you can see through it, and it’s empty inside.”

Jar noted, “You can still touch it, and it keeps the same shape.”

Mada shared, “The water moves, look when you pour it.” “Don’t you think that liquids move?”

“Laura, you blow up the baggie with the straw.”

“Why me?”

“Because you didn’t do anything yet.”

“Hey the air fills the bag. Shouldn’t that be part of the definition? It takes the shape?”

Each group stayed on task as they worked with the materials and one another to construct the definitions. They seemed to enjoy “playing” with the materials which helped lead them to observations they could use in forming the definitions that in the past they had simply recorded in their notebooks without much thought.

Mixed Up Lab?

This could really be messy, I thought, as I hoped my principal wouldn’t walk in, not sure of what she would think when she saw what might appear to be a chaotic classroom. I placed all the materials in the middle of the lab tables. Students had real choices to make. They were actually directing their own lab for the first time. Could they make a compound, solution, mixture, colloid, or suspension from the materials on the table? I had my fingers crossed.

Students were excited to mix substances together to form a compound, solution, mixture, suspension or colloid. Students later noted they liked this lab and felt that they learned a lot from the experience. There was, however, some initial confusion. Students were unsure what to do. They had never had the opportunity to just "mix" their own substances before. After experiencing this lab, most of my students demonstrated understanding of the differences between the substances.

As I observed each group I noted their findings:

Luka: "No, that's not a mixture. You can't easily separate it."

Erika: "Some things react with a chemical reaction and some don't."

Nicola: "If you mix vinegar and baking soda it will start fizzing and create a gas."

Christine: "Hey look at this, I think it's a suspension. Look at the baking soda in the oil."

Em: "Mrs. Karabasz, help! We exploded!"

Mrs. Karabasz we need paper towels, now!!!

Figure 2. Student Insights – Mixed Up Lab

At first they were a bit timid, afraid of making a “mess” not knowing what they were going to get. But as the lab progressed each group became more adventurous and tried many different types of combinations of substances as they then worked to analyze the result. I was relieved and somehow amazed; they rose to the challenge. The quality of the experience is definitely an improvement over the “Cookbook” labs they’d done with me in the past. Students actually got not only to observe the substances but to create them. Through this inquiry, students experienced firsthand what a mixture, solution, colloid and suspension look like and how they are different from one another.

Up, Up and Mid-Way!!

At the beginning of November, I provided a mid-study survey to all of my 46 students that included a series of sixteen questions with possible answers of always/usually, sometimes, and seldom/never. I discovered that the majority of the students enjoy science and feel confident in science class and are beginning to become comfortable with the inquiry method.

Table 1: Mid-Study Survey (N= 46)

Question	Always/Usually	Sometimes	Seldom/Never
1. I enjoy science.	95%	5%	0%
2. I think I am good at science.	70%	23%	7%
3. I feel confident in science class.	82%	16%	2%
4. Science scares me.	0%	9%	91%
5. I think science is boring.	0%	19%	81%
6. I would describe science as fun.	82%	14%	4%
7. I liked 5th grade science more than 6th.	7%	30%	63%
8. I like 6th grade science more than 5th.	65%	26%	9%
9. I would like to be smarter in science.	70%	21%	9%
10. I like science when it it is challenging.	33%	40%	27%
11. I like science when it is easy.	45%	30%	25%
12. I pay attention in class.	91%	8%	2%
13. I enjoy science when it involves a hands-on activity.	95%	3%	2%
14. I like the Inquiry Method when I get to make choices and discover the answers.	54%	26%	20%
15. I think the Inquiry Method helps me learn Science better.	58%	21%	21%

Overall, 95% of my students said that they enjoy science. I was especially pleased to find students still enjoying science even though the content is getting more difficult as they become more deeply immersed in their study of chemistry. I wondered how the inquiry method was related to this result? I was also pleased to see that seven out of ten students said that they think they are good at science. Clearly, their success in our activities supported the academic confidence of most learners. While 82/84% of students report feeling comfortable with the inquiry method, I worry about the number of students who do not.

An important finding is that 93% of my students sometimes or always prefer sixth grade science to fifth. I really think this had to do with the number of labs and the inquiry component in the labs. As I mentioned earlier, I did not include as many labs last year, and none of those we did included an inquiry component. I surmised that the 7% that indicated that they usually or always preferred 5th grade science either liked the subject matter (Invertebrates, Motion and Energy, Weather, or Skeletal System) better in 5th grade or that they realized the content is more challenging and they do not prefer that.

Overall, 70% of my students said that they would like to be smarter in science, I was pleased to see that they wanted to learn and understand more. The inquiry method is forcing them to think, but at the same time it was incenting my students to want to know more, to understand more, to learn more.

Finding that only one-third of my students like science when it is challenging was surprising to me. I had anticipated that most of my students would enjoy a challenging experience, but for most, this was clearly not the case. I suspect that my students are really telling me that they feel comfortable when they are in their zone of proximal development. When I push them beyond that level, they feel frustration and do not enjoy that particular learning experience. Most surprising to me was the realization that many of my highest scoring students indicated that they did not like science when it was challenging.

More than 90% of my students said that they always or usually pay attention in science class. Clearly, the inquiry method helps to keep students, interested, engaged and focused on the learning task at hand.

Only slightly more than half of my students responded that they always or usually like to make choices and discover an answer for themselves. This tells me that I still need to do some modeling and guiding for students to feel comfortable with the inquiry method.

I was also surprised to learn that only 42% of my students at this point said that the inquiry method only sometimes or seldom helped them to learn science better. There I wonder if those students still don’t quite understand what I mean by the inquiry method or if they still equate learning with memorizing and reciting.

The mid-study survey was enlightening for me as a teacher. I think my students were largely motivated and engaged because of the use of the inquiry method, but I noted that at times they felt uncomfortable. Pushing them beyond their comfort zones, or challenging them, is not always a welcome experience even for my top performing students. As the study progressed, I would need to continue to provide guidance, support, and motivation as needed. I can't assume that all my students are able to independently make choices to discover answers to scientific questions without additional support structures.

What is Slime?

Later in November, students observed and tested slime and its properties to determine whether it was a solid, a liquid, or perhaps a hybrid. They also attempted to discern if it was created through means of a physical or chemical reaction. Keeping in mind the need to provide just a bit more scaffolding, I gave students some direction indicating various tests that they might perform on the slime. For example, I suggested that they might try to roll it into a ball. They could poke it quickly and then slowly to see if it splashes and if there are any differences attributed the change in speed. They then could add their own exploration to help to make their final conclusions about slime. Students appeared to be quite engaged as they explored and tested the slime by examining its properties by poking, prodding, rolling, dripping, etc. I was as excited as they were. As I rotated among the six lab stations, students were excited to share their observations.

Jo: "Mrs. K., look what happened when I applied pressure! It looks hard."

Mrs. K: "What might that indicate?"

Jo: "I don't know."

Mrs. K: "Well, what do you think? Discuss the properties of solids and liquids with your lab partners. See if you can arrive at an answer."

Mrs. K: "Laura, what happened when you put your finger into the slime slowly?"

Laura: "It felt like a liquid. It was soft and seemed to move."

Mrs. K: "What happened when you put your finger in the slime quickly?"

Rye: "It felt different."

Mrs. K: "What do you mean? Can you describe it?"

Rye: "Well, it was kind of hard when we did it fast. And it kind of splashed just a little."

Mrs. K: "What do you think that means?"

Sammy: "It's almost like a solid."

Mrs. K: "Why?"

Sammy: "Well it kind of has a shape like we said like a solid has and it feels mostly hard."

Mrs. K: "Brian do you think slime is a solid or a liquid?"

Brian: “I don’t know yet. I want to test it some more. Sometimes I think it is a liquid and sometimes a solid.”

Mrs. K: “Why can’t you make up your mind between slime being a liquid and being a solid?”

Dom: “Sometimes it acts like a liquid depending on what we’re doing and sometimes it acts like a solid.”

Mrs. K: “Do you think it could be both a liquid and a solid?”

Dom: “Is that possible?”

Mrs. K: “If you have the data to prove it, it certainly can be.”

Rila: “Mrs. K, I don’t understand what you mean when you asked us if the slime was a physical or chemical change.”

Mrs. K: “Well, Rila, what do you think created the slime? Think about your definitions of a physical change and a chemical change. You saw me make the slime. What do you think it is?”

Shana: “I think it is a chemical change because it looks different, and it’s a new substance. It’s not cornstarch or water anymore.”

Mrs. K: “ Shana, what is the definition of a chemical change?”

Shana: “ Uh, I think it is when two or more substances are combined and they create energy and a new substance is formed.”

Mrs. K: “Do you think you saw any energy being released?”

Shana: “I don’t know.”

Mrs. K: “Madge, what do you think?”

Madge: "I think it is a physical change because I noticed after a while when the slime was sitting out, the water started to evaporate and it starts to look like a powder again, you know, the cornstarch. So I think it really didn't make a new substance, really."

Mrs. K: "What did it make? Do you remember what other substances we talked about other than compounds?"

Christine: "Do you mean mixtures and solutions and all that?"

Mrs. K: "Yes, that's what I mean. What do you think it is?"

Christine: "Well, I think it might be a solution because we said that solutions involve a liquid and it is usually a solid mixed in a liquid and we mixed the cornstarch with the water."

Mrs. K: "You are very close, Chris. If it is a solution, is it a physical or chemical change?"

Augustus: "It's a physical change!"

Mrs. K: "You're right, Augustus. But is it really a solution? Think about what we said about a solution that has small suspended particles in it. What is it called?"

Augustus: "I don't remember. Hey, Jar, don't you remember? You're good at science."

Jar: "I think it might be a colloid."

Mrs. K: "Why do you say that Jar?"

Jar: "Because you said that colloids are solutions where there are tiny particles suspended in the liquid. I think that's what slime is."

Mrs. K: "Good Job! Great thinking there, Jar!"

Mrs. K: "Kait, does the slime look different now than when you first started the experiment?"

Kait: "It's dried and hard."

Mrs. K: "Why is that? What happened?"

Jen: "I don't know. It's not wet anymore."

Mrs. K: "Think about that. What does that mean?"

Jen: "It's cooling?"

Mrs. K: "Not quite. It's at room temperature. What happened to the liquid? What process is that?"

Kat: "Evaporation?"

Mrs. K: "Eureka!! The water evaporated, and the slime is starting to dry."

Mrs. K: "So, if the substance separates easily, what does that tell you?"

Kat: "I think it was a physical change."

Mrs. K: "Good Job."

I enjoyed being part of the lab dynamic, and students often needed the support provided by my questions. The level of scientific thinking was taking off. Of course, I had to be very careful to use a Socratic approach, however. Kids are often looking for the right answer, and I needed to make sure I helped them to

Here We Go Again, There's Baking Soda!!

My observations suggested that the level of scientific thinking was improving in our collaborative lab setting. Students gained confidence using scientific vocabulary and discussing scientific content to arrive at new solutions. I enjoyed students' willingness to discuss and debate an answer.

In our next lab, students created a chemical reaction using baking soda and vinegar in a soda bottle. The resultant carbon dioxide gas inflated the balloon that was attached to the bottle. Students observed the properties of the reaction and worked to explain what kind of chemical reaction was created.

I began by pulling together content knowledge to see if the students could recall and connect what they had previously learned. I began with a chemical equation.

The narrative form that follows identifies the importance of teacher questioning and guiding as critical components of the inquiry lesson.

- $NaHCO_3 + CH_3COOH \rightarrow CO_2 + H_2O + CH_3COONa$
- Sodium Bicarbonate + Acetic Acid ➡ Carbon Dioxide + Water + Salt

It begins here. Here comes the series of questions. Do they really understand?

What kind of reaction is this?

Hands go up there seems to be excitement in the room. They appear eager.

Eureka! Yes, it is a chemical reaction, but why?

Never let them off the hook. Always ask them to expand their thinking.

Yes! It created a new substance. What else should we look for to determine if it is a chemical reaction?

Push them further. Force them to think. Help them to connect what we've discussed before with what they see now.

You're right. I wonder if it will release energy?
What other kind of Reaction is it? Look carefully.

Fewer hands go up. I wonder if they will remember and make the connection. How can I help them. Wait. They can do it.

Why did you say it was a Neutralization Reaction?

Always have them explain. Never just accept an answer. Further explanation benefits not only the individual student, but the whole class. It helps the students form their scientific thinking.

You remembered! When an acid is mixed with a base it produces a neutralization reaction resulting in water and a salt being produced. Which substance is the acid, which is the base?

They are able quickly to identify the acid (vinegar) and the base (baking soda).

What other kind of chemical reaction might it be? Think about the possibilities.

Blank stares. They seem stuck. I know they know this.

Did the reaction form something new? What type of chemical reaction is that? What did we call it?

I hope this stimulates their recall. We talked about this a lot and in the mixed up lab it was one of the concepts used.

Yes!! You remembered. It is a composition reaction when substances come together to create something new. Way to go Sam!

I am beginning to see that my students who struggle the most really seem to be benefiting from using a hands–on inquiry learning approach. They are making the connections and becoming more confident in science class.

Why Do We Have to Bring in Pennies?

As we moved into December, it was time for students to conduct an inquiry lab on oxidation, where I asked them to observe the amount of oxidation on pennies and experiment to see if they could remove it using a solution of white vinegar and salt. I then asked them to remove the pennies with some of the coins being rinsed with water while others remained un-rinsed to determine if they could note any differences. Students also placed metal screws in the solution after the pennies were removed to see if there was any reaction occurring that might affect the screw.

By this point in the school year, students know the procedure. I activate prior knowledge by discussing the concepts involved and have students make predictions before we begin. My students seemed motivated and eager to begin the scientific journey once they know what the inquiry challenge involves.

My assistant principal had the opportunity to observe students at work, and I found her comments to be most encouraging and insightful as she examined first-hand what my students were experiencing in the classroom through scientific inquiry. She noted:

- ✓ "The students were eager and excited to complete the lab …. "
- ✓ "The class was very cooperative and focused quickly."
- ✓ "The teacher guided the students to the conclusion that a new substance was formed."
- ✓ "The students worked extremely well in their groups."
- ✓ "There was great discussion among the groups as well as great teamwork."
- ✓ "I was very pleased to see the students focused and on task the entire time."

- ✓ “They were very interested in the science aspect of this lab.”
- ✓ “The teacher continued to walk from table to table making positive comments, asking questions, and reviewing procedure.”
- ✓ “Again, the teacher guided the students to explain how this was possible.”
- ✓ “I was impressed with the students’ ability to explain this process.”
- ✓ “I noticed great discussions with the teacher guiding the students to explain their answers using science verbiage.”
- ✓ “All students are active participants.”
- ✓ “It is amazing to watch a teacher guide a class through a discussion and help the students “see”.

Having an observer see the active student learning through inquiry in my science classroom proved to be a powerful experience for me. I was pleased to see her comment upon student engagement and focus during the lesson, which is a key factor I have recorded throughout my field log observations. She also noted several times that I “guided” the students. I must admit that it really is a struggle at times knowing how much support to give students, trying not to give away the answer, but to provide the support students need to make progress. It is important to maintain the Socratic approach and continue to push students to discover their own solutions. She also noted good teamwork and discussion among students, as well as students being on task. Again, her observation confirms what I had previously experienced throughout the various inquiry labs and activities.

Students have continued to develop their scientific skills in terms of observation and analysis. The scientific discourse among lab groups as observed in whole group discussion continues to improve in quality. More and more students seem to be growing in their confidence in science class as measured by the amount of hands that goes up during whole group discussion. Even my struggling students appear confident enough to venture an answer or a solution during the scientific discussion with the whole class. Students are growing in their scientific skill and their overall confidence with their scientific knowledge and understanding.

Who's Fritz?

In December I introduced the second graded collaborative problem solving activity. I wanted to assess how my students had been able to develop their scientific content knowledge and scientific problem solving skills, as well as, scientific writing to this point in the year. As we began, I made a note to focus my observations on students' use of scientific language to provide a clear explanation of events and concepts.

<u>Problem One</u>

> **"Mrs. Karabasz's dog Fritz loves to go outside. One early Summer morning he went outside. When he came back in, he was all wet. It wasn't raining outside. Nor did he run into a sprinkler or a hose. What happened to Fritz? Use your best scientific explanation to explain how Fritz got wet."**

<u>Sam</u>*: *When Fritz went outside he got wet because of the dew on the grass. Overnight the dew appeared because there was moisture in the air.

Almost there. Sam is dyslexic and, at times, struggles in science, but I think for the most part she has the idea. She didn't mention the process of condensation, but her language demonstrated that she was thinking of it. I really think this was a victory for her. She was starting to come into her own in science and is much more confident and willing to offer answers than she had been at the start of the school year.

<u>Kat</u>*: *Fritz was rolling around in the morning dew on the grass. Morning dew is a wetness on the surface of the grass because the heat of the earth is coming up and mixing with the cold air makes it wet and so that is how it got there.

Kat is a top student. She has the idea, but rather than mentioning the term of condensation, she explains the concept. Scientific writing and explanation have proved to be quite difficult for most students, Kat included. They seem to understand the content, but writing it is a whole other matter.

***<u>Erika</u>*: The dog got wet because when he went outside it might have rolled in the grass and on the grass there was moisture. In the night before the moisture in the air cooled and condensed into liquid and formed on the grass.**

Erika got it. Here she was insightful and demonstrates knowledge of scientific content and language. Many times early in the year, she was not good at sharing her knowledge in collaborative situations. She grew more confident to discuss concepts among her classmates and help lead them to a solution.

<u>Problem Two</u>

> **"Mrs. Karabasz just bought a huge Christmas Candle. She lighted it and it started to burn. She sees that the wick has turned black and there is melted wax running down the side of the candle. She would like to know if what she is seeing is a chemical reaction or a physical reaction, or even both? Please explain using your best scientific knowledge."**

***<u>Em</u>*: It is both a chemical and physical reaction because it doesn't form a new substance, but some energy is released in heat. The candle changed in size and shape, which is a physical change. The chemical bonds changed, which is a chemical reaction.**

She almost had it. She just didn't recognize that the black substance formed on the wick is carbon and in fact a "new substance." But her group did identify that both a chemical and physical change had occurred, and they presented a fairly strong, detailed solution demonstrating their content knowledge and understanding.

<u>Erina</u>*: *The burning wick is a chemical reaction because all burning is a chemical change because heat and energy is released during this process and the melting wax is a physical change because it is changing its form.

This was a strong answer for Erina, who often struggles to understand the scientific content. Here, she demonstrates her scientific reasoning. I am proud of her work, noting that her hands-on inquiry experiences to create real understanding of scientific concepts seem to work for Erina.

<u>Luka:</u>* *It was a physical change and a chemical change. Because the wick burning is a chemical change, because it is releasing heat. And the candle melting is a physical change because it is changing its state of matter from a solid to a liquid.

Luka was a top performing student who was knowledgeable and took a leadership role in his group to make sure everyone understood the solution. When his group mates needed additional scaffolding, he often helped his peers identify appropriate scientific content and led their discourse.

This problem solving activity helped me gain an insight into the level of my students' scientific skills. By requiring them to write down their answers I was able to capture where they are in their level of scientific thinking, understanding and scientific writing. Overall, all 46 students were able to achieve a 90% or above on this activity. I scored students using a rubric evaluating scientific content, problem solving skill, collaborative activity and writing mechanics. I was impressed with the quality of answers and the level of understanding. Of course, I wondered how student collaborative success would translate to performance on independent problem solving assessments.

Wrapping it Up!

As we prepared for the upcoming holiday break and the formal conclusion to my teacher action research study, I asked my students to wrap up their thoughts in a final survey. Table 2 includes six end of study questions with a percentage tabulation of students' responses.

Table 2: End of Study Survey (N= 46)

Question	Always/Usually	Sometimes	Seldom/Never
1. I have enjoyed 6th grade Science so far.	95%	5%	0%
2. I have developed my scientific problem solving skill in 6th grade.	78%	22%	0%
3. I have improved my observation skills.	96%	4%	0%
4. I have improved my scientific thinking skills.	87%	9%	4%
5. I think group work in Science helps me learn better.	82%	16%	2%
6. I think the inquiry labs helped me learn the science concepts and ideas.	80%	16%	4%

Listed below are student comments provided on the survey:

1. I have enjoyed 6th grade science so far.

It is usually exciting and entertaining.

It is filled with excitement and I always learn something new.

We do more labs. I like hands on but book learning can get boring.

I like experimenting. Learning new things is fun but occasionally tricky.

2. I have developed my science problem solving skills in 6th grade science.

The inquiry method helps me think outside the box. I can see that I understand more.

I **know how to figure out things. I enjoy finding out what the solution was.**

We get to do stuff ourselves.

I have become a lot better with my problem solving skills since the beginning of the year. I find it easier to find answers and solve scientific problems.

3. I have improved my Observation Skills.

I try to add some more detail than I ever did before.

I have a different way of looking at things and can find out more about them.

Because I can see more little details than I did before.

4.I have improved my Scientific Thinking Skills.

I've learned to think about what I may do.

I have a lot more thinking skills than last year.

Yes. The problem solving skills make me think and use my brain.

5. I think group work in science helps me learn better.

If I do not understand something my group might and could explain.

Because many ideas help you think more and explore deeper.

Because maybe if you do not know something someone in your group can help.

6.I think the Inquiry labs helped me learn the science concepts and ideas.

Positive Responses:

It makes me think harder about the questions and what the answers are.

It explains more so I can understand it more.

Because I get hands-on activity and actually get to see what happens rather than just being told about it.

Because I can figure it out for myself.

They give me more points of view to look at besides just what happened.

The inquiry lesson helps me find new observations and ideas.

I like to work on my own and find out what happens.

It helps me think about the subject more deeply and observe more clearly.

We learn easier.

It helps me think better.

Because when I explain and find out an answer it helps me to remember or become a better scientist.

Negative Responses:

Sometimes I don't know how to use the Inquiry Lab but when I go to the lab I can use it.

They sometimes help me, but sometimes I don't get it.

Because sometimes the experiment doesn't make sense.

There again, sometimes hard.

I was relieved and greatly encouraged by the responses of the students on the end of study survey. Overall, 95% of my students said that they either always or usually have enjoyed 6th grade science to this point in the school year. The students have come along way. I was pleased to see that nearly eight out of ten students reported a sense of having developed their scientific problem solving skills in 6th grade.

The Observation Skills activity was really worth its weight in gold. With all but one or two of my students reporting that they always or usually have improved their observations skills throughout their study of 6th grade science.

My students are getting it. They really are learning how to expand their thinking and use their knowledge to solve a problem or arrive at a solution. They can do it! 87% of my students said that they have improved their scientific thinking through their study of inquiry. 9% or 4 students said that they sometimes feel they have improved their scientific thinking. Two students, or 4% felt they seldom have improved their scientific thinking. Both of these students have emotional/learning disabilities and have a tendency to respond negatively to questions.

Collaborative lab work was clearly beneficial to promote scientific skill among students. Students were able to work together to help each other develop scientific thinking skills, and 8 of 10 students believe they usually or always feel that group work helps them learn science better. 16% said that they sometimes feel that is true. 2% or one student said that she never thinks group work helps her learn better. Of course, I must continue to support the needs of the lone student who did not feel the group supported her learning.

Overall, most students reported a benefit to the use of inquiry learning. While 80% of my students shared that they think that the inquiry labs helped them to learn the science concepts and ideas, I still have much to learn about how to help the few of the students who believe that the approach is helpful sometimes or not at all. I need to continue to scaffold scientific thinking and the inquiry concept to help those students who still feel uncomfortable and help them develop their ability to "think".

Independent Thought – The Emergence of the Young Scientist

The final student work I examined was test data. I usually put at least one scientific problem on my chapter tests, and students must respond in essay format. Here I intend to assess individual scientific problem solving skills and content knowledge. Previous problem solving done in the classroom was collaborative, and students were encouraged to rely on one another. Could they now solve a scientific problem with an accurately written scientific explanation? The question I posed to find out went like this:

"It is a very hot day in Summer and you have just filled a glass with lemonade and added ice. You notice that there is water on the outside of the glass. How can you explain this scientifically? is the glass leaking?"

58% of my 46 students answered this question correctly, which was quite an increase from prior years, where I had gotten far less of a positive response. Another 14% of my students had a partially correct response, representing an important step forward for some of my struggling learners. One student in particular who had a partial response is severely learning disabled. For her to "get" any part of the concept represented a major victory. 28% of my students, though, responded incorrectly. Eight of the 13 students who got this question wrong were at times struggling science students in terms of test results and have various diagnosed learning disabilities. Five of the 13, however, are at times the top scoring students on science tests. Top scoring students often become masters at memorizing and regurgitating without engaging in scientific thinking. The inquiry approach may frighten traditional top performers and explain some of the "negative" student responses to the approach. Clearly, the data had yielded some

Some surprising results for further consideration.

METHODS OF ANALYSIS

Throughout the action research study, I focused on my research question. My question was: “What are the observed and reported experiences using the Inquiry Method in a 6th grade science classroom?”

Data Collections Analysis - Memos

In the process of analyzing the data I prepared analytic, reflective and methodological memos to summarize, guide and focus my analysis. I also examined my data through the use of four reflective memos using the educational theories of John Dewey, Paulo Freire, Lev Vygotsky and Lisa Delpit. I was able to apply their theories to my own study and draw connections that enabled me to better understand and interpret my data. As I conducted every inquiry activity I continued to reflect upon Dewey and ensured that the “experience” was an educative one for my students. Paulo Freire (2003) emphasized the importance of inquiry, which helped in guiding my study. “For apart from inquiry, apart from the praxis, individuals cannot be truly human” (p.72). Friere continued to stress the importance of students as active learners or participants in the process of learning. To be “truly human” one must experience to learn (Friere, 2003). Vygotsky reminded me that each inquiry activity should be designed within the students’ proximal zone of development. I needed to ensure the activity was right on target, not above my 6th grade science students’ level of development or below it to achieve the desired result of optimal learning. Delpit indicates that discourse is a powerful component of learning. Teachers need to listen to that discourse to because, “by not listening, teachers cannot know what students are concerned about, what interests them, or what is happening in their lives. Without that knowledge it is difficult to connect the curriculum to anything students find meaningful” (p. 43). Teaching with inquiry allows teachers to “listen” as there is more student talk taking place than teacher talk in the student driven experience.

I also completed a methodological memo summarizing my mid-study data assessment. In this memo I prepared a chronological list of field log entries highlighting areas where insights were gained. I followed the same procedure for surveys and student work.

Field Log Coding

During the study, I entered information into my field log after every activity. I recorded my observations and notes and later typed my observations from my field log. In the process of evaluating and reflecting upon my field log, I coded and binned all of the data I gathered throughout the study. I looked for patterns in the data and looked for emerging themes. I created bins in order to organize themes which led me to create my final theme statements.

I analyzed my field log and reflected on it, after every inquiry activity. I discussed the data with my colleagues and professors who helped me gain new insights in the process. I separated observations and teacher reflections so I could compare what I saw with how I felt about what I saw.

I maintained a coding index for my field log and updated it as needed. I created a graphic organizer to display my codes and bins. After reviewing the bins, I was able to create theme statements for each bin. At the end of the study, I reevaluated my bins and themes and made adjustments as necessary to compose my final theme statements.

Student Surveys and Student Work

I summarized and analyzed all data from the pre-study survey, mid-study survey and post-study survey and created a statistical analysis. This information helped me to assess, evaluate and understand student feedback regarding the quality of the experience. I evaluated student work and tests and summarized results in the form of analytical tables. I looked for patterns in the data and looked for emerging themes. I created bins in order to organize themes which led me to create my final theme statements.

Memos, field logs, student surveys, student work and tests were all used to triangulate the data as recommended by Holly, Arhar, and Kasten (2005). By reviewing data in all areas I was able to construct the following theme statements.

Theme Statements

Scientific Skills
In the process of using the inquiry method in the science classroom most students demonstrated improvement in the level and quality of scientific discourse, scientific problem solving skills and scientific skills, and the quality of the scientific writing of students.

Motivation and Engagement
Student motivation and engagement largely increase as a result of participation in inquiry experiences.

Real World Connections
The inquiry method suggests connections between conceptual understanding and real world experiences. Some traditionally high performing students, however, may have difficulty making connections when asked to do so independently.

Collaboration
The use of collaborative lab groups helps to develop student scientific thinking and problem solving through the use of scientific discourse.

Student Driven Inquiry
When scientific inquiries are student driven, students are motivated to create more meaningful connections and understandings of scientific content.

Teacher Reflection and Teacher Guidance
The balance between teacher given support and student independent discovery must be monitored and adjusted as needed for each collaborative group and each inquiry experience.

Dilemmas in the Teaching of Inquiry
Difficulties and challenges in using the inquiry method revolve around adequate teacher training and teacher content knowledge, as well as, learning how to design lessons that balance teacher support and student independence.

Figure 3. Theme Statements

FINDINGS

Eureka!

I began my study with the following question, “What are the observed and reported experiences when using the inquiry method in my 6th grade classroom?” I wanted to determine how the inquiry method might support scientific skills, scientific thinking and problem solving and scientific discourse and writing in the classroom. In addition, I wanted to see how student motivation and engagement might be affected by the use of this method.

Scientific Skills

In the process of using the inquiry method in the science classroom most students demonstrated improvement in the level and quality of scientific discourse, scientific problem solving skills and scientific skills, and the quality of the scientific writing of students.

The foundation of scientific investigation is the use and knowledge of the scientific problem solving skills that comprise the scientific method. Identifying a problem, developing the hypothesis, experimenting, collecting data and making observations and finally forming conclusions and theories is what the scientific method is all about. As the students participated in inquiry labs and problem solving activities during the data collection period, I was able to observe students in the process of becoming more confident in their ability to understand and explain the scientific principles being studied and use the scientific skills they were developing.

While most students did not use scientific terminology they demonstrated their ability to explain key scientific concepts that they encountered in action. Colburn (2004) explained that for a greater understanding of science and scientific concepts, inquiry-based teaching gives students the opportunity to "actively grapple with the content" (p. 64).

During the Mixed Up Lab Activity, State of Matter Activity and especially Slime Lab students demonstrated their knowledge and understanding of content in their group discussions, while actively engaged in "grappling" with the content to arrive at a solution.

The quality of the scientific discourse among students continued to increase throughout the study. Over time, students became more confident and knowledgeable in their shared reflections in the collaborative setting. As Cazden (2001) points out, talk allows us to process the learning and leads to understanding. As I observed lab groups working to solve an inquiry problem, it was the quality and quantity of the scientific discourse that struck me the most as in Slime Lab and the Mixed Up Lab experiences. This told me they "understood" the content and task at hand. They were in control of their learning and were capable of directing themselves through the activity. "Articulating the cognitive activity" (Zohar, p. 340) or rather thinking-aloud may produce important connections between the concrete and the abstract in science. When my students engaged in the process of the inquiry lab experiences, they were able to make connections between the hands on activity and the science content. For example, in the Building Molecules activity, students were able to transfer the knowledge gained from the activity to achievement on the related assessment.

Analysis of student work involving the Collaborative Scientific Problem Solving activities revealed that most students were beginning to develop their ability not only to "discover" the solution to an inquiry problem using their scientific knowledge and skill, but they were able to articulate their scientific reasoning in writing. The development of students' ability to perform scientific inquiry depends on the development of oral and written skill (Dyasi, 2006). Students were better equipped to solve problems collaboratively than they were independently. The ability to discuss and construct solutions collaboratively was extremely beneficial. Every group, including all 46 students for the two collaborative problem solving activities conducted during the study, received a 90% or higher on these activities.

Student test data revealed that most students improved their level of independent scientific problem solving skills and science content knowledge and were working to develop their level of scientific writing. The formative assessment results as listed in Table 1 show that, according to classroom test data, most but not all students improved their problem solving skills. Two thirds of the 46 students either improved levels of independent scientific problem solving or maintained an existing high level of problem solving skills. Overall, test averages of Chapter 6 (89%) and Chapter 7 (88%) on the topics of Chemistry were quite high for a class of 46 diverse learners. Student survey responses suggested that hands-on, inquiry based learning helped students to retain scientific content and promote understanding. Fisher, Geres, Logue, Smith & Zimmerman (1998) linked the use of active learning strategies in the classroom.

Table 3

The following contains Formative Assessment Results for Chapters 6 and 7 and Independent Scientific Problem Solving for Chapters 6 and 7. The independent scientific problem solving assessments were included in the Tests for Chapters 6 and 7 as short essay questions.

Teacher Gradebook Excerpt:Chemistry

	Chapter 6 Test Avg	**Chapter 6 Prob.Solving**	**Chapter 7 Test Avg**	**Chapter 7 Prob.Solving**	**Change Prob.Solving**
Jar	98	no	98	good	**+Improved**
Jen	94	good	100	very good	**+Improved**
Sam .	100	partial	100	good	**+Improved**
Jo	87	no	95	good	+**Improved**
Rye	100	no	96	no	-Not Impr
Ichobod	81	good	94	good	+**Same**
Mag	95	no	95	good	+**Improved**
Kait	86	no	85	good	**+Improved**
Kaitw	88	no	92	no	-Not Impr
Alee	98	partial	97	good	**+Improved**
Nick	89	partial	91	good	**+Improved**
Kat	100	no	94	good	+**Improved**
Mercey	97	partial	97	very good	+**Improved**
Luka	100	partial	97	no	-Not Impr
Rila	95	partial	95	no	-Not Impr
Gracey	95	good	92	no	-Not Impr
Laura	94	partial	88	no	-Not Impr
Lorie	88	no	90	no	-Not Impr
And	89	no	89	good	+**Improved**
Brian	90	good	92	good	+**Same**
Micha	92	good	91	no	-Not Impr
Rye	97	no	90	good	+**Improved**
Erika	90	good	93	good	+**Same**
Jaro	94	no	89	good	+**Improved**
Mada	94	no	90	good	+**Improved**
Augustus	85	no	87	good	+**Improved**
Christine	99	good	92	very good	+**Improved**
Madge	94	no	86	good	+**Improved**
Shana	98	no	86	no	-Not Impr
Erinna	81	no	84	no	-Not Impr
Nicola	76	partial	80	partial	+Same
Nickki.	83	no	81	good	+**Improved**
Brin	83	partial	90	good	+**Improved**
Christa	83	good	91	no	-Not Impr
Lailall	75	no	74	partial	+**Improved**
Katier	95	no	88	partial	+**Improved**
Nickcc	81	no	82	partial	+**Improved**
Devo	88	no	78	partial	+**Improved**
Matt	88	no	84	good	+**Improved**
Al	80	no	75	no	-Not Impr
Dom	84	no	78	good	+**Improved**
Gray	92	partial	83	good	+**Improved**
Em	82	no	78	partial	+**Improved**
Sammy	71	no	67	no	-Same
Ryand	73	no	65	no	-Same

In Table 1, I share excerpts of my grade book data from our chemistry unit. The test average for Chapter 6 was 89% and for Chapter 7 was 88%. 31 out of the 46 students or 67% improved in their problem solving skills from Chapter 6 to Chapter 7. Students who were assessed as a no for problem solving did not demonstrate understanding of scientific concepts and/or were unable to use correct scientific verbiage in explanation on the teacher-made chapter test. Students who were awarded partial credit demonstrated partial understanding of scientific concepts and/or were able to use correct scientific verbiage. Students who were assessed with a “good” or “very good” were able to demonstrate understanding of scientific concepts and were able to use correct scientific verbiage in their explanation.

Student Survey data gathered at the end of the study corroborated my observations and analysis of student work. Overall, 76% of the study participants felt that they improved and developed their scientific problem solving skills. As Christine noted on the final survey, “I have become a lot better with my problem solving skills since the beginning of the year. I find it easier to find answers and solve scientific problems.”

In that same survey, 87% of participants felt that they had improved their scientific thinking skills through the use of inquiry methods in the classroom, Which was in alignment with what I was observing and the data I had collected from student work and tests. Another student commented, “I have a lot more thinking skills than last year.” Haranda and Yoshina (2004) describe inquiry learning as having the ability to promote deeper levels of thinking and to improve students’ motivation for the learning of science.

When asked if they felt that the inquiry labs helped them to learn the science concepts and ideas, 80% responded that they always or sometimes did. Hofstein, Shore and Kipnis (2004) in their research report go on to conclude that “inquiry-centered laboratories have the potential to enhance students’ meaningful learning, conceptual understanding and their understanding of the nature of science” (p.1).

Many of the students became comfortable with pushing themselves further and using their own brain power to arrive at an answer rather than having the solution handed to them. Some students, however, continued to struggle, and not all reached a comfort level with the inquiry approach. An examination of the test data reveals that some of the top-scoring students in terms of scientific content knowledge had difficulty applying that knowledge, whereas some previously struggling students clearly demonstrated higher level problem solving ability.

It is important to continue to scaffold and model the skills I expect my students to develop and use. As a teacher of inquiry I must continue to support and guide my students through the process ensuring that all students have a quality experience. White and Frederiksen (1998) indicated that there is a need for scaffolding to enhance and develop students' inquiry development.

Scientific writing assists students to think more deeply about science concepts and to communicate their understanding (Sutherland, McNeill, Krajcik, 2006, p. 163). Writing helps students to come to terms with what they know and aids in the creation of meaning. Writing opportunities in the classroom should be designed to enhance and develop scientific understanding and scientific knowledge. I have found that when students write collaboratively they are quite capable of forming accurate scientific responses. When students answer independently it becomes more difficult to articulate a correct scientific response.

Motivation and Engagement

Student motivation and engagement largely increase as a result of participation in inquiry experiences.

Students throughout the data collection period were largely engaged and focused on their scientific learning. During the observation of the oxidation lab, for example, my Assistant Principal noted several times that the students were, "eager and excited to complete the lab…" She added, "The class was very cooperative and focused quickly." They also appeared to be motivated as demonstrated overall by the quality of their discourse and positive collaborative behaviors. Caroll & Leander (2001) wrote that incorporating active learning strategies like inquiry learning influences student motivation positively. A study conducted by Fisher, Gerdes, Logue, Smith & Zimmerman (1998) found that an increase in motivation for science was achieved through the use of hands-on inquiry based learning in the science classroom, and my data suggest similar increases.

In the mid-study survey, 95% of the students said that they either always or usually enjoyed science, despite the fact the chemistry-based curriculum generally proved to be difficult for many students. Using the inquiry method appears to have made an impact on their attitude toward science. 91% of my students said that they sometimes or usually preferred 6th grade science to 5th grade science. As the fifth grade science teacher, I did not include as many labs; nor did any of the labs include an inquiry component. 91% of participants also indicated that they either always or usually paid attention in science class, indicating their own high level of engagement. Teaching with inquiry seems to draw them in and keep students focused on the task at hand.

In the end of study survey, 95% of my 46 students said that they have enjoyed 6th grade science so far. It is my belief that the number speaks to engagement and motivation in the science classroom.

Real World Connections

The inquiry method suggests connections between conceptual understanding and real world experiences. Some traditionally high performing students, however, may have difficulty making connections when asked to do so independently.

Using scientific problem solving to help students make real world connections proved to be beneficial to students to demonstrate their understanding of challenging scientific concepts, including such as physical and chemical changes and states of matter. By using inquiry based learning strategies, the science classroom can be transformed from a place were teachers are filling students' heads with numerous science facts and concepts to a place were students are actively engaged in creating real world understanding for themselves.

In the students' first attempt at collaborative problem solving with the topic of static electricity, many students struggled. As I monitored each group and tried to guide them through the activity, I found that they became more focused and comfortable when I allowed them to use their text and copybook as resources. They were not yet ready to rely on their own content knowledge, so I continued to re-direct students as needed, inserted guiding questions, and both encouraged and prompted them to think like a scientist. Using their resources, 10 out of 12 groups were able to develop an accurate scientific solution. Only one group, though, was able to take it to a higher level of scientific thinking and explain how electricity can travel through the body. That piece of knowledge was something that the students themselves surmised from the circumstances of the problem. I was quite proud of that group— scientific thinking at its best.

In the second attempt at collaborative problem solving I was able to get further insight into my students' scientific skills. By requiring them to write scientifically, I was able to assess their level of scientific thinking and understanding. Overall, all 46 students were able to achieve a 90% or above on this activity. They worked collaboratively, but I did not permit them to use their outside resources for support as they did the first time. I noticed much more engaged discourse about the direction their solutions would take. The scientific language was bouncing about all over the classroom as the students worked to arrive at a collaborative solution. I needed to provide less guidance than I had the first time. Students seemed more confident in attempting the solution this second time, I suspect because this was their second experience. They were becoming more confident. I was impressed with the quality of their answers and the level of their understanding. Inquiry had allowed the student to "identify their assumptions, use critical and logical thinking and consider alternative explanations" (Newman, Abel & Hubbard, p. 258). For example when Em's group debated whether a burning candle was a physical or chemical change they brought the definitions of physical and chemical change into their discussion to help them determine a solution. They identified the key characteristics of both types of changes to solve the problem and shared their reasoning as they worked to construct an explanation.

In a formal independent assessment of student content knowledge and problem solving skills for Chapter 7 (See Table 1), 58% of the students scored either good or very good on their written scientific solutions to the problem part of the test. 14% of the students demonstrated partial solutions, but 28% were unable to construct a correct solution to the scientific problem.

Some of the students who scored quite well on the test overall demonstrated solid content knowledge but were unable or only partially able to construct an answer to the problem solving part of the assessment. 33 students scored an 86 or above on this test. Of those students, 9 or 27% were unable to give a correct solution to the scientific problem. This result was surprising. Of the 33 students who demonstrated academic achievement with high test scores, only 9 of them were successful at independent scientific problem solving. Of the 13 students who scored below 86, 9 of them or 69% were able to successfully construct an answer to the independent problem solving portion of the test.

Again, it comes back to the scientific thinking skills. Some traditionally high achieving students may be better at memorizing and regurgitating information, but really thinking about something in a new way offers new and somewhat uncomfortable challenges.

Collaboration

The use of collaborative lab groups helps to develop student scientific thinking and problem solving through the use of scientific discourse.

Manlove, Lazander and de Jong (2006) note that the National Research Council recommends that science educators assist students in building their scientific understanding through the use of interactive processes like collaboration. In science, collaboration consists of groups of students working together to solve a scientific inquiry which involves communication among group members as a way of sharing ideas, concepts, science knowledge and understanding and to analyze data and arrive at a conclusion.

Throughout the study as I observed the students working on the various inquiry-based activities and solving scientific problems, collaboration seemed to be the key component that helped lead students to a deeper understanding of the content. For example during the slime lab when the students debated and discussed the merits of slime and its form of matter, rich discussions unfolded as the students worked to understand their observations and connect it to their combined content knowledge. Similarly, during the state of matter activity, as students worked to construct definitions for a solid, liquid or a gas, their observations of the materials and the characteristics of those forms of matter allowed me to witness how new understandings emerged for each student in the group.

When students were asked to solve scientific problems collaboratively, they were able to maintain a 90% and above success rate. It is much more difficult to rely only upon oneself to solve the problem. Students' independent problem solving was not nearly as successful as the collaborative activity. While 31% struggled with independent problem solving, nearly all found success when working with peers. Lunetta (1990), too, found that students who learn within a collaborative setting learn more than students who work as individual learners working individually.

In the final end of study survey when asked if students thought that group work helped them learn better, 82% of the students said that they usually or always felt that group work helped them to learn science better. One student explained, "Many ideas help you think more and explore deeper." Another added, "Maybe if you do not know something, someone in your group can help." Collaborative learning proved to be a powerful learning strategy.

Student Driven Inquiry

When scientific inquiries are student driven, students are motivated to create meaningful connections and understandings of scientific content.

Inquiry learning incorporates the idea of learning being student centered rather than traditionally teacher directed. When students help to shape the direction of their learning, they are empowered and learning is taken to a whole new level. Students take ownership for their own learning, which results in more effective learning (Brown, 2008). Throughout the study, as I observed students and made notes in my field log, I always came back to the idea that I would never follow a cookbook recipe for a lab in the future. Students need to have the ability to "discover" their own answers, to lead their own inquiry. The students rose to the challenge and were motivated and engaged to "direct" their own learning. Creating an environment where students are engaged and motivated to direct their own learning is an exciting and enriching experience for all.

In the Mid-Study Survey 54% of my students said that they either always or usually like the inquiry method when they get to make choices and discover the answers. At that point, students were just beginning to get comfortable with the idea of student discovery and relying more on themselves and their lab partners than the teacher for the answers. By the end of the study, 80% of the students thought that the inquiry labs either always or usually helped them to learn the science concepts and ideas. At that point, students were making the connection between the idea of student driven inquiry and its role in helping to promote science knowledge and understanding.

In that same survey 87% of the students said that they either always or usually felt that they had improved their scientific thinking skills by using the inquiry method. In the end of study survey, one student noted that, “the inquiry method helps me to think outside the box. I can see that I understand more.” Another student added that “we get to do stuff ourselves.” Finally, a third student wrote that “I know how to figure out things. I enjoy finding what the solution was.”

Teacher Reflection and Teacher Guidance

The balance between teacher given support and student independent discovery must be monitored and adjusted as needed for each collaborative group and each inquiry experience.

“Good inquiry-oriented teachers listen well and ask appropriate questions, assisting individuals in organizing their thoughts and gaining insights. Inquiry-oriented teachers seldom tell but often question” (Trowbridge & Bybee, 1996, p. 156). It is critical to maintain the guide on the side stance when supporting inquiry-based learning. Students have all too often become accustomed to sitting back and getting fed the answers. It takes real effort to work to discover a solution to an authentic problem. Students need to be encouraged and guided through inquiry and model how to conduct an inquiry investigation. To be successful students must learn how to build their confidence for inquiry over time. Continued practice with multiple experiences is an effective prescription. Students need modeling before and support while engaging in inquiry learning (Friedrichson & Meis, 2006).

In the slime lab, I recorded all of my teacher questions and comments to demonstrate how critical it is for the teacher to guide, focus and direct students rather than simply offering the answer. Pushing students to achieve greater heights in their own thinking is a driving force in inquiry learning and teaching.

It is important to maintain a Socratic approach, always making students work for the answer. In the end, it pays off. In the end of study survey my students commented that inquiry-based learning "helps me to think about the subject more deeply and observe more clearly." "Because when I explain and find out an answer it helps me to remember or become a better scientist."

Dilemmas in the Teaching of Inquiry

Difficulties and challenges in using the inquiry method revolve around adequate teacher training and teacher content knowledge, as well as, learning how to design lessons that balance teacher support and student independence.

Teachers need to be knowledgeable in the scientific content in order to utilize an inquiry approach. If teachers are weak in scientific content knowledge, they will be ill equipped to guide students through the process. I could not have attempted this project in my first year or two of teaching. I needed to feel comfortable with the curriculum and knowledgeable in the content. I also benefited greatly by participating in a professional development opportunity designed to help me become a qualified teacher of inquiry. Without the support of the Da Vinci Science Center, I would not have been able to transition my classroom to an inquiry-based learning environment in the ways I have described here. Many teachers have limited experience with using inquiry activities in their classrooms (Newman, et al., 2004). Teachers definitely need to be well prepared and confident in their knowledge and understanding in order to properly direct, guide, focus, challenge and even negotiate with students as they are guide them through the process. Knowing what questions to ask or how to ask them, to help students make meaningful connections and lead to meaningful educative experiences is challenging. Proper preparation and knowledge is the key. More professional development in the area of inquiry learning needs to be available for teachers of science. With that support, teachers can begin to make the transition from traditional science classrooms where knowledge is absorbed to an environment where students work to create their own powerful understandings of the science all around them.

Students need modeling and support while engaging in inquiry. “Inquiry-oriented teachers seldom tell but often question” (Trowbridge & Bybee, 1996, p. 156). If teachers have not had any exposure to learning how to teach with inquiry, they will experience difficulty in providing a classroom environment that supports it. Many teachers lack the understanding of how to effectively teach with inquiry (Newman, et al., 2004).

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THE FUTURE

The study has concluded, but my passion for inquiry based teaching and learning has not. I have continued to include opportunities for inquiry-based activities and inquiry problem solving for my students. They continue to amaze me as they take on the challenges and I continue to see the development of their scientific thinking. I continue to want to improve my level of teaching and especially the teaching of inquiry.

Because my 6th graders have benefited in so many ways from the use of inquiry, I plan to incorporate it into my teaching of 5th grade science. I will be working on redesigning my 5th grade curriculum and lab experiences so that I can include an inquiry component. Teaching students to really “grapple” with the science, is where true understanding and knowledge comes into play. I cannot allow them to just passively sit and “absorb”. It is clear to me that involving the students in a student-driven, hands-on inquiry activity has the potential to develop, enhance and enrich scientific skill and knowledge.

I will continue on developing scientific writing by modeling and creating opportunities for practice. Students may know and understand the science, but somehow they still struggle with “writing” it in a clear and understandable fashion.

My most surprising outcome was that my highest achieving students had difficulty with independent problem solving and yet many of my lower achieving students were successful at independent problem solving. I will continue to encourage and model and provide opportunities for both collaborative and independent problem solving practice. I will continue to include problem solving activities no matter what unit I am covering. I have found that students benefit from this opportunity to inquire and it serves to help develop critical problem solving skills that students will use in every realm in the future.

I am most proud of my students increase in scientific skill and their ability to confidently engage in scientific discourse. Even my struggling students seem to have a new found confidence in science class and are not “afraid” to attempt an answer in class. The quality and level of my students’ thinking continues to expand as I continue the path of inquiry even as we end the year with our study of light, sound and electricity.

I am committed to continue to create a classroom environment where inquiry is the key to helping students focus on building their scientific skills and achievement.

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APPENDIX A: HSIRB APPROVAL

MORAVIAN COLLEGE
A SMALL NATIONAL TREASURE
1742

1200 Main Street
Bethlehem, Pennsylvania 18018-6650
TEL 610 861-1300
WEB www.moravian.edu

March 16, 2009

Paula Karabasz
4538 Virginia Drive
Bethlehem, PA 18017

Dear Paula Karabasz:

The Moravian College Human Subjects Internal Review Board has accepted your proposal: "What are the reported and observed experiences of 6th grade science students using the inquiry method?." Given the materials submitted, your proposal received an expedited review. A copy of your proposal will remain with the HSIRB Chair.

Please note that if you intend on venturing into other topics than the ones indicated in your proposal, you must inform the HSIRB about what those topics will be.

Should any other aspect of your research change or extend past one year of the date of this letter, you must file those changes or extensions with the HSIRB before implementation.

This letter has been sent to you through U.S. Mail and e-mail. Please do not hesitate to contact me by telephone (610-861-1415) or through e-mail (medwh02@moravian.edu) should you have any questions about the committee's requests.

Debra Wetcher-Hendricks

Debra Wetcher-Hendricks
Chair, Human Subjects Internal Review Board
Moravian College
610-861-1415

APPENDIX B: PARENT CONSENT FORM

September 5, 2008

Dear Parents or Guardians,

I am currently taking courses toward a Master's degree in curriculum and instruction at Moravian College. These courses assist me in improving my use of teaching methods and classroom practices. They also help me to become more reflective in my teaching.

From August 28th to December 22nd, I am required to conduct a systematic study of my teaching. My research will examine the impact of using the inquiry method in the course of teaching 6th grade science. Exposing students to the inquiry method I expect will increase student achievement and motivation for science.

I will be gathering information to support my study through student interviews, surveys, work samples and participant observations. Students will be able to provide feedback at any point during the study. I will only be using the information I have collected from students who have been given parental permission to participate in the study. However, all students will be exposed to the same teaching and learning methods throughout the study. All students' names will be kept confidential. Names will not be included in student work samples or in any part of my written report. All of my research materials will be kept confidential.

If students should need additional resources should any type of psychological stress result, parents may contact either Mrs. Kathy Maziarz, Principal of Notre Dame of Bethlehem Elementary (610) 866-2231 or Dr. Joseph Shosh, Moravian College, 610-866-1482.

All of my 6th grade science students will be participating in the inquiry method; therefore, no student will be singled out as a non-participant. Only students where I have received written permission from their parent will be considered participants in this study. Students will be allowed to withdraw from the study at any time without academic ramifications. If a student withdraws they will still be required to participate in classroom activities using the inquiry method, but data will not be collected or included in any written report. Please notify me in writing if a student would wish to withdraw from the study or the student may withdraw by their own request.

If you have any questions or concerns about my research at any time, please contact me. My faculty sponsor is Dr. Shosh. He may be contacted at Moravian College by phone at 610-861-1482 or email at JShosh@moravian.edu.

If you approve of your child being a participant in my teacher research, please sign below. Thank you in advance for your continued support and cooperation.

Sincerely,

Mrs. Paula Karabasz

I understand that Mrs. Karabasz will be observing and collecting data as part of her research on using the inquiry method as a means to increase student achievement and motivation in her sixth grade science classroom, and my child has permission to be a participant in this study.

Child's Name: ______________________________

Parent/Guardian Signature: ___________________________

Date: ___________

APPENDIX C: PRINCIPAL CONSENT

September 5, 2008

Dear Mrs. Maziarz,

I am currently taking courses toward a Master's degree in curriculum and instruction at Moravian College. These courses assist me in improving my use of teaching methods and classroom practices. They also help me to become more reflective in my teaching. From August 28th to December 22nd, I am required to conduct a systematic study of my teaching. My research will examine the impact of using the inquiry method in the course of teaching 6th grade science. Exposing students to the inquiry method will increase student achievement and motivation for science.

I will be gathering information to support my study through student interviews, surveys, work samples and participant observations. Students will be able to provide feedback at any point during the study. I will only be using the information I have collected from students who have been given parental permission to participate in the study. All students' names will be kept confidential. Names will not be included in student work samples or in any part of my written report. All of my research materials will be kept confidential.

All of my 6th grade science students will be participating in the inquiry method; therefore, no student will be singled out as a non-participant. Only students where I have received written permission from their parent will be considered participants in this study. Students will be allowed to withdraw from the study at any time without academic ramifications. If a student withdraws they will still be required to participate in classroom activities using the inquiry method, but data will not be collected or included in any written report. Parents will be required to notify me in writing regarding withdrawal of a student from the study or a student may request to withdraw.

If you have any questions or concerns about my research at any time, please contact me. My faculty sponsor is Dr. Shosh. He may be contacted at Moravian College by phone at 610-861-1482 or email at JShosh@moravian.edu.

If you agree to allow me to conduct this research in my classroom, please sign below. Thank you in advance for your continued support and cooperation.

Sincerely,

Mrs. Paula Karabasz

I support and understand that Mrs. Karabasz will be collecting data as part of her research on using the inquiry method as a means to increase student achievement and motivation in her sixth grade science classroom.

Principal's Signature: ______________________________

Date: ______________

APPENDIX D: RAW EGG INQURIY INVESTIGATION

Name:________________________ Date: ___________

Inquiry Investigation

Problem: Can a raw chicken egg be crushed in the human hand?

Engage: What do you know about chicken eggs?

____
____
____
____
____
____
____
____

Explore: What do you predict will happen and why?

____
____
____
____
____
____
____
____

Explain: What was the result? What were your observations?

____
____
____
____
____
____
____
____

Elaborate/Extend: What more would you like to know about chicken eggs?

Is there another inquiry you would like to explore? How would you design this experiment?

Evaluate: What did you learn about chicken eggs?

APPENDIX E: STUDENT SURVEY PRE-STUDY

Student Survey

Directions: Please respond to each question in as much detail as you can. Please make sure responses are clearly written.

1. Do you like Science? Why or Why not?

2. If you like Science, are there any specific things that you especially like to do or learn about in science?

3. If you don't like Science, is there anything you would change or include about Science class that might make it more enjoyable for you?

4. Do you like to experiment in Science? Why or why not? Please explain.

5. What do you feel is the best way that you learn Science knowledge? For example – it might be reading the text, etc.

6. If you could change the Science Curriculum is there anything you would change?

7. Are there any further comments you would like to add?

APPENDIX F: SKITTLES LAB

Name: ____________________ Date: ________

6th Grade

Skittles lab Worksheet

Problem: How many Skittles are in a package? Which is the most frequently occurring color?

Research: Experience with Skittles.

Hypothesis:

____

____

____

____

____

Data:

1. How many Skittles are in the Package? __________

2. How many Skittles of each color?

Color	Number
1.________	________
2.________	________
3.________	________
4.________	________
5.________	________
6.________	________
7.________	________

Total Skittles __________

Record anything you observed – about the total count, about the color arrangement, about the class results, etc.

Observations:

____
____
____
____
____
____
____
____
____
____

Design another experiment with Skittles:

____
____
____
____
____
____

APPENDIX G: OBSERVATION SKILLS LAB

Name: ____________________ Date: __________

Observation Skills

Use your skills of observation as a young scientist. Challenge yourself to attempt to make 20 quality observations about your quarter. Record below.

1. ____
____
2. ____
____
3. ____
____
4. ____
____
5. ____
____
6. ____
____
7. ____
____
8. ____
____
9. ____
____
10. ____
____
11. ____
____

12. ____________________

13. ____________________

14. ____________________

15. ____________________

16. ____________________

17. ____________________

18. ____________________

19. ____________________

20. ____________________

Is there anything else you noted or would like to explore with your quarter?

____

____

____

____

____

APPENDIX H: LAB ACTIVITIES OBSERVATION CHECKLIST

Lab Activities Observation Checklist

Name of student or student group ____________________

Class ____________ Date ____________ Period ________

Activity ____________________

Ratings - Frequently 1
Sometimes 2
Not Yet 3

Understanding			
Seems to understand task	1	2	3
Seeks to find answers	1	2	3
Works cooperatively to create solution	1	2	3
Student needed assistance and redirection	1	2	3
Interest and Engagment			
Student engaged in activity	1	2	3
Student gives positive feedback	1	2	3
Evidence of positive group communication	1	2	3
On - task	1	2	3
Off - task	1	2	3
Outcome of Inquiry			
Student Solution is Excellent and shows signs of knowledge application	1	2	3
Result is well thought out and detailed	1	2	3

APPENDIX J: PROBLEM SOLVING RUBRIC

RubiStar Rubric Made Using:
RubiStar (http://rubistar.4teachers.org)

Lab Report : Static Electricity Problem Solving

Teacher Name: p karabasz

Student Name: ________________________________

CATEGORY	4	3	2	1
Scientific Content	Answer contains scientific language and concepts and a clear scientific explanation of events.	Answer contains scientific language and concepts and mostly clear scientific explanation.	Answer may not contain complete scientific language and scientific concepts and not quite clear scientific explanation.	Answer does not contain scientific language and scientific concepts and does not offer a clear scientific explantion.
Problem Solving	Question 2 contains at least two scientific reasons supported by scientific details.	Question 2 contains at least two scientific reasons almost supported by scientific details.	Question 2 contains only one scientific reason and may be supported by scientific detail.	Question 2 does not offer a scientific reason and is not supported by scientific detail.
Collaborative Activity	Group worked toward a solution by effectively communicating and utilizing applicable resources. Group made effective use of their time.	Group mostly worked toward a solution by almost effectively communicating and utilizing applicable resources. Group made effective use of most of their time but not all of it.	Group worked toward a solution by communicating and mostly utilizing applicable resources. Group may not have made the most effective use of their time.	Group had difficulty working toward a solution and did not effectively communicating and utilize applicable resources. Group did not make effective use of their time.
Extended Exploration	Students were able to effectvely create an extended exploration that contains an inquiry component.	Students were almost able to effectvely create an extended exploration that contains an inquiry component.	Students were mostly able to effectvely create an extended exploration that contains an inquiry component.	Students were not able to effectvely create an extended exploration that contains an inquiry component.
Mechanics	Answers given in complete clearly written sentences with no errors in grammar, spelling, punctuation, capitalization, etc.	Answers given in almost complete clearly written sentences with two or less errors in grammar, spelling, punctuation, capitalization, etc.	Answers given in mostly complete clearly written sentences with three to five errors in grammar, spelling, punctuation, capitalization, etc.	Answers given in complete clearly written sentences with six or more errors in grammar, spelling, punctuation, capitalization, etc.

Date Created: Oct 19, 2008 07:54 am (CDT)

APPENDIX K: STATES OF MATTER ACTIVITY

Name: ______________________ Date: ______________

6th grade science
chapter 7

Write the definition of a Solid –

Name as many solids as you can (up to 6)

What makes them a solid?

Write the definition of a Liquid –

Name as many liquids as you can (up to 6)

What makes them a liquid?

Write the definition of a gas –

Name as many gases as you can (up to 6)

What makes them a gas?

APPENDIX K: MIXED UP LAB

Name: ______________________ Date: ______________

Mixed Up Lab

Compounds, Mixtures, Solutions, Suspensions and Colloids

1. What is a **compound**?

___

2. What is a **mixture**?

___

3. What is a **solution**?

___

4. **Suspension** - Mixture that contains particles that are large enough to be seen. They cannot be filtered out.

5. **Colloid** – A suspension that isn't easily filtered out because particles are smaller.

@@@

1. Create a Mixture. What did you combine? Why is it a mixture?

___

2. Create a second mixture. What did you combine? Why is it a mixture?

___

3. Create a Solution. What did you combine? Why is it a solution?

4. Create a second solution. What did you combine? Why is it a solution?

5. Create a suspension. What did you combine? Why is it a suspension?

6. Create a second suspension. What did you combine? Why is it a suspension?

7. Create a colloid. What did you combine? Why is it a colloid?

8. Create a compound. What did you combine? Why is it a compound?

9. Combine the vinegar and baking soda. What happened? Did it create a compound, mixture, solution, suspension or colloid? Why? Support your answer with scientific evidence.

10. What more would you like to explore about compounds, mixtures, solutions, suspensions or colloids?

11. What did you learn from this lab?

APPENDIX L: MID-STUDY SURVEY

Name: ____________________ Date: __________

Science Survey – Mid-Study

I enjoy Science	Never	Seldom	Sometimes	Usually	Always
I think I am good at science.	Never	Seldom	Sometimes	Usually	Always
I feel confident in Science class.	Never	Seldom	Sometimes	Usually	Always
Science scares Me.	Never	Seldom	Sometimes	Usually	Always
I feel nervous in Science class.	Never	Seldom	Sometimes	Usually	Always
I think science is Boring.	Never	Seldom	Sometimes	Usually	Always
I would describe Science as fun.	Never	Seldom	Sometimes	Usually	Always
I liked 5th grade Science better than 6th grade.	Never	Seldom	Sometimes	Usually	Always
I like 6th grade Science better than 5th grade.	Never	Seldom	Sometimes	Usually	Always
I would like to be Smarter in science.	Never	Seldom	Sometimes	Usually	Always
I like science when it Is challenging.	Never	Seldom	Sometimes	Usually	Always
I like science when it Is easy.	Never	Seldom	Sometimes	Usually	Always
I pay attention During science class.	Never	Seldom	Sometimes	Usually	Always
I enjoy science when The lesson involves a Hands-on activity.	Never	Seldom	Sometimes	Usually	Always
I like the inquiry Method when I get To make choices And discover the Answer myself.	Never	Seldom	Sometimes	Usually	Always
I think the inquiry Method of learning Science helps me Learn science Better.	Never	Seldom	Sometimes	Usually	Always

APPENDIX M: SLIME LAB

Name: ______________________________ Date: ______________

Slime Lab

What is a solid:

____
____

What is a liquid:

____
____

What are your observations of Slime: (List at least 10 quality observations)

____
____
____
____
____
____
____
____
____
____
____
____

What state of matter is slime based on your observations? *Give a detailed scientific explanation explaining your choice.*

____
____
____
____
____
____

What is a physical change?

What is a chemical change?

Is the creation of slime a physical or chemical change? Explain using your scientific knowledge of physical and chemical changes.

If the water dries and evaporates and leaves the cornstarch behind, what kind of substance was this? Think about your observations. Was it a compound, mixture, solution, suspension or colloid? Support your answer.

Further Questions about slime or suggestions for further experimentation.

APPENDIX N: OXIDATION LAB

Name: ____________________ Date: ______________

Oxidation Lab

To Oxidize or not to Oxidize, that is the question?

1. **What is oxidation?**

___

2. **What type of reaction is it?**

___

3. **How do you know oxidation has occurred?**

___

4. **Do you think you can reverse oxidation?**

___

Procedure:

Step 1: Mix ¼ cup white vinegar and 1 teaspoon salt in bowl and Stir.
Step 2: Place Pennies in Bowl.
Step 3: Observe what happens.
Step 4: Take ½ of pennies out of liquid after 5 minutes.
Step 5: Place them on Paper Towel and leave to dry.
Step 6: Take rest of pennies and rinse them in cup of water and place on paper towel to dry. Keep track of rinsed versus un-rinsed pennies.
Step 7: Place screw in liquid. Leave in solution for 10 minutes.
Step 8: After elapsed time look at pennies on the paper towels.
Step 9: Observe. Are there any differences?

5. **What happened to the pennies when they were in the vinegar and salt Solution?**

___

6. **What happened to the rinsed and un-rinsed pennies? Are there any differences?**

___

7. What happened to the screws? What were your observations?

8. Why did that happen? What do you think happened?

9. What did you learn about oxidation?

Remember to think like a scientist!!

APPENDIX O: PROBLEM SOLVING CHAPTER 7

Name: ______________________ Date: ____________

6th Grade Science Chapter 7
Problem Solving

Mrs. Karabasz's dog, Fritz, loves to go outside. One early Summer morning he went outside. When he came back in, he was all wet. It wasn't raining outside nor did he run into a sprinkler or a hose. What happened to Fritz? Use your best scientific explanation to explain how Fritz got wet.

Mrs. Karabasz just bought a huge Christmas Candle. She lighted it and it started to burn. She sees that the wick has turned black and there is melted wax running down the side of the candle. She would like to know if what she is seeing is a chemical reaction or a physical reaction or is it both? Please explain using your best scientific knowledge.

APPENDIX P: PROBLEM SOLVING RUBRIC

RubiStar Rubric Made Using:
RubiStar (http://rubistar.4teachers.org)

Lab Report : Chemical and Physical Changes

Teacher Name: **Mrs. Karabasz**

Student Name: ________________________________

CATEGORY	4	3	2	1
Scientific Content	Answer contains scientific language and concepts and a clear scientific explanation of events.	Answer contains scientific language and concepts and mostly clear scientific explanation.	Answer may not contain complete scientific language and scientific concepts and not quite clear scientific explanation.	Answer does not contain scientific language and scientific concepts and does not offer a clear scientific explanation.
Problem Solving	Answer contains at least two scientific reasons supported by scientific details.	Answer contains at least two sceintific reasons almost supported by scientific detail.	Answer contains only one scientific reason and may or may not be supported by scientific detail.	Answer does not offer a scientific reason and is not supported by specific details.
Collaborative Actitvity	Group worked toward a solution by effectively communicating and utilizing applicable resources. Group made effective use of their time.	Group mostly worked toward a solution by almost effectively communicating and utilizing applicable resources. Group made effective use of most of their time but not all of it.	Group worked toward a solution by communicating and mostly utilizing applicable resources. Group many not have made the most effective use of their time.	Group had difficulty working toward a solution and did not effectively communicate and utilize applicable resources. Group did not make effective use of their time.
Mechanics	Answers given in complete clearly written sentences with no errors in grammar, spelling, punctuation, capitalization, etc.	Answers given in almost complete clearly written sentences with two or less errors in grammar, spelling, punctuation, capitalization, etc.	Answers given in mostly complete clearly written sentences with three to five errors in grammar, spelling, punctuation, capitalization, etc.	Answers given in mostly complete clearly written sentences with six or more errors in grammar, spelling, punctuation, capitalization, etc

Date Created: **Apr 05, 2009 10:15 pm (CDT)**

APPENDIX Q: END OF STUDY SURVEY

Name: ____________________ Date: __________

Science Survey – End-Study

I have enjoyed 6th grade Science so far.	Never	Seldom	Sometimes	Usually	Always
Why?					
I have developed my science Problem solving skills In 6th grade science?	Never	Seldom	Sometimes	Usually	Always
Please explain.					
I have improved my Observation skills.	Never	Seldom	Sometimes	Usually	Always
Please Explain.					
I have improved my Scientific thinking skills.	Never	Seldom	Sometimes	Usually	Always
Please Explain.					
I think group work in Science helps me learn Better.	Never	Seldom	Sometimes	Usually	Always
Please Explain.					
I think the Inquiry Labs Helped me learn the science Concepts and Ideas.	Never	Seldom	Sometimes	Usually	Always
Please Explain.					