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THE EFFECTS OF INQUIRY SCIENCE ACTIVITIES IN KINDERGARTEN

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ABSTRACT

This qualitative research study documents the observed and reported experiences when kindergarten students are involved in inquiry-based science lessons that includes hands-on activities and experiments. In this study, the teacher explored the process of developing lessons and experiments that would answer inquiry questions asked by the students.

The author designed the study to provide an interactive approach to teach science concepts to a kindergarten class. The purpose of the study was to discover the effectiveness of inquiry and hands-on activities in a kindergarten setting. To allow inquiry learning to occur, the students experimented, questioned, observed, predicted, and displayed concepts learned in science notebooks. In order to establish an environment conducive to inquiry learning, the teacher served as facilitator to the learning, assisting the students as they conducted experiments to answer their questions. Through the inquiry lessons and hands-on activities, the students were able to build a solid foundation in science education.

The author found that the inquiry-based lessons were a successful strategy to teach science concepts to kindergarten students. The science notebooks allowed the teacher to see any misunderstandings that may have occurred during a lesson. Inquiry science learning engages students, fosters a desire to learn, and produces student achievement in learning the science curriculum.

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Overview

I can still remember my first years of formal education—the friends I made, learning to read and write, and science class. Most of my early memories of school are good memories; however, science does not fit into this category. When I began receiving formal science education in third grade, I found it extremely dull. The teacher simply had us read from the textbook, take notes, and complete the occasional worksheet. I came to dread this time of day because I felt science was uninteresting. These feelings toward science continued through my high school and college years as well. Even though we occasionally participated in activities and experiments during science class, I still greatly disliked this subject. To me, dissecting a frog was disgusting and making pennies look gold was somewhat interesting, but seemed to serve no real value. It even came to the point when, in my senior year of high school, I could choose between taking a science class or an additional math class, I chose the second math class. I would rather double my math load than force myself to suffer through yet another year of science. It was not that I did poorly in science; rather, I did very well thanks to my own high standards to do well in all areas of school. It was simply that I had no interest in science because of my initial, boring, and uninteresting experience in elementary school science.

When I began teaching, I admit that I did not give the same effort to science lesson planning that I did to other subject areas. As I planned math and reading lessons, I created fun and interactive activities for the students to learn the concepts and skills in those subject areas. However, when it came time to science planning, I either just used an idea from the Teacher's Manual or looked up something on the internet. Many times it was a coloring sheet or cut-and-paste activity that was related to the lesson topic. Rarely did I have the students do experiments and hands-on activities that were enjoyable and educational. I knew this was not the best way to benefit my students in terms of science instruction; but, I felt, it was only kindergarten and science was just a special they had once a week, like gym or art. There were even weeks when science was not taught because of snow days, delays, or assemblies. In Experience and Education, Dewey states that "science has been applied more or less casually" (1997, p. 81). This is the same manner in which I approached science instruction. I felt it was more important to teach the other subjects, and science would get picked up the next week. And because something for science was in my plan book every week, my principal never said anything, and I just continued on in this manner throughout my first four years of teaching.

As I began the road towards obtaining my Master's degree, I was not sure exactly where that road would take me. I knew I wanted to pursue a path that would not only be a benefit to my students, but a motivator to me as well.

Then, during the course of my fourth year, while I was teaching second grade and approaching science in the same manner as I did teaching kindergarten, everything began to change. Several colleagues were involved in a three-year science program through a local college. At the end of their three-year program, they were required to give an in-service to their building teachers about the program in an attempt to get more teachers using the program's methods and to recruit teachers for the program. This in-service focused on the benefits of inquiry science and ways to bring it into the classroom. We even did some of the games and activities they used with their students to get a feel for how it works. It was during this in-service that I began to realize that science could be fun, but it was up to me to make it so for my students. The more I reflected on my past science teaching experiences, the more I realized that the few times I did bring experiments and hands-on activities into science lessons, the more engaged the students were during the lesson. And, as a result, they were able to better grasp the concepts presented in the lesson. By the time I left the in-service that afternoon, I had made up my mind that I would focus my Master's thesis on inquiry science instruction. I was not quite sure how I would go about this, but I knew this was my study. I even considered signing up for the program to help with my study; however, I was four months pregnant, in the process of buying a house, and working on my Master's. Therefore, I decided that was not the best choice at that time. Even still, I knew this study needed to be done in order to benefit my students. It would be a way for me to implement science lessons in such a way as to excite my students and me as well. As a result, I would no longer find excuses to avoid bringing science into the classroom.

Not only would this study affect my approach to teaching, but I hoped it would also make an impact on the students. It is very important for students to receive formal science instruction, even as early as kindergarten. It is during the early school years that children have a natural curiosity which can be developed into an interest in science (Haury, 1995) and, as President Obama said in his Address to Congress, “we know that the most formative learning comes in those first years of life” (2009). I believe that instruction at a young age enables the students to have a solid foundation in science concepts for future learning. Likewise, the students begin to understand the world around them as they explore their immediate environment (Hunn, Glasson, & Morse, 1998). Also, through the use of hands-on activities, the students are not only learning but will come to enjoy science as well. Radford and Ramsey point out in their study that the students were “conducting more experiments, science was more fun, and they were learning more science” (1996, p. 9-10). Finally, if they are enjoying learning and building a solid foundation, the students will come to appreciate science (Staten, 1998). By embarking on this study, I believed that several benefits would result: the students would learn science, they would enjoy science, and they would come to appreciate the importance of science.

When I began to research the topic of inquiry-based science, I began to realize that science instruction was often put on the back burner to favor subjects like math and reading. I found it upsetting that because science was not currently part of standardized tests, it was not seen as being as necessary as the other subject areas. In a way, the teachers I read about in my research findings took on the same outlook towards science that I once had, just for a different reason. With that thought in mind, I was even more motivated to dive into this study and provide my students with a well-rounded education that includes science and prove that science is advantageous in other subject areas as well.

As I implemented this study, I was once again teaching in a kindergarten classroom. I was even more excited to be conducting this study in kindergarten because students at this age are eager to learn and open to all kinds of ideas and approaches to learning. Also, it gave me an opportunity to build a solid foundation in science so my students would have a basis for future science learning.

Inquiry science allows students to develop a strong foundation that they will use to understand and develop key scientific concepts. With this understanding, students are then able to effectively perform scientific inquiries (Thompson, 2007). Implementing an inquiry-based approach to science enabled me to teach science in such a way as to gain student interest while also keeping the students motivated and engaged. As Shimizu points out, if the children are interested in their learning, it will be more effective for them (1997).

Background for the Study

The first stop of my journey, when I was teaching second grade, led me to look at ways to improve the writing skills of my students. Thus, in my first research class, I studied the effects of written and verbal feedback as a means to help students produce writing pieces that showed a stronger display of creative expression. As I progressed through the course, I found this approach to writing instruction extremely beneficial for my students. All students showed improvement in their writing from first draft to published copy. While it was a highly effective study and I learned a great deal about the research method, I did not feel truly passionate about it. Thus, I still use these techniques for the benefit of my students; however, I knew it would not be the final stop of my journey.

As I continued down the road, knowing the end was getting closer, I looked in another direction on my path. This time, I wanted to focus on Math, more specifically, solving word problems. For my next research class, I developed an approach to tackle word problems that allowed the students to use a graphic organizer to break apart a word problem to create an easier way to successfully solve word problems. Once again, the use of the graphic organizer was an advantageous method for the good of my students. Nonetheless, I did not feel inspired to continue down this path.

After completing these two courses, I still did not know what would be the focus of my thesis study. Through these courses, I came to better understand how to develop a question and as well as how to research it to support my question. I also learned how to conduct a study using a variety of data sources and how to analyze them to reach my findings. Therefore, I had a firm foundation to begin my study, I just needed a topic.

The final leg of the journey was now in front of me and the decision had to be made—what was it going to be? And then, after a very worthwhile teacher in-service, I realized that the answer lay in science instruction. I was now teaching kindergarten, and I wanted to do something that my students would truly enjoy and learn from at the same time. When I began to contemplate how to approach my study using the knowledge I gained from the in-service, I knew I had to develop a study that would excite both me and my students. The more I thought, the more I realized that using student inquiry and hands-on activities would be fun, educational, and adventurous. Science was never my favorite subject, so this would the time for me to find a way to make it enjoyable for me to teach. If I found it to be fun, I could bring that excitement into my teaching. In turn, the students would feed off my excitement and develop a passion for science as well.

Research Question

Within this study, I planned to take my students on a journey through science that was hands-on and interactive. I wanted them to not only learn science, but also to experience it as well. When students are actively involved in inquiry-based science, they are part of a powerful learning experience in their quest for scientific knowledge (Pine & Aschbacher, 2006). As Dewey states, "there is an intimate and necessary relation between the processes of actual experience and education" (1997, p. 20). For my study, I developed inquiry-based lessons and activities that educated the students on science concepts and allowed them to experience science through interactive, inquiry-based, hands-on activities. Based on my concerns, I developed the following research question: **What will be the observed and reported experiences when kindergarten students engage in inquiry-based science lessons?**

LITERATURE REVIEW

Introduction

In schools today, there is a critical need for the reform of science education. As a result of greater emphasis on high stakes testing, which currently does not include science concepts and skills, science instruction is suffering in many schools (Hargrove & Nesbit, 2003). Not only is science at a disadvantage because it is taking a back seat to math and reading, which are the focus of standardized tests, but the quality of science instruction, when it is taught, is suffering as well. In 1991, researchers discovered that teachers used hands-on science quite often at the start of the school year; however, as test time approached, science instruction drastically decreased and, by the end of the year, science was frequently not taught at all (Hargrove & Nesbit, 2003). This is a key concern of many science educators today (Buchanan & Rios, 2004). Nonetheless, many reforms in science education are being made. Contemporary reformers are emphasizing the importance of learning science through inquiry (Haefner & Zembal-Saul, 2004). Reports since the 1960s have called for more inquiry-based instructional methods which would also provide a chance for students to become engaged in their science learning (Haury, 1995). Inquiry science allows the students to experience science, which, “as any scientist knows, is the best way to learn science” (Lind, 1998, p. 2).

All children should have the opportunity to know and understand scientific concepts. According to the Statement of Principles on School Reform in Mathematics and Science from the U.S. Department of Education and the National Science Foundation, “all children should receive a challenging education in mathematics and science based on world-class standards beginning in kindergarten and continuing every year through grade 12” (Sivertsen, 1993, p. 4). For this to be possible, teachers need to expose children to science experiences as early as possible (Lind, 1998). In addition, students need to be involved in activities that are purposeful and interactive (Hinrichsen & Jarrett, 1999). If students become involved in science, they, in turn, will become interested in science. Also, if children have an interest in learning science, the instruction will be more effective for the students (Shimizu, 1997). Likewise, when students actively participate in inquiry-based teaching methods, they will be part of powerful learning experiences (Pine & Aschbacher, 2006).

Schools need to prepare students for the future. Inquiry science provides one important opportunity for our students in this preparation. Schools need to incorporate a “science that not only is ‘hands-on,’ but ‘minds-on,’ as it inspires and prepares children for the future” (Nesbit, Hargrove, Harrelson, & Maxey, 2004, p. 21).

Inquiry

"If a single word had to be chosen to describe the goals of science educators during the 30-year period that began in the late 1950s, it would have to be INQUIRY" (DeBoer, 1991, p. 206). Science reforms have continued into the 1990s in which scientific inquiry has been seen as a component to address content and process in science education (Hinrichsen & Jarrett, 1999). Inquiry science is an instructional approach that involves the students participating in hands-on activities so they will gain a stronger understanding of scientific concepts and skills. This approach is an effective method of teaching science because it focuses on content while also increasing motivation and helps to develop critical thinking skills (Kauchak & Eggen, 1998).

Definition

Scientific inquiry is a process that engages the students in experimentation and investigation (Haury, 1993) so that they can answer questions and solve problems pertaining to the world around them (Pine & Aschbacher, 2006). Through inquiry learning, students develop a deeper understanding about nature (Chiappetta & Adams, 2004). Inquiry science also allows students to control their own learning under the guidance of their teacher (Hinrichsen & Jarrett, 1999). Inquiry learning takes the students from passive learners to active participants. In a sense, "inquiry transforms science learning from watching and listening to doing" (Hinrichsen & Jarrett, 1999, p. 6).

The process of learning through inquiry is an approach to teaching in which the students actively gather facts and make observations in order to answer their own questions (Kauchak & Eggen, 1998). Students go from asking questions and investigating to interpreting data and evidence in order to reasonably explain their conclusions (Haefner & Zembal-Saul, 2004) and share their findings. Key elements involved in the inquiry process include, but are not limited to, questioning, analyzing data, drawing conclusions, and sharing results with others (Staten, 1998). The ultimate goal of inquiry learning is to create a sense of independence in the students as they actively investigate scientific concepts (Nesbit, et al., 2004).

Inquiry-based instruction allows students to be vigorously involved in a search for knowledge in order to satisfy their natural curiosities (Haury, 1993). As they reach this level of satisfaction, they achieve a better understanding of scientific concepts. Along the way, teachers and students reach a level of understanding and mutual respect since they are both responsible for the learning process that is occurring (Hinrichsen & Jarrett, 1999). This mutual respect is due to the fact that the teacher is no longer just a facilitator, but rather a guide for the students as they actively search for answers to their questions.

Inquiry-based instruction encourages students to develop existing knowledge further. Students use the scientific method to answer questions and revise previously held beliefs so as to share their newfound understandings with others (Staten, 1998). In this process, students are actively involved in expanding on their pre-existing notion of science theories. "As Dewey notes, inquiry helps us consider our past understandings in light of what we're learning" (Hinrichsen & Jarrett, 1999, p. 4). As students learn via inquiry approaches, they are using hands-on activities which fully immerse them in their learning.

History. Inquiry science instruction is by no means a new concept. In fact, it has been in existence since the 17^{th} century when Galileo used the concept of inquiry in his experiments. In the 1860s, scientists such as Herbert Spencer and T.H. Huxley encouraged the use of inquiry-based science instruction. Later, in the early 1900s, John Dewey showed his support of the idea of experiencing science through inquiry (Pine & Aschbacher, 2006). Dewey believed inquiry learning was beneficial to students because they were involved in their learning and he felt it would allow them to develop questions and answers based on areas of study that interested them (Heppner, Kouttab, & Croasdale, 2006). Despite all of this support, inquiry science remained rare until 1957 when Sputnik was launched. This put the United States in competition with the Soviet Union. In response, the National Defense Education Act provided money to improve science education. During the 1960s, scientists and educators, through the aid of grants, worked to improve science curriculum in schools (Ediger, 2001). Beginning in the early 1960s, science educators were promoting the use of teaching science through an inquiry approach (Staten, 1998).

Learning outcomes. Students in classrooms that use inquiry-based science instruction methods are able to develop a strong foundation in understanding key science concepts and thus are able to perform scientific inquiries (Thompson, 2007). Students in inquiry classrooms will also learn the fundamental skills needed to answer their inquiries. Students who partake in inquiry-based science instruction will learn how to infer, experiment, ask questions, observe, and communicate their findings. By learning how to use these skills, "students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills" (Haefner & Zembal-Saul, 2004, p. 1654).

Elementary Curriculum

According to the National Science Education Standards, a key learning goal for all K-12 students is to be able to carry out scientific inquiries (Pine & Aschbacher, 2006) so they can use the knowledge they gain to solve problems and make decisions (Hunn, Glasson, & Morse, 1988). Likewise, primary age children should experience key elements of science inquiry (Hapgood, Magnusson, & Palinscar, 2004) because it is during these years that children will develop an interest in science (Haury, 1995). The National Science Education Standards also state that by the time children are in fourth grade, they should have the ability to use scientific inquiry skills to perform science experiments and investigations (Ediger, 2001). In addition, if children maintain nonscientific ideas, which they may develop on their own, for prolonged periods, these notions may be difficult to change (Pine & Aschbacher, 2006).

The current trend in schools focuses on the process of science, but not the content. In this approach, the skills are emphasized; however, critical thinking and reasoning, which are key elements of scientific inquiry, are often overlooked (Haefner & Zembal-Saul, 2004). Nonetheless, many reforms are being made that put inquiry as the central component of science instruction for all grades, kindergarten through twelfth (Hinrichsen & Jarrett, 1999). Reforms in science began in the 1960s when scientists and teachers began to develop science curriculum that was based on student inquiry (Pine & Aschbacher, 2006). This reform still exists today as teachers try to coordinate traditional science content and inquiry-based instruction (Hammer, 1997). Educators are trying to develop a cohesive curriculum that is rigorous and focused while incorporating experiments and hands-on activities and also taking into account how students learn (Bybee & Van Scotter, 2006-2007).

As teachers work their way through science curriculum, they are making changes to it so as to include inquiry learning. As opposed to looking at it in advance, they are creating the curriculum as they work through it and discover the inquiry elements (Hammer, 1997). Teachers are developing a science curriculum that further develops children’s natural curiosities about science and the world around them (Hunn, et al., 1988). Educators are creating a curriculum that meets the demands of the U.S. Department of Education as well as the National Science Foundation. Both organizations endorse the idea of a science curriculum that promotes active learning and problem solving and includes inquiry teaching approaches (Haury, 1993). Schools are slowly beginning the change to make science a regular part of the school day; to make it as common for the students as math and reading (Pine & Aschbacher, 2006). Thus, schools are focusing more on science inquiry and content in creating curriculum instead of just the scientific process and skills.

Elementary Science Instruction

In order for students to get the most out of science instruction, it must be appropriate and meaningful to them (Ruiz-Primo, Li, & Shavelson, 2002). With young students, this is best accomplished by allowing them to experience science through exploration of the world around them and by allowing them to ask questions, conduct investigations, and reach conclusions. In addition, they need to apply basic, pre-existing concepts to their inquiries so as to develop more complex concepts. Thus, inquiry science is the best approach to teaching elementary science—it focuses on an active search for knowledge while engaging students in the investigative aspect of science (Lind, 1998). Likewise, if students learn science through inquiry-based instruction, “they will know *what* they know, *how* they know it, and *why* they believe it” (Ruiz-Primo & Furtak, 2006, p. 206). Inquiry instruction also allows for differentiation because students think and work at their own level and on their own interests, just as real scientists do (Allen, 2004).

Elementary science is the foundation for future science education. The elementary years are a critical time period to engage and develop student interests while also developing thinking skills and positive attitudes towards science. Thus, instruction in the elementary grades needs to be given on a regular basis, because waiting may be too late to develop a natural interest and enjoyment in science (Sivertsen, 1993). If young children have the opportunity to experience science regularly, they will build a basic understanding of science for future learning (Lind, 1998). Therefore, it is imperative that teachers provide students with an abundance of opportunities to explore and experience scientific phenomena by using real-world examples with which they are familiar (Sivertsen, 1993).

While science instruction should include hands-on, inquiry experiences, the complex thinking skills are developed through dialogue and exploration of the hands-on materials (Sivertsen, 1993). Therefore, science materials used for instruction must promote learning science concepts. Teachers also need to insure that students have adequate time to explore these materials and be given opportunities to show their understandings in various ways. Finally, the materials must make a connection to the concept being learned (Bybee & Van Scotter, 2006-2007). If these criteria are not present, students will not be able to develop and learn scientific concepts; they will see inquiry learning as “play time” and not instructional. As a result, teachers should use hands-on activities in conjunction with lecture, reading, or discussion in order for students to fully conceptualize scientific skills (Bybee & Van Scotter, 2006-2007). As Hinrichsen and Jarrett state, “good inquiry is planned and occurs within the context of activity, but activity alone does not guarantee good inquiry” (1999, p. 6).

Inquiry-Based Instruction

A major area of interest in education is the teaching of science using inquiry-based instruction (Lind, 1998). Research supports the idea that inquiry instruction is highly effective and can help teachers to meet the needs of all students (Hinrichsen & Jarrett, 1999). In addition, through inquiry learning, teachers can provide students with a variety of opportunities to develop and practice skills (Kauchak & Eggen, 1998) such as scientific concepts, problem solving, and critical thinking.

Necessary Elements

In order to implement inquiry science into any classroom, there are some key elements that need to be part of the program. One integral part of inquiry is the idea that the classroom needs to be seen as a community of learners and needs to function as such in order to explore and answer student questions (Hapgood, et al., 2004). Within the classroom, the students should be involved in exciting and interesting activities and experiments and the students should also be involved in asking questions, searching for answers, and solving problems. In addition, an environment must exist that is motivating and inspiring for the students to feel comfortable enough to take risks and want to learn (Staten, 1998).

Teachers also need to be trained and confident in presenting inquiry-based instructions. Hunn, et al., also point out the necessity of appropriate science materials and teacher familiarity with the science content and skills (1988). In addition, they need to make sure there is adequate time in the day to provide sufficient instruction as well as a strong desire to make sure it is taught and is a regular part of the school day (Buchanan & Rios, 2004). “Acquiring new knowledge can only happen if a student is given unhurried experiences and the motivation to allow learning to happen” (Buchanan & Rios, 2004, p. 84).

Inquiry-Based Science Lessons

Teachers vary greatly in their approaches to teaching. Nonetheless, teachers who use inquiry methods will actively include their students and engage them in the learning process (Haury, 1993). Teachers using inquiry methods create lessons in which their students are directly involved in the observing, examining, and experiencing of nature and the world around them (Buchanan & Rios, 2004). Inquiry teachers provide opportunities for their students to question and investigate. These students can move from abstract to concrete ideas as they hypothesize, experiment, and reach conclusions. These students are given the chance to have an active part in their learning, a key element to inquiry-based education (Hinrichsen & Jarrett, 1999).

Inquiry is the “nature and quality of students’ participation in exploration, invention, and discourse” (Hammer, 1997, p. 488). Inquiry instruction must engage students (Haury, 1995); teachers need to promote student inquiry through a variety of activities and projects (Hammer, 1997) that involve students in observing and experimenting with scientific phenomena (Eick, Meadows, & Balkcom, 2005). For young children, this process is best accomplished using natural phenomena that they can study over time and that they are familiar with in their own environment (Lind, 1998).

Inquiry teaching does not need to be based on activity alone. In fact, additional tasks and learning should occur in conjunction with the inquiry-based activity so as to further develop student understanding (Staten, 1998). Good inquiry lessons are well-planned and take place in conjunction with activity; however, activity in and of itself does not create a good inquiry lesson (Hinrichsen & Jarrett, 1999). Many teachers lecture and assign activities and problems to cover the necessary content before embarking on inquiry-based activities that are more hands-on. Even still, these activities do need to apply to the content that has been covered in the lesson (Hammer, 1997). Also, the inquiry-based activities can be used to further student understanding of what is discussed in the lectures (Thompson, 2007). Teachers need to keep in mind when planning inquiry-based lessons that they must engage students and involve them in a quest for knowledge (Lind, 1998).

The teacher, who is the most vital component of educational reform (Buchanan & Rios, 2004), plays a powerful role in science inquiry lessons. It is the function of the teacher to support the learning of the children, motivate them as they move through their inquiry activities (Hapgood, et al., 2004), and guide their scientific inquiries (Hammer, 1997). As Hammer states, the teacher can encourage student learning through projects, science fairs, and experiments which would allow them to develop their own questions and reach their own conclusions (1997). However, the teacher does not tell the students what they will learn in an inquiry classroom. The teacher creates an environment in which the students are actively involved in their own learning (Sivertsen, 1993). Likewise, teachers need to use children’s natural curiosity to develop science lessons (Hunn, et al., 1988).

As with any lesson, teachers need a way to assess student learning. One way to accomplish this goal is for teachers to follow a lesson with a class discussion on the topic learned. In this manner, students can share what they learned and teachers can assess their understanding (Kur & Heitzmann, 2008).

Hands-On Activities

“Active, hands-on, student-centered inquiry is at the core of good science education” (Lind, 1998, p. 2). It is with this thought in mind that teachers create activities that are hands-on in order for students to develop an understanding of science concepts. Hands-on activities are used to enhance the content being taught so as to further student understanding. They provide students with concrete experiences that help to build a foundation for future learning of more abstract concepts. In a classroom that implements hands-on science learning, students are engaged while thinking about and applying what they are learning (Sivertsen, 1993). Students can learn skills and concepts by using manipulative materials, such as water or sand, as well as during dramatic play or outdoor activities (Lind, 1998).

When students have fun, they will want to learn. Hands-on activities and experiments create an element of fun in science instruction. As a result of inquiry instruction, students create and conduct their own experiments. They investigate, observe, and defend their results (Hammer, 1997). Not only does hands-on science add an element of fun to learning, it is essential for students to be actively involved in their learning if they are to find meaning in what they are learning (Chiappetta & Adams, 2004). If students are enjoying learning, the teachers will, in turn, enjoy teaching (Haury, 1995). This creates a community of learning that is open to new ideas and welcomes inquiry education.

Recent trends in science education have pushed for the use of hands-on science activities. By using hands-on science, teachers feel that students will walk away with a positive attitude towards science (Shimizu, 1997). A hands-on approach to science also allows students to understand science better. When students participate in activities and projects and are involved in interactive science lessons, students will be better able to grasp science concepts (Bybee &

Van Scotter, 2006-2007). Hands-on science is also extremely effective when teaching young children. Through this approach, children are given real-world experiences and are able to explore their curiosities in a safe and natural setting (Buchanan & Rios, 2004). Hands-on science is the best approach to “explore, discover, and learn scientific concepts and relationships in contexts that involve real-world problems” (Staten, 1998, p. 9).

Experiments

Experiments are another beneficial component of successful inquiry-based science lessons. Through inquiry learning, students learn how to conduct their own inquiries and experiments. In addition, students take part in “experimental logic and systematic observations” (Shimizu, 1997, p. 2) in order to conduct experiments and learn scientific concept. By taking part in experimentation, students become actively involved in their own learning (Chiappetta & Adams, 2004). Also, through the implementation of experiments as part of the science lesson, students better understand and appreciate science and science concepts (Thompson, 2007).

Notebooks

A key component of the inquiry-based method of instruction calls for students to have the opportunity to share their personal experiences and findings within science instruction. By using science notebooks, the students are given this opportunity to write or, depending on age or ability level, draw what they wish to share with classmates, teachers, or family. The science notebook is a means for students to tell the knowledge they have obtained to others (Klentschy & Molina-De La Torre, 2004).

Science notebooks are structured writing accounts of what occurs in the science classroom (Nesbit, et al., 2004). They are a compilation of observations, experiments, and experiences related to science instruction (Ruiz-Primo, et al., 2002). As Ruiz-Primo, Li, Ayala, and Shavelson, state, “science notebooks. . .are seen as a log of what students do in their science class” (2004, p. 1477).

Within the science notebook, students can describe the problems being solved, explain the procedures used, write about their observations, or reflect on the lesson from the day. In addition, notebooks can be a tool to assist students in their thinking process (Ruiz-Primo, et al., 2004) and a tool to aid in their reasoning and problem solving skills when appropriately used by the students (Ruiz-Primo, et al., 2002).

Students will take pride in their notebooks because, as Nesbit, et al. point out, the “science notebook ultimately belongs to the student” (2004, p. 26). Thus, it is a useful tool to incorporate into inquiry-based science instruction. It gives them an outlet to share their thoughts and a method for teachers to offer feedback and assess student understanding. Overall, the science notebook is an extremely important addition to science learning as a learning and an assessment method.

Implementation

Science notebooks are beneficial for student inquiry and learning. Unlike with traditional methods of learning science, the implementation of the science notebook into the science lesson allows the students to be more actively involved in the learning process because they are engaged (Hargrove & Nesbit, 2003) through such methods as asking questions, conducting experiments, reaching conclusions, and recording results (Reid-Griffin, Nesbit, & Rogers, 2005). First of all, the use of science notebooks helps to increase standardized test scores (Nesbit, et al., 2004). Making writing a part of science can help to improve the learning and understanding of science concepts by students (Ruiz-Primo, et al., 2004) as well as improve student achievement in writing (Nesbit, et al., 2004). Secondly, science notebooks provide the teacher with feedback on the students' understanding. Information gained by teachers from the use of science notebooks can help them to improve their lessons and activities. This information can be used to create lessons that develop a deeper and clearer understanding of science concepts (Nesbit, et al., 2004).

Not only does the implementation of science notebooks allow the learner to be more engaged, it also helps to develop higher order thinking skills. Even at the kindergarten level, students can develop skills that allow them to think at a more in-depth level about what they are learning. Because the students are engaged in meaningful science investigations, they can apply language arts and math skills to help describe their science processes (Reid-Griffin, et al., 2005). Students begin to learn how to keep written accounts of their learning and experiences which can be later used to make decisions and reach conclusions (Klentschy & Molina-De La Torre, 2004). During inquiry-based lessons, the students are involved in authentic learning experiences. By writing in their science notebooks, they are then involved in "authentic scientific thinking" (Hargrove & Nesbit, 2003, p. 3) as they conduct their investigations and record their findings.

In order to effectively implement science notebooks, students must be guided in how to set up, use, and maintain them. In the primary grades, this may mean doing several examples with the students before setting them off on their own. It is also necessary for them to have an understanding of inquiry learning and writing as a means to communicate with others (Nesbit, et al., 2004). In the beginning, students, especially in the primary grades, may only draw what they are observing and experiencing; however, as the school year progresses, they will be able to put their thoughts and observations into written form as well. Also, science notebooks may be done as a whole class process at the start. Eventually, once the students have a more solid grasp on the concept, this can be implemented as an individual activity (Nesbit, et al., 2004).

The important thing to remember when implementing science notebooks is that they are a method for students to share their findings with others, solve problems, record their observations, and make reflections on the lesson. They are also an opportunity for students to share what they have learned. It gives students a place to tackle misunderstandings of scientific concepts (Reid-Griffin, et al., 2005) while also improving writing skills and students' learning and understanding of science content (Ruiz-Primo, et al., 2004).

Observations

One primary reason for the use of science notebooks is for students to record their observations from the science lesson. During the inquiry-based science class, the students will be experiencing a number of different things and activities. By recording their experiences in their notebooks, the students are helping themselves to retain the content they have just been taught. Thus, the notebook should, at least partially, reflect some of the activities and lessons conducted in that day's lesson (Ruiz-Primo, et al., 2002). The science notebook should be a written account of what the students are learning in science (Ruiz-Primo, et al., 2004).

The teacher should also be able to look at a student's notebook to provide feedback on observations made and what they have learned through the science lesson (Nesbit, et al., 2004). The teacher can make observations about the student based on his/her science notebook. This is a means for the teacher to determine if a student can develop his/her own questions, carry out an experiment, analyze data, and record findings (Nesbit, et al., 2004). It is a written document for the teacher to make observations and assessments of the students.

Evidence of Understanding

In addition to being a learning aid for students, science notebooks can also be used as an assessment tool for the teacher. The notebook provides an authentic record of student understanding over the course of the science lesson and activity and gives a clear picture of the level of understanding of each student in the classroom (Nesbit, et al., 2004). It gives the teacher insight into student thinking and misconceptions related to learning and allows the teacher to provide the students with feedback needed to improve their understanding (Ruiz-Primo, et al., 2004).

The science notebook is not only a tool to measure students' understanding of science content, but also a method for students to better grasp science concepts. Based on the research by Ruiz-Primo, et al., "the science notebook entries, across all the classrooms and units, were pertinent/appropriate to the learning of science" (2002, p. 10). Younger students can support their conclusions with examples, pictures, and their own words so to demonstrate a solid foundation in the attainment of scientific knowledge (Buchanan & Rios, 2004).

Nonetheless, it must be remembered, that the science notebook is only one piece of the inquiry puzzle teachers must put together to create inquiry-based science lessons for their students.

Advantages

When students actively participate in good classroom inquiry lessons, their understanding of science concepts is greatly improved (Hinrichsen & Jarrett, 1999). As a result of such experiences, students can achieve a better understanding of science concepts as well as how science knowledge is generated (Haefner & Zembal-Saul, 2004). Despite the fact the inquiry learning is demanding, everyone is involved and active in the lesson (Sivertsen, 1993) and students learn basic science concepts in such a manner that they do not forget what they have learned (Staten, 1998). In addition, active involvement leads to higher achievement by the student. Students who are actively involved in inquiry science are not only learning science, but enjoying science as well.

A key element of education is learning how to define problems, gather data in order to solve problems, and develop higher order thinking skills. Inquiry instruction is an effective way to provide students with these necessary skills (Kauchak & Eggen, 1998). Science inquiry experiences familiarize students with the methods and procedures of questioning and answering those questions (Haefner & Zembal-Saul, 2004). In addition, science inquiry instruction enhances scientific literacy and vocabulary as well as the understanding of science concepts. Likewise, critical thinking skills are developed so to improve achievement on standardized tests (Haury, 1993).

Students are also more receptive to learning science when involved in the inquiry approach. In such an environment, students actually feel like they are learning science and having fun at the same time (Radford & Ramsey, 1996). Students are able to learn more about things that interest them through observation and experimentation. They use the data they have gathered to answer self-generated questions (Haefner & Zembal-Saul, 2004) that are based on their own curiosities (Allen, 2004). Inquiry-based instruction also helps students increase their understanding of scientific concepts and gives them new insights into science notions previously held (Kur & Heitzmann, 2008).

In a comparison of inquiry classrooms and traditional classrooms, Sevilla and Marsh discovered that students taught science through an inquiry approach were better prepared to carry out science processes, had a more positive attitude toward science, and retained more science content than those in traditional classrooms (1992). The students were also more involved in experimentation and hands-on activities and had more fun learning science (Radford & Ramsey, 1996). Another benefit to inquiry-based instruction is that students are better able to master a subject when they are engaged in their learning. And, while it may be a difficult teaching approach to implement, it is the only approach that allows students to explore science at their own level and pace (Staten, 1998).

Inquiry-based instruction engages students and helps them to develop critical skills such as:

1. understanding of scientific concepts
2. an appreciation of 'how we know' what we know in science
3. understanding of the nature of science
4. skills necessary to become independent inquirers about the natural world
5. the dispositions to use the skill, abilities, and attitudes associated with science

(Staten, 1998)

By developing these skills, inquiry learners are able to better understand science and have a deeper respect for learning science. They are able to answer their own curiosities by asking and answering questions and sharing their results with others. Research states that the more personal the inquiry process is to a student, the more vested they are in finding the answers (Allen, 2004).

Disadvantages

Despite all the advantages and support that inquiry science receives, it is not accepted by all teachers. Many feel that inquiry is time consuming and that the questions students generate do not match the required curriculum that needs to be taught. Teachers also feel unprepared to help students in an inquiry setting (Ediger, 2001) because they have not been exposed to inquiry-based instruction themselves (Haefner & Zembal-Saul, 2004). Many teachers have not been given the opportunities themselves to develop the skills needed to bring inquiry and hands-on learning into the science classroom (Sivertsen, 1993).

Teachers find it easier to conduct a guided discussion and know what is occurring in the classroom based on their plans. Inquiry classrooms need to allow for flexibility and open-ended questioning, which some teachers are not comfortable with in their classrooms (Ediger, 2001). Also, teachers may not know how to effectively manage a classroom that would allow for inquiry investigation to occur (Hinrichsen & Jarrett, 1999). Overall, some teachers do not have the time, training, or comfort to conduct inquiry-based instruction in their science classroom.

In today's educational world, the standards have been used to put science at the forefront of education; however, "in many states politicians and school administrators are more focused on raising test scores in reading, writing, and math" (Buchanan & Rios, 2004, p. 86). Even when teachers try to bring more science instruction into the classroom, it is rejected in favor of more reading, writing, and math instruction. Even supporters from the initial reform of the 1960s on inquiry science have been unable to sustain its use in their classrooms (Sevilla & Marsh, 1992). Half-day kindergarten programs especially find it difficult to implement a science program while still trying to fit in time for literacy and math instruction (Buchanan & Rios, 2004). That being said, even if teachers wanted to implement science inquiry into their daily schedule, administrators may not allow it because of the simple fact that they are more concerned with raising test scores.

Another key disadvantage to bringing inquiry into the classroom is that many schools lack the basic equipment necessary to support an inquiry-based science program (Hunn, et al., 1988). If materials are present, there is a lack of time in the school day to set up the materials so the students can effectively use them (Staten, 1998).

Students also see disadvantages to inquiry learning. They too find it time consuming and that it takes additional time and effort from other areas of the school day (Heppner, at al., 2006). Students also struggle with formulating their own questions to study. They are often not familiar with the information at the start of each unit and lack sufficient knowledge of the concepts to generate questions (Shimizu, 1997).

Finally, some teachers do not use inquiry-based learning because there is no solid evidence of its effectiveness in the classroom. Articles do exist that provide evidence supporting inquiry learning; however, these are few and far between. More often, reports showed little change in academic achievement when in an inquiry classroom. In addition, research does not show any long term benefits because of the fact that no study has been conducted to observe students receiving inquiry instruction through high school and college (Heppner, et al., 2006). Lastly, Heppner, et al., states that “many research studies supporting the effectiveness of inquiry, especially early ones, do not meet contemporary standards of rigor" (2006, p. 390).

Conclusion

Due to the current state of education and the emphasis placed on standardized tests and No Child Left Behind, programs of study that promote learning and achievement in multiple areas should not be ignored (Hargrove & Nesbit, 2003). With that thought in mind, teachers and administrators need to find ways to incorporate inquiry learning into the curriculum. Many teachers and the public alike feel that inquiry is at the heart of science instruction (Shimizu, 1997) and is a method that allows children to construct their own meanings of science concepts being taught (Buchanan & Rios, 2004).

As with any new educational reform, there will always be some sort of obstacle that needs to be overcome, whether it be lack of time or materials, insufficient administrative support, or inexperienced teachers. Nevertheless, we must remember that

> "All students can learn science, and all students should have the opportunity to become scientifically literate. The strength of the science standards, be they national or state goals, is the commitment for educators to understand that science is a discipline that must be taught to every student in every elementary school." (Buchanan & Rios, 2004, p. 86-87)

Science inquiry allows students to more effectively learn and understand science concepts. Inquiry needs to become a greater focus in science education. Children need to learn how to question and investigate on their own and be given opportunities to do so. “An understanding of scientific inquiry and the critical thinking skills that go with it have become valuable in the modern world” (Pine & Aschbacher, 2006, p. 308). As a result, science inquiry needs to be part of the science curriculum. Reforms need to be made and science needs to receive the focus it deserves if we want our children to be successful in science understanding.

METHODOLOGY

Introduction

My research study looked at the effects of inquiry-based science lessons in a kindergarten classroom. I used key topics from my school's kindergarten science curriculum and developed lessons that included hands-on, inquiry-based activities. The students learned key science concepts and topics through inquiry-based, hands-on activities and lessons.

Setting

I conducted this study in my kindergarten classroom, which is located in a small Catholic school. The school is located in a small city/county seat. The school, which ranges from pre-school to grade 8, has approximately 140 students, primarily Caucasian. There is only one of each grade, which means I am the only kindergarten teacher in the school. The staff totals 20 adults, and the student/teacher ratio is 16:1.

Participants

The students taking part in my study were 5 and 6 year old boys and girls in kindergarten. There are 16 students in my full day kindergarten class, 9 boys and 7 girls. Of these 16 students in my full day kindergarten, 5% receive extra support in the areas of speech, math, and/or reading skills and one has been identified as learning disabled. Of all the students in my kindergarten class, the majority attended pre-school.

The students were put into groups within the science class. These groups consisted of 3 to 4 students for Science Inquiry Groups. The students were randomly placed in their groups due to the fact that it was the start of the school year and no prior knowledge existed of the students. These groups were changed for each new science unit. All students completed the same activities and experiments; however, they worked within their inquiry groups to complete the activities.

Procedures

I began my study by getting consent to conduct it. Before bringing the study to my classroom, I received permission to proceed with my study from the Moravian College Human Subjects Internal Review Board (see Appendix A). Before beginning any science instruction, I had to obtain permission from both my school principal and the parents and students who would be involved in the study. First, I sent a letter to my principal explaining my study as well as the safety measures I would be taking to protect my students (see Appendix B). After receiving her consent, I sent a similar letter home to the parents (see Appendix C). The parents and students had to sign this letter and return it to school. Once I had permission from all interested parties, I was able to actually begin the study.

The lessons in my action research were presented one day each week for approximately one hour. A number of experiments also required a follow-up observation day for approximately 20-30 minutes. Each unit was broken up into 4-6 lessons, and each lesson followed the same structure.

To begin a unit, the class started a KWL chart on the central topic of the unit (see Appendix D). The KWL chart was then completed during the final lesson of the unit.

The students began each lesson with a small activity to be completed in their Science Inquiry Groups. This activity had the purpose of activating prior knowledge as well as introducing the topic for the lesson. Following this activity, there was be a brief, whole class instructional period on the lesson topic. At times, this whole class instruction also included some sort of hands-on activity. Next, the students completed an inquiry activity that related to the topic. When necessary, the students came back in 2 or 3 days for a follow-up observation.

Upon completion of each activity, the students made an entry in their science notebook. Each dated entry included a picture and written description about what they did in the lesson as well as what they learned. Finally, at the end of each unit, the students completed a formal assessment in order to measure their knowledge and understanding of the unit topic.

The first lesson was an introduction to science. For this lesson, the students completed a survey that pertained to their thoughts and feelings about science before any formal instruction had taken place (see Appendix E). This same survey was also completed at the end of the study to determine if and how their thoughts and attitudes changed as a result of inquiry-based science lessons. The lesson continued with the introduction of key terms and tools that are used throughout the year in science. These included, but were not limited to: science, experiment, microscope, and balance. To conclude, the students completed their first notebook entry entitled, “What does science mean to me?”

Plants

Our first unit was on the topic of Plants. The first lesson, “Parts of Plants,” focused on plant parts and their functions. During this lesson, the students assembled plant parts through a card matching introductory game. Then they began the Plant KWL chart, stating what they already knew about plants as well as what they wanted to learn about plants (see Appendix F). For the whole-class instruction aspect of the lesson, the class discussed roots, stems, leaves, fruits, and flowers, identified them on a plant diagram, and learned their key functions (see Appendix G). The final part of the lesson was the inquiry activity, which students completed in their inquiry groups. For this experiment, the students placed a piece of cut celery into a cup of water and added food coloring. The result showed the students how the stem of a flower “drinks” the water and takes it to the rest of the plant. This was evident because the colored water could be seen in the celery veins. The students observed their celery after two days in the colored water and saw the colored veins. After they made their observations, they recorded their notebook entry for this lesson. They included a picture of the activity as well as a written explanation of what happened and why it happened.

The second week of the plant unit, entitled “What Plants Need,” addressed the idea that plants need water, air, sunlight, and soil nutrients in order to grow. In their inquiry groups, the students created a prediction list of what they thought was needed for a plant to grow. During the whole class instruction, we addressed the prediction lists and then created a whole class list of all necessary components for plant survival. Next, they labeled these items on a large picture (see Appendix H). For the inquiry activity, the students compared what happens to two plants, one that receives all survival elements and one that does not. After several days, we compared the plants and the students completed their notebook entry.

The plant unit continued for two more weeks. In Week 3, the students learned “How Plants Grow” as they progress from a seed to a flower or fruit and the stages that occur along the way. The class identified each part of the growth process on a diagram (see Appendix I). The inquiry activity required the children to plant seeds in wet paper towels and plastic baggies. They completed a worksheet depicting the progress of the seed over the course of several weeks (see Appendix J). To conclude the unit in Week 4, the students were given a formal assessment in which they had to identify parts of a plant and what plants need to grow. A rubric was used to evaluate the assessment (see Appendix K). Finally, the class completed the KWL chart they began at the start of the Plant unit. To complete the KWL, the students listed what they learned about plants during the 4-week unit.

The Five Senses

We then completed a unit on the Five Senses. Each week's lesson focused on a different sense and its corresponding body part. Again, we began and concluded the unit with a KWL chart and finished with a formal assessment focusing on the concepts learned over the course of the unit (see Appendix D).

The students completed an inquiry activity at the start of each lesson that required them to use the sense of the day. After the activity was completed, the students identified the sense they used and the body part associated with that sense. This activity served as our jumping off point for the day's lesson. Another common part of each lesson in this unit was that the children did a worksheet where they had to cut and paste together the body part for the sense being discussed. For each lesson, we discussed how we use each sense and why it is important.

We began with the Sense of Touch where the students had to feel various items and describe how these items felt. They had to feel items such as blankets, ice, and a block and described them as soft, cold, and hard. Our final experiment required the students to feel inside a touch box and attempt to identify the object inside it. Those that guessed correctly then shared with their classmates what clues they used to help them make their guess.

The topic of our next lesson was the Sense of Sight. To begin this lesson, the students looked at a picture for 15 seconds and had to list the items they remembered seeing in the picture. This brought about a discussion of our eyes, and how the use of colors and a quick look at the picture caused us to see things that were not really in the picture. In the picture were brightly colored autumn leaves, grapes, and flowers; however, the children thought they also saw pears, trees, grass, and peaches. This lesson continued with teacher-led instruction on sight and a cut and paste worksheet. For the final experiment, the students blindfolded themselves and tried to walk to a certain part of the room. The blindfolded students relied on their inquiry groups to be their “eyes” and get them to their ending point safely.

The third week on this unit brought us to a lesson on the Sense of Taste. In this lesson, the students had to generate a taste list to describe a gold fish cracker. After discussing the lists, the lesson continued with instruction and sharing. Within the instruction, the students were required to put food items into the correct categories of salty, spicy, sweet, or sour. Such items to be categorized included pretzels, salsa, cookies, and pickles. To conclude the lesson on taste, the class took part in a jellybean experiment, where the students had to taste a jelly bean and try to identify its flavor. Because this was a lesson on taste, I felt it fitting to end the lesson with a little treat—a Hershey kiss.

The fourth sense we looked at was the Sense of Smell. As in the past, the lesson began with an inquiry activity that required the students to use their sense without being told what sense they were using. The groups had to smell a flower and describe to their classmates how it smelled. After we completed this activity, the students identified our lesson topic as the sense of smell and the body part of the nose. In a similar manner as the lesson on the sense of taste, the students had to put pictures of items into the correct categories of good smell and bad smell. Some good smell items were lotion and perfume; some bad smell items were a skunk and garbage. In the final experiment for this lesson, the students, who were blindfolded, had to smell an item and try to guess what it was. Before being blindfolded, everyone was told what the items were: strawberry banana baby food, peaches, lotion, perfume, and salsa. Based on this knowledge, and relying on their sense of smell, they made their guesses. And, as with all lessons, they concluded by recording what they learned in their science journals.

The final sense of our unit was the Sense of Hearing. To begin this lesson, I played music on a CD player, and the students had to state whether I was playing it loudly or quietly. We then discussed how our ear drum works and how the sound vibrates off it so we can hear. For our final experiment, I filled some containers with different items and then shook the containers for the children to hear. They had to attempt to identify what was in each container after I gave them the things they could choose from to make their guesses: cotton balls, seeds, goldfish crackers, pretzels, and macaroni noodles.

As we concluded this unit with a formal assessment, we also had a final experiment that tied together all five senses. This experiment, the Popcorn Challenge, had the students describing how popcorn smells and sounds as it is being popped, how it feels and looks after it is popped, and how it tastes (see Appendix L). The experiment was presented in such a way that the students could see that we often have to rely on all of our senses. Finally, we concluded the entire unit with the completion of the KWL chart in which the students shared what they learned about the five senses.

Matter

Our final unit of the study focused on the subject of Matter. In this unit, we compared some types of matter and looked at the stages of matter in the lesson on water.

Once again, we began the unit by starting a KWL chart (see Appendix D). Our introductory lesson served to let the students know some examples of matter materials, such as: plastic, wood, metal, cloth, and paper. I also displayed items in each of the three states of matter: solid, liquid, and gas.

The first forms of matter we worked with were paper and cloth. For this lesson, the students felt a piece of cloth as well as a piece of paper. As they were handling each item, they were generating a list of how each one felt. Then, as a class, we compared the two materials to determine if they were easy or hard to bend, fold, cut, tear, and rip. Finally, we concluded the lesson by making recycled paper. The students ripped up a newspaper page into small pieces and added them to water in a blender. Then we mixed the water and paper into an oatmeal-like "mush." Afterwards, we spread the mush onto a screen and placed it between two newspaper pages. We let the mush sit for a few hours to dry before revealing our recycled paper. The students then had the opportunity to handle it and write on it to see that it truly was paper. They recorded their observations and what they had learned about in their notebooks.

The second lesson of this unit compared wood and metal. We began the lesson by finding items in the classroom that were made from wood, metal, or both. The lesson continued by discussing a picture that compared wood and metal, items that are made from each material, and how each material is cut. We continued the lesson by making a Venn Diagram of things that could be made from one or both types of matter. Finally, we ended the lesson with a simple experiment using our touch box. I placed four small items in the box: stapler, paper clip, pencil, and block. The students had to try to guess what items were in the box as well as if these items were made from wood or metal based on what they felt. After all students made their predictions, the items were revealed and the students could identify if they were made from wood or metal.

The final lesson of the matter unit focused on water and the three stages of matter. The lesson began with an inquiry activity where the students had to name what was in each container: ice cubes, water, and air. We continued the lesson by looking at a picture where the students had to identify the various places each stage of matter could be found. We began the experiment where I placed ice cubes in a cup, and the students had to predict what would happen at 10 minute, 20 minute, and one day intervals. After they observed the ice and made predictions, the students completed an activity where they had to put pictures in order that showed the sequence of the water cycle. As they worked, we observed the ice at the end of ten minutes. The students were able to observe that the ice was beginning to melt into water. Once again, the students made further predictions based on their observations. Once they completed the water cycle sequencing, they began work on their science notebooks. This was interrupted when the 20 minute interval had ended and we once again observed the ice cubes. They could then observe that the ice had melted further. The following day, we observed the ice again to see that it had all melted. After a snow day and a weekend, the students observed that all of the water had evaporated.

On the final day of the unit, the students completed the KWL chart and shared what they had learned about matter. Finally, the students completed their formal assessment for this unit.

Data Sources

Throughout my study, I kept a field log containing observations, student work samples, and separate observer comments for each science lesson. This log served as a record of what I saw and heard in my classroom as my study progressed. The observations were a record of what I saw my students doing during science instruction and inquiry activities. These consisted of participant and non-participant observations as well as shadow logs of individual students and small inquiry groups. The student work samples were a timeline of science concepts that were covered as well as a snapshot of student progression, misconceptions, and understanding of science content throughout each unit. Observer comments depicted my personal view and thoughts relating to observations made and student work.

The survey the students completed allowed me to track students' perceptions of science and rank their enjoyment level of science (see Appendix E). It also allowed the students to share what they thought science was before and after formal instruction had been given. In addition to the surveys, I interviewed the students throughout the course of the study. While I started each interview with the same questions in mind, the course of each interview varied depending on each student's answer and comments (see Appendix M).

The students also completed a science notebook entry for each inquiry activity or experiment. This was used as a weekly assessment of their understanding level of the science topics. A rubric was used to assess each notebook entry (see Appendix N).

In addition to these non-traditional forms of data collection, the students also completed worksheets and formal assessments throughout the study. These traditional forms of assessment enabled me to monitor student comprehension of the topics covered as well as their ability to apply the skills learned in a different format.

Trustworthiness Statement

Trustworthiness is a critical component in my research study. After having read Arhar, Holly, and Kasten (2001), I was able to develop a variety of methods to protect the kindergarten students involved with my research study. Before I even brought the study into my school, I obtained approval to conduct my study from the Moravian College Human Subjects Internal Review Board (see Appendix A). Once I had their approval, I was able to proceed with my study in the classroom. At the onset of my action research study, I secured permission from parents, students, and my principal through signed consent forms (see Appendix B and C). Within the parent consent forms, they were made aware of the fact that the student could withdraw from the study at any time without penalty. I was also able to explain my study to parents prior to the start of school at our Kindergarten Orientation. This allowed them the opportunity to ask questions or share concerns they may have had pertaining to my study.

In addition to getting written consent, I also made sure to inform my kindergarten students about my study at their level. I explained to them that I was in school to become a better teacher and would be sharing what we did in science class with the other teachers in my class. Likewise, I explained that they would be learning lots of interesting things in science and doing lots of fun experiments and activities; however, if there was anything they did not like or were uncomfortable with, they could let me know. This way they were also aware that they could withdraw from the study.

I was extremely careful during the course of my study to ensure confidentiality. I used pseudonyms in my writing for all students involved to ensure anonymity. Some field log entries included portraits of one or several students; nonetheless, their identity has been concealed.

Furthermore, any data and information I collected that pertained to my action research study was kept in a locked cabinet when I was not using it for study-related purposes. After the study was completed and my final document had been written, any information collected, including my field log, was destroyed.

Another important facet brought up by Arhar, Holly and Kasten is to “build a relationship of trust” (2001, p. 17). I did this by keeping the lines of communication open between myself and the parents, students, and principal regarding my study. At the conclusion of each unit, I informed them how the study was progressing based on formal assessment results. Along with this update, the parents viewed their child's formal assessment to monitor individual progress. At the conclusion of my study, I shared the final results with all involved participants.

As I conducted my study, I looked at the data through the eyes of teacher and student. I collected data through a variety of methods, including student observations, performance assessments through lesson experiments, formal assessments at the end of each unit, student notebook entries, and surveys. In addition, I shadowed individual students and small groups, noting observer comments, addressed biases in my field log, and completed both participant and non-participant observations. In order to address biases, I reflected on my study throughout the process and recorded any biases that occurred along the way as well as how I dealt with them (Hendricks, 2006). Finally, I evaluated the students' notebooks and assessments using a rubric.

Once my study was completed and I analyzed my data sources, I coded field log entries in order to find patterns, successful and failed activities, problems, and student reactions. I also created layered stories and pastiches containing student comments, observations, thoughts, and work regarding the inquiry-based activities. The students also completed pre- and post-study surveys which allowed them to share their thoughts and feelings towards science both at the start and end of my action research study. The multiple data sources I collected and the various ways they were analyzed enabled me to get a more thorough and well-rounded understanding of the process and the results. Also, my research group gave me support and third-party viewpoints to keep me on track. My research group helped to validate and analyze my study by questioning my observations and offering suggestions along the way (MacLean & Mohr, 1999). Therefore, I had a variety of lenses to view my study. As Ely, Vinz, Downing, and Anzul point out, I was able to interpret meaning from the data I collected through many outlets to help understand the study (1997).

Establishing and following this trustworthiness statement, ensured that I stayed true to myself, my study, and, most importantly, my students. Conducting my thesis study was part of my day-to-day routine of teaching science; however, it was also a “way to improve [my] teaching and increase and improve the learning of [my] students” (MacLean & Mohr, 1999, p.131). This trustworthiness statement allowed the process of the study to be open, honest, and ethical, and protected my students. It served as a guideline for me to be fair to my students and ensure it was a process that benefited me and my students in the study of science.

Biases

Before beginning my study, there were several biases I held that I knew needed to be addressed. If I wanted to conduct a study that was fair to everyone involved and would honestly display the effects of inquiry learning in science, I knew these issues needed to be addressed so I could be open to the possibility of anything that may happen in my kindergarten classroom during the course of the study.

The first issue that had to be dealt with was my expectation of the students. Based on my limited knowledge of them, I anticipated some students to do very well and others to struggle. When creating the science lessons for my study, I addressed this bias by not differentiating my instructional techniques based on pre-conceived notions of ability. I presented all students with the same activities and was surprised when struggling students made profound observations from time to time and advanced students occasionally struggled with a concept. Overall, I was pleased with the fact that all students did well, given the fact that all were presented with the same lessons and activities to complete.

Another bias that I knew had to be addressed was my concern that the students would not enjoy science just as I did not in elementary school. However, the simple fact that I was conducting this study was my way to overcome this particular bias. I was teaching science in a way quite different from how I was taught. At the very least, I knew the students would be involved in their learning, even if they did not enjoy it in the long run. I had to accept the fact that science is not for everyone. As long as they were learning the concepts being presented, my study would be a success.

The final bias I held before beginning my study was my belief that the concepts to be covered would be difficult for the students to grasp. I overcame this bias by creating lessons that presented the topics at their level of understanding. Furthermore, by including experiments and hands-on activities in each lesson, I was allowing the students to experience science so they could better understand the concepts being taught.

Summary

Throughout my action research study, the goal was to motivate students and engage them in science. By designing inquiry-based lessons around the established kindergarten curriculum, I set out to develop a strong understanding of science concepts and skills in my students. Through the various data sources I used, I could determine if inquiry-science was beneficial to teaching children science content. The notebooks, worksheets, and assessments served as a source to evaluate their understanding so as to determine that they were in fact maintaining the content learned as a result of inquiry-based activities. Through this study, I could use the information gained to determine if inquiry-based science lessons are a beneficial and advantageous method of learning science.

MY STORY

Introduction

"Problem-posing education bases itself on creativity and stimulates true reflection and action upon reality, thereby responding to the vocation of persons as beings who are authentic only when engaged in inquiry and creative transformation" (Freire, 2003, p. 84)

It was the start of the school year and I knew that it would be a challenging year before even meeting my class. This year I would be conducting my thesis study on inquiry science. I was scared, nervous, and excited all at the same time. What would happen? Where would I end up? Would it be worth all the time and effort? Would the students enjoy science?

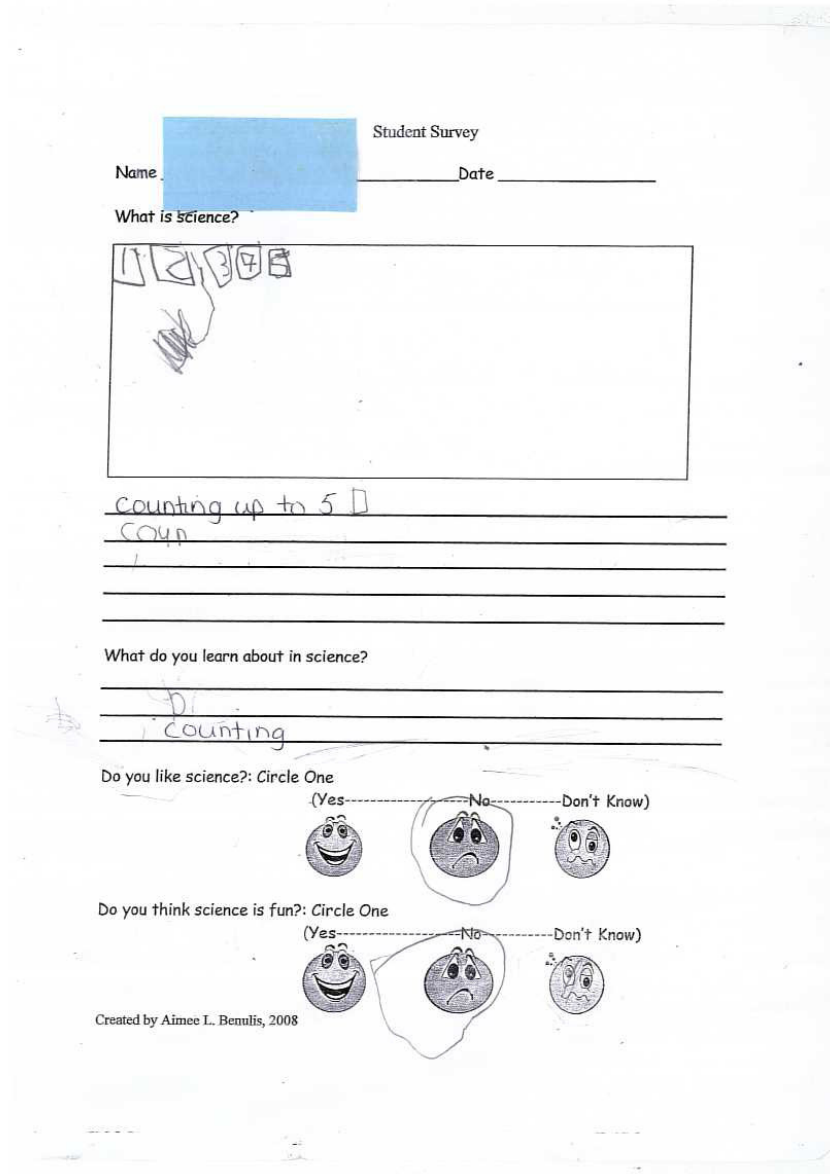
There was no better way to find out the answers to these questions other than to begin. And so, once those initial days of learning the routine and procedures were over, I knew it was time to start. Thus I began the journey of science inquiry with my kindergarten students.

It was my goal to make science fun and interactive. The students would be engaged in learning. Likewise, they would be learning science concepts in a creative way through experimentation and hands-on activities. I would develop my lessons based on their questions. They would be making observations and sharing them in their notebook entries. The learning and experiments the students would be taking part in would be an authentic way for the students to come to learn and understand the various science topics presented in the curriculum.

The Journey Begins

"Knowledge emerges only through intervention and re-invention, through the restless, impatient, continuing, hopeful inquiry human beings pursue in the world, with the world, and with each other" (Freire, 2003, p. 72).

The question that lay before my students was simply, "What is science?" They had never received formal science instruction, I did not give any insight into it, and there was nothing in the classroom that they could see that would give them an indication towards science. And yet, there I stood, asking it to a group of 5 year old students. I honestly did not know what to expect. I had hoped their answers would be along the correct path. But if they were totally off target, I knew I had my work cut out for me. This survey was a way for me to listen to my students so I could develop lessons around their existing knowledge and introduce topics they are not familiar with in science (see Appendix E). And so, I gave the students the survey that required them to answer this question in words and pictures. The following figure is a sample of one student's pre-survey.


Student Survey

Name ____________ Date ____________

What is science?

1 2 3 4 5

counting up to 5

coun

What do you learn about in science?

counting

Do you like science?: Circle One

(Yes------------No------------Don't Know)

Do you think science is fun?: Circle One

(Yes------------No------------Don't Know)

Created by Aimee L. Benulis, 2008

Figure 1 . Pre-survey student work sample.

As I reviewed the survey results, I found some answers that could be considered “science concepts” while others were completely unrelated to science. The following pastiche displays the responses from the students.

WHAT IS SCIENCE?

Counting up to 5

Mixing stuff and it blows up

Books

Toothpicks floating in milk with food coloring

I think science is 2+2

Spider

Rocket ship

Making someone go away

Cup-dropped it

Magnifying glass to see little bugs

Lava

Cake

People

NUMBERS

Colors exploding

Figure 2. Pastiche using student responses from Pre-Survey.

In addition to the comments given by the students, they also shared their opinions on whether or not they liked science and if they thought it was fun. The following table shows the students responses to these questions.

Table 1

Student Pre-Survey

Do You Like Science?	**Yes**	**No**	**Don't Know**
	12	2	2
Do You Think Science Is Fun?	**Yes**	**No**	**Don't Know**
	10	3	3

I found these results to be surprising. When the students started the survey and had to draw what science was, the majority of the class did not know what to write. Similarly, in reviewing the pre-surveys, only several students wrote an answer to the first question that was connected to science.

I hoped that the varied results of the pre-survey were simply the product of lack of previous science instruction. Nonetheless, I could clearly see that my lessons would need to be basic enough to build a foundation because the students had no clear perception of what science was or what was learned in science. Even though the lessons would teach the basics, I knew they also had to be interactive and interesting so the students would stay focused. This study certainly presented me with a challenge. Was I up to meet the challenge? Would my students meet the challenge I would be presenting them with each week? Only time would tell.

One thing I knew for sure, if I wanted to change their thoughts about science, I had to make it enjoyable for the students.

Plant Inquiry: The First Stop

"Everything depends upon the quality of the experience which is had"

(Dewey, 1997, p. 27).

Our first stop on the road of inquiry was plants. This unit would allow the students to see what makes up a plant as well as how those parts work together to serve the plant. It was a unit I felt very comfortable teaching so I figured it would be the best place to start. Where it would take us would be up to the students. Their inquiries would help me to develop activities that would answer their questions.

Inquiring Minds Want to Know

We began looking at plants by first discovering what the students already knew and what they wanted to know about plants on our Plant KWL chart (see Appendix F). The students seemed to know a lot of basic plant information, like "they grow" or "they need rain." Everyone seemed to know something about plants and wanted to share their knowledge. But, when it came time to inquire about plants, there were not quite so many hands being raised. What reassured me about this was that those who did ask questions asked very inquisitive questions about plants. They wanted to know, "How does rain make flowers grow?," "How do they grow seeds and split open and make little roots?," and, as Shawn summed it all up, “I want to learn all about it.” I could then use this knowledge to connect what interests the students to curriculum (Delpit & Dowdy, 2002).

And So It Grows

Before even beginning our first lesson, I broke the students up into inquiry groups. I just randomly placed them in their groups because I did not have pre-existing knowledge of their science abilities. Also, being the start of the school year, I did not know who would work well together and who would not. Besides, it was only one day a week, so even if it did not work, it was not something I had to deal with every day.

As we began, the students had to build a flower using pictures of flower parts. It was interesting to see how well some groups worked together in this activity while other groups did not fare so well. One group really stuck out to me because only one student was working while the other two sat and talked.

Connor's Story: Part 1

Here we are working on this activity and Pam and Rose won't help me. All I wanna know is when are we going to do the science project? Mrs. Benulis said we are going to do fun experiments, but this really isn't fun. They just keep talking, why won't they help?

My Story

Connor seems to be working hard but his partners are not. I have to make sure they get more involved in the assignments so they get something out of it. At least I know that Connor is eager to learn. Of course, he just wants to do the experiment. I did tell him that we have to learn the idea before we can do an experiment. Hopefully that satisfied his excitement for now.

Figure 3. Part 1 of Connor's layered story.

The lesson continued with some minor disturbances, but the students seemed focused and on task. Then the big moment: the experiment. It was really a simple experiment where we put celery in colored water to see how a flower stem "drinks" water, but I thought it would be a good first experiment for the students to get a feel for the process of experimentation.

After about two days, when we came back to observe the celery, the students were very receptive and "oohed and aahed" a lot when they took the celery out of the water. They discovered "polka dots" on the bottom of the celery and said it looked like a strawberry. When I asked them why this happened, Connor correctly responded, 'it drank that water." Their excitement grew when I cut open the celery and they could see the color shooting up the stem. Thomas found it “awesome” and Rose saw “red and white” from the food coloring.

I wanted to make sure they had a way of recording each lesson, so I had the students keep a science notebook. They would draw a picture and write up what we learned in each lesson. Because this was their first notebook entry, we did this one all together. We discussed what we learned and how to set up our notebooks to record this information. Some students were unsure of the set up and questioned it further, but for the most part they were able to get right to work. They helped each other with areas that needed clarification or with ideas of what to draw. They showed good cooperative working skills and were focused on the task at hand. Lesson one went well and I just hoped the rest would be as successful.

The inquiry of the students continued into the following week when Thomas asked, “How does celery drink water?” We recalled our previous week’s lesson and the celery experiment to answer his question. To further explain, I made a comparison to a drinking straw and described that just as when we drink through a straw the drink goes up the straw into our mouth, so to does the water go up the stem to the flower and leaves of the plant.

This inquiry led to us directly into our next lesson where the students had to figure out what a plant needs to survive. I looked to see how Connor's group was working on today's activity. This time, Pam was helping; however, Rose was still unfocused and not participating.

When I showed the students a flower picture, they observed the different elements that a plant needs to survive (see Appendix G). These observations set the tone for a very interactive class discussion on what a plant needs to survive.

Mrs. Benulis: How do plants get water?

Grace: When it rains, the water goes into the soil.

Brad: From the hose, it goes into the soil.

Connor: Get like a cup in the sink and put water in it and dump it in the mulch for the flower.

Jack: watering can

Mrs. Benulis: How does the water get into the plant.

Mary: The stem drinks it.

David: roots

Mrs. Benulis: What else do we see in the picture that a plant needs?

Kindergarten class: light or sun

Mrs. Benulis: Why do the plants need light?

Connor: To keep it warm.

Brad: To keep it growing.

Mrs. Benulis: Did you know that a plant uses water and the sun to make food? Where does it make food?

Garrett: The leaves

Kindergarten class: Plants need the ground.

Mrs. Benulis: What's in the soil that plants need?

Pam: water

Grace: seeds

Mrs. Benulis: The soil gives food for the flowers. It contains nutrients. Just like a vitamin contains things to make you strong and healthy, the nutrients in the soil do the same for a plant. How does a plant get the soil nutrients?

Garrett: from the dirt

Brad: When you have a big bag of it and a shovel and spread it around.

Jack: by the garden

Mrs. Benulis: The last thing a plant needs is air. Where does the air come from?

Mary: Wind comes by it.

Allie: Comes down and lands on top of it.

Mrs. Benulis: What about the plants that are inside?

Grace: Air conditioner

Shawn: The door open lets air in.

Mrs. Benulis: Air is all around you. Fan yourselves with your hands (children fan themselves). Feel the air?

It was through this dialogue that the students learned from me and I learned from them. As Freire put it, “the teacher is no longer merely the one-who-teaches, but one who is himself taught in dialogue with the students, who in turn while being taught also teach” (2003, p. 80). I felt it was a good indicator as to future interactions during science lessons.

As we finished our discussion, we moved into our experiment. However, before we began the hands-on activity, Connor stated that he was “dying to get an answer to my question.” The question he was referring to was his KWL question when he asked, “How does a seed split open and the plant come out?” His inquisitiveness was very intense and I knew I had to develop some type of experiment to answer his question. But for now we had to focus on the lesson at hand.

I showed the students two plants and told them we would put one in the closet, where it would receive no water or light, and we would put the other on the window sill and water it daily. The students made predictions as to what would happen to each plant. Everyone agreed that the second plant would live. However, they did not reach a shared prediction about the plant being put in the closet. While most students did feel that it would die because of lack of water, some students did think it would live.

Now that they knew what makes up a plant and how it lives, the next step was to learn how it grows. The students moved through this lesson with ease. As we concluded our discussion, Jack asked a very inquisitive question, “Why does a plant grow so slow?” I used his question to lead us into our experiment and told him his question would be answered in due time.

When it came time for the experiment, I will admit I was a little uneasy. I had never performed this experiment myself and was not really sure how it would work. But, I had seen it done and quite successfully at that. When I told the students we would be planting a seed without soil, they looked at me with eyes wide open and mouths agape. They were puzzled, curious, and eager to get started. So, they wet their paper towels, folded the seed inside, and sealed up their baggies.

The students really took an interest in science. As they worked in their groups, they helped each other. As we progressed through the unit, they were able to recall previously learned concepts and were applying it to each new lesson. They all seemed eager to learn about plants and discover what would happen with each new experiment.

Look What’s Blossomed

I could see that the study had been going well, but I did not really know if the students were retaining the information. As we began the final lesson on the plant unit, I was eager to see what they had learned. So, we started the day by completing our KWL. The following pastiche shows what the students shared that they had learned during the plant unit.

What We Learned

They drink water up like a straw.

They need air.

Water goes in the roots.

They have seeds.

They need sun and they have roots.

They need water.

They grow from seeds.

The leaves catch the rain and help make food.

Lose leaves by not getting rain.

THE WIND BLOWS THE LEAVES OFF.

Seeds grow more flowers.

Figure 4: Pastiche on what students learned in plant unit.

They had so much to share that they actually filled up two and a half chalkboards with the knowledge they learned. I was overwhelmed by the information they had retained during the course of the unit. They were on target with everything and at no point did I even have to prompt them to divulge further information. I could only hope that their formal assessment would turn out as well.

As I walked around the classroom while the students worked, I could see question after question being answered correctly. Even students who often struggle appeared to be doing well.

The students were assessed on two areas for the plant assessment. To begin with, they had to identify the parts of a plant, which includes the roots, stem, leaves, and flower. Secondly, they had to name the four key elements a plant needs to survive. These survival elements are water, air, soil, and light. As is evident in Figure 5, the students were successful with this assessment.

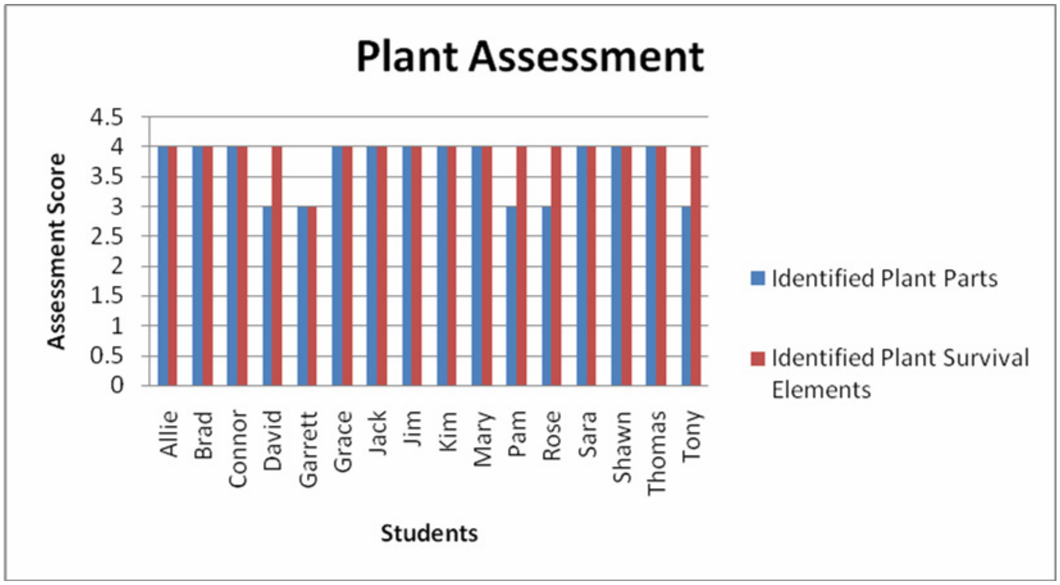


Figure 5. Plant Assessment results.

Throughout the entire unit, the students were actively engaged in their learning. They showed that they gained the knowledge presented to them in each lesson. I was quite pleased with the results of the assessment.

The plant has emerged. I knew I could not end the unit without answering Connor's question. But I was not quite sure how I could do this. And then I remembered an experiment Dr. Z had talked about and realized that this was the perfect way to answer Connor. I knew this was the perfect ending to an overall very successful unit.

Connor's Story: Part 2

I am dying to get an answer to my question. How does a seed split open and a plant come out of it? I keep asking every week and I still don't know. Now we are done learning about plants and I just wanna know.

My Story

I know Connor is overly eager to find out how plant comes out of a seed. However, this is not really a point covered in the curriculum. Nonetheless, I know I cannot move onto a new unit without answering his question. But what can I do? Wait, Dr. Z mentioned an experiment. That is perfect. We will soak the seed in water and after a few hours, they can handle the seed and eventually open it and see the new seedling inside.

Connor's Story, Continued

So, we put our seeds in water. I think when we cut it open we're gonna see the seed without the skin on it.

Mrs. Benulis asked me what I saw when I cut my seed open. I told her it was the real seed. But then she showed us the little leaf inside it. It looks like a tail. I still can't see it, it is so small. I bet it's going to turn into a rose. It looks like a rose.

Hey, that was pretty neat. So the baby flower is inside the seed. I have to put this in my science notebook.

My Story

It was neat to see the thrill in Connor as he discovered the answer he was "dying" to find out. He made some very insightful observations and comparisons. It was a challenge because I did not know what to look for. I even had to ask my sister and then go in the next day and show the students again. But I am glad I was finally able to answer his question. He definitely inquired the most during this unit, of course it was always about the same issue. Even still, his eagerness to record his observations showed his excitement to learn. That passion makes this study worth it.

Figure 6. Part 2 of Connor's layered story.

Connor was then able to portray what we learned and did during the experiment in his science notebook. He reported what was done during the experiment as well as what he observed.

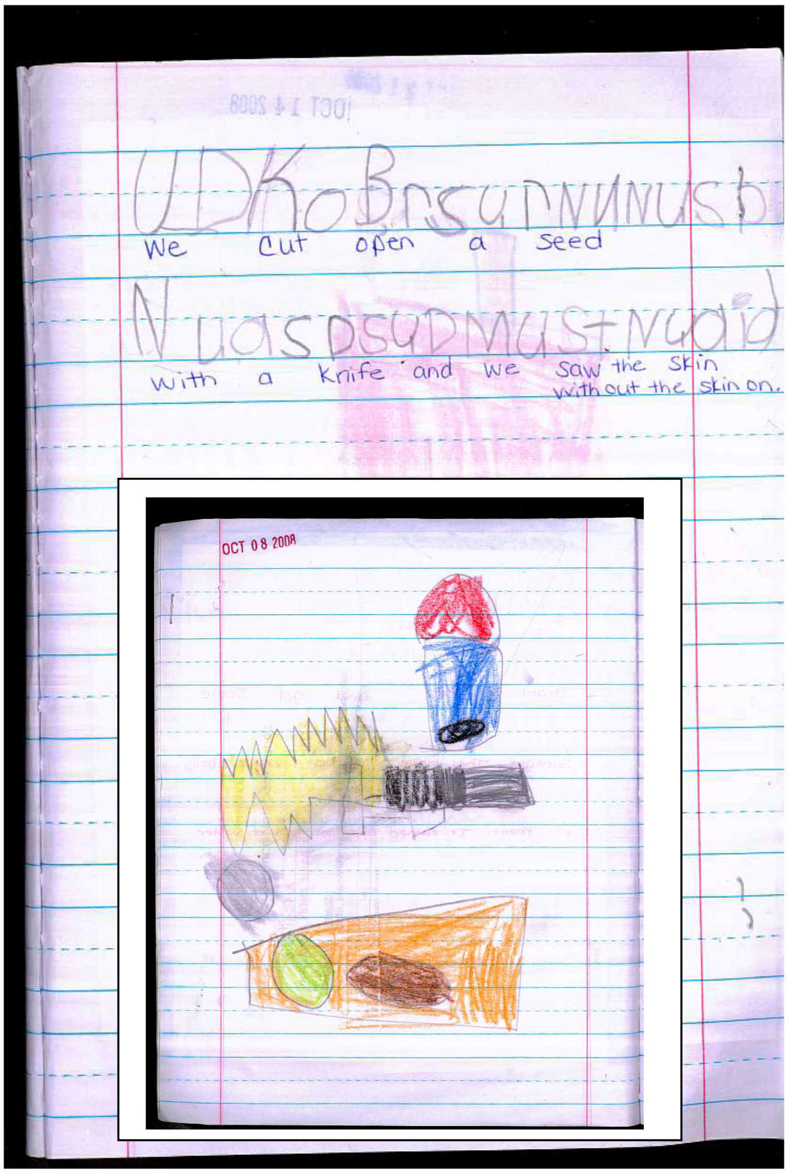


Figure 7. Student notebook entry on the "What's in the seed" experiment.

Stop, Look and Listen: The Five Senses

"Through this process they expand their understanding of how the various parts interact, which will later help them penetrate the totality itself" (Freire, 2003, p. 111).

It was a new unit, a new opportunity for me to explore the inquiry of the students. This unit would focus on the five senses as well as the body parts that are used for each sense. We would explore a different sense each week with the final week looking at how all the senses can work together to help us enjoy things.

I began this unit with the presumption that the students would have adequate background knowledge on the five senses; however, I still wanted to know what knowledge they did have. And so, I began with a KWL chart just as I had started the plant unit. I was alarmed at the fact that most of the facts they shared had to deal with the sense of touch. However, when I later reflected on the lesson, I determined this was because they completed an activity using the sense of touch before doing the KWL. This sense was at the forefront on their thoughts and thus that was the knowledge they were sharing. I realized that I should have begun with the KWL chart and not an inquiry activity.

Why I asked them to share what they were interested in learning about their five senses, their main inquiry revolved around how each sense worked and how we use them. This was a great starting point for me to develop lessons and activities to answer their questions.

We Can "Sense" Some Learning Going On

After completing a successful inquiry unit on plants, I had high hopes for the five senses unit. As we began with the sense of touch, I wanted to show the students why we have the sense of touch as well as how we use it. That led to a discussion of the importance of being able to feel things. Thomas pointed out that we can feel if something is hot, to which Grace followed up with "or cold." Allie noted that we can feel if something hurts. Connor added that we can feel things that are soft. I felt they made some interesting points and could clearly see why the sense of touch is so important.

We followed up our conversation with a fun experiment that further helped the students understand how we use our touch. All of the students had the opportunity to feel what was in the Touch Box and guess what was inside it. They made guesses from dolls and rabbits to lions and bears. I thought all of their guesses were on track for the most part; however, three students did correctly identify the object as a horse. The following skit describes how Allie, Grace, and Connor took their turn with the Touch Box and explained how they reached their guess.

Grace: (looking up at the ceiling as she felt around inside the box) I guess a horse

Allie: (moving the item around in the box) I think it's a horse, too.

[A few more students take their turn and make incorrect guesses]

Connor: (with his eyes closed) hmmm. . . I bet it's a horse.

[After all students took their turn, I revealed the horse in the box. Grace smiled, Allie clapped her hands.]

Connor: yes!

Mrs. Benulis: Allie, Grace and Connor correctly guessed a horse. How did you make your guess? What clues did you use to make your prediction?

Grace: I felt the mane and the nose.

Allie: I felt the nose and the hair coming down.

Connor: First I thought it was a giraffe because of the neck but it wasn't that long so I thought it was a horse because horses have medium necks.

I wanted to continue the senses unit with more interactive lessons. As we looked at the sense of sight, the students had to answer their inquiry in a backwards approach. Instead of looking at why we need to see, I had the students experience not being able to see. The students had to move around the classroom with their eyes closed using their group members as their eyes.

What an experiment this turned out to be. The students had a really good time with it. While some groups carried this activity out without any complications, others were rather entertaining to watch. When it was Connor's turn, his partner did not give any directions. Connor just wandered around the room feeling his way as we went along. It truly was a sight to see.

Then it was David's turn. He was partnered with Jim, who decided he had to go to the bathroom. Not realizing that David had started walking around the room, I allowed Jim to go. When I looked up and saw David wandering around, I recognized what had happened. So I became David's eyes, but not before he bumped into a table and knocked over a water bottle—closed thankfully.

Everyone was already laughing and having a good time, and then it was Allie's turn. As she started walking around the room, she was bumping into tables and chairs and had no sense of where to go. Even though her group was giving her directions, she was still colliding with anything in her path. Somehow, she finally managed to get to her destination. Thomas really enjoyed her during this activity. He said it was "Awesome because Allie kept bumping into stuff because she wasn't listening to us." It seemed as if she was doing it simply to get a laugh from her classmates, "anything for attention" (Delpit & Dowdy, 2002, p. 6). When asked to further describe the experience, Garrett commented that it felt like Brad was his guard dog. Jack added, "it was funny."

I hoped to bring this same sense of enjoyment to our lesson on the third sense, taste. For a simple, interactive lesson, the students had to place food pictures into the correct category of spicy, sweet, salty, or sour. Overall, they did very well with this task. Of course, it did not occur without a few minor problems. Connor complained that Thomas told him the answer, some students were talking and whispering, and Garrett disrupted the class by calling out "Wow, those are big cookies" as Pam took her turn.

After refocusing the class, we proceeded to the Jelly Bean experiment. The students had to attempt to identify the flavor of the jelly bean they had been given. A few were able to name their jellybean flavor. Some were close in their guess, such as Kim's guess of orange for a tangerine bean. However, some were way off the mark, like when David called a watermelon bean sour. To end this lesson, all the students got to taste a Hershey Kiss, which they described as tasting good, chocolaty, and sweet.

Connor's Story, Part 3

We have to write down how a flower smells. Well I know all flowers smell different. Sara made a mistake, I will tell her so she can fix it. She spelled yellow wrong. We can copy it off the color poster. Then it will be spelled correctly.

We have to listen to the other groups. I am really going to try to pay attention. It's hard though. Oh look a string. Let's see what I can do with it. Oh, right, I am supppsed to be listening.

Mrs. Benulis called on me to put the lotion in the right column. If I put it in the bad smell column, will they laugh at me? Let's see. Mrs. Benulis kinda gave me a funny smile. Ok, I'll put it in the right place

I wonder how I did last week on my notebook. Time to get to work today. I think I will draw myself smelling something. I have to remember to do meatball spaces.

My Story

Connor is working really well with his group. He is offering lots of help and suggestions. I really like how he is using the classroom resources to spell words.

He really seems to be paying attention as the other groups. He is showing genuine interest in Grace's group. The more focused he is, even on the other groups, the better he will learn today's concept of the sense of smell. Of course, he is easily distracted as a simple string draws his attention away. I have come to expect this from kindergarten students though.

Connor is definitely the character. Always looking for a laugh. It reminds me of the quote from Delpit, "anything for attention" (2002, p. 6).

Even though he fools around some, he still gets the work done when it comes to it. And he pays attention to details and tries to make sure he includes everything he can to show what we did in class. I think this is a great indicator of his eagerness and desire to learn. I am very pleased with how he is moving through the lessons each week. He is improving in many ways which will carry into other subjects as well.

Figure 8. Part 3 of Connor's layered story.

The unit on the five senses continued in much the same manner with the lesson on the Sense of Hearing. The students really began to work cooperatively in their inquiry groups. They had a lot of information to share concerning how our ears work. They participated in the lesson and were eager to experiment, as was evident in Garrett's reaction of jumping and dancing around when it was time to do the lesson experiment.

The irony of the lesson on hearing was that many of the students were not listening. As we discussed how our ears work, Sara and David were talking or playing with things on the floor. Then, Brad and Garrett were also able to find something to distract them. As they completed their cut and paste worksheet, only two groups were actually working—the other three groups were talking, singing, or fooling around. Their lack of listening was even more evident when David and Tony finished their notebook entries, which were not related to the lesson at all. I could hear the tiny voice inside me screaming, "Ahhhhhh! Will they please listen?" I know every teacher has days like these, I just hoped it was only today and next week would be better.

I was concerned that they did not fully gain the knowledge presented on the sense of hearing. Time would tell if this lesson was successful and if the students did learn about the sense of hearing or if the students did not gain any knowledge about this sense.

Things are "Popping" in Kindergarten

When compared to the plant unit, the experiments during the unit on the five senses were not as involved and exploratory. Therefore, I wanted to end this unit with something more interactive that would utilize all five senses. So, I developed the "popcorn challenge" (see Appendix K).

To do the challenge, we had to take a field trip to the faculty room so we could use the microwave. The children had to listen to the popcorn as it popped. To incorporate the sense of touch, the students had to feel the bag after the popcorn was done popping. We then returned to the classroom where all the students got a cup of popcorn. Once everyone had their cup, they smelled the popcorn and used their sense of sight to determine how it looked. Finally, they were allowed to taste the popcorn. The following figures are a sample of two of the students' popcorn observations.

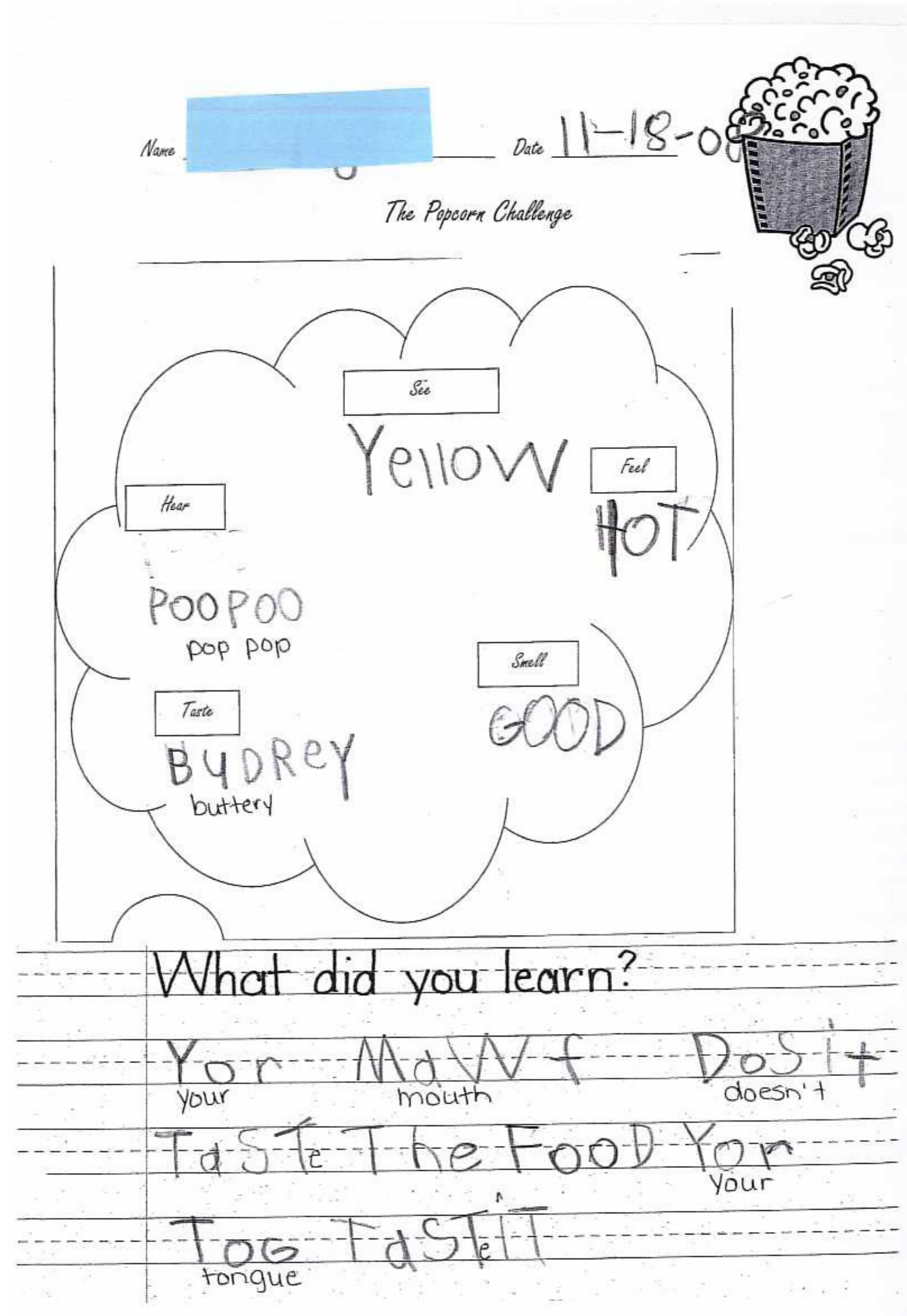


Figure 9. Student sample 1 from the Popcorn Challenge.

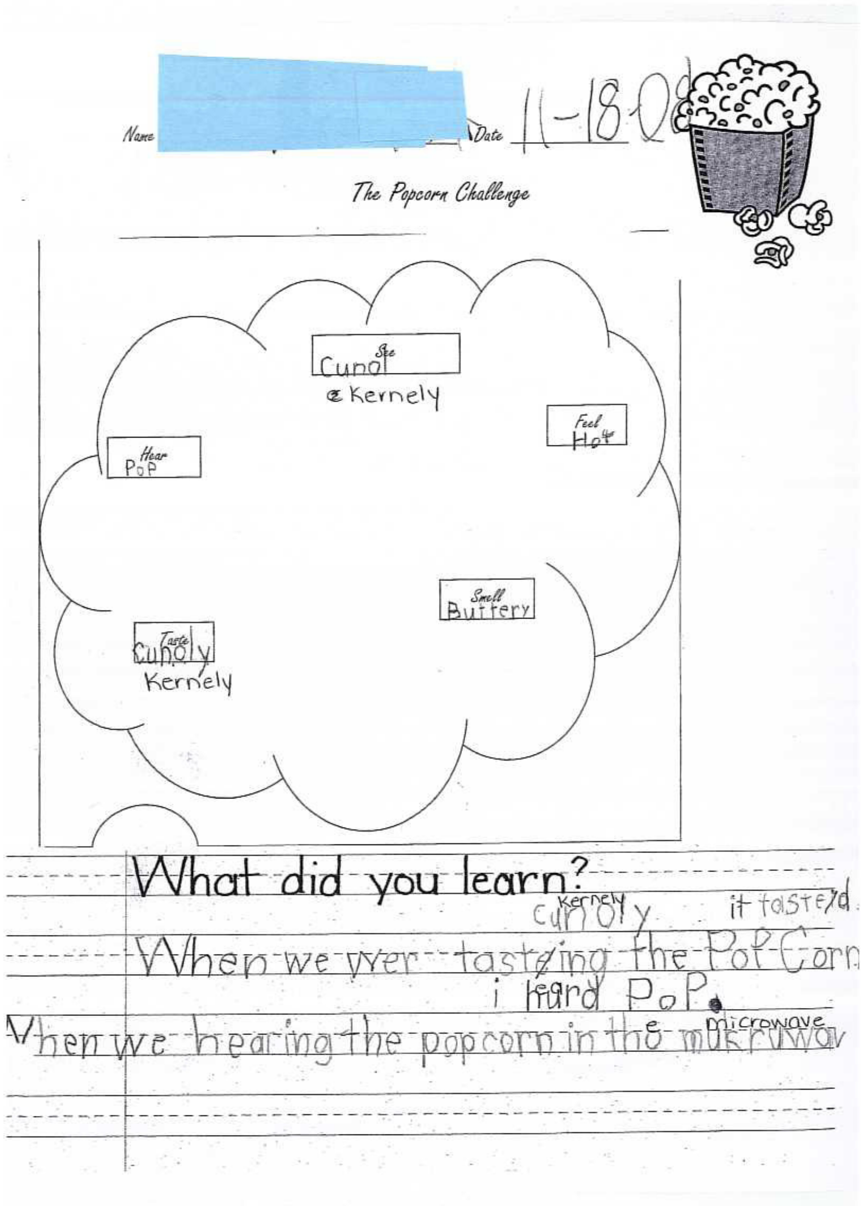


Figure 10. Student sample 2 from Popcorn Challenge.

Due to the fact that this lesson took place in a different setting, it seemed to affect the students. They were being silly as they kept trying to sneak more popcorn. When I was catching them out of the corner of my eye, they were amazed that I was not even looking and could still see them. I had to laugh because I remember my grade school teachers telling me they had eyes in the back of their heads. I guess I have them too now.

Even though the students were being silly today, they were able to see how we use all our senses to enjoy something. I felt confident that the class met the unit objective and had their inquires answered. Based on their assessment results, they all showed a considerable understanding of the five senses and the body part used for each sense as is indicated in Figure 11.

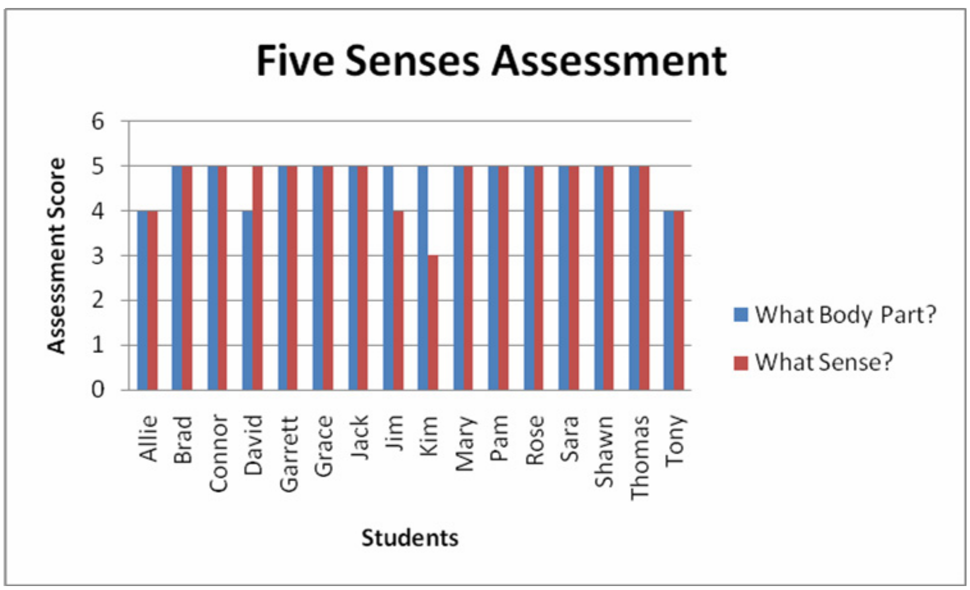


Figure 11: Five Senses Assessment results.

What "Matters" To Us

"A well known and empirically established fact is that learning should be matched in some manner with the child's developmental level" (Vygotsky, 1978, p. 85)

The final unit of the study was on matter. In the previous two units, I used the KWL questions from the students to guide my lesson and experiment planning. However, this was difficult for this unit because the students had no background knowledge about matter. Therefore, the students only had two questions. These were, "What is matter?" and "What does it mean?"

I knew I had to provide the students with the opportunity to work with different types of matter. Allowing the children to play with various matter materials would enable them to develop a relation "between the field of meaning and the visual field—that is, between the situations in thought and real situations" (Vygotsky, 1978, p. 104). By developing this relationship, what they see and experience visually will help them to contextualize the concept in their minds. This would help them to retain the knowledge they gained on the subject matter.

I felt the best way to introduce a lesson on a topic they really had no prior knowledge was to make them aware that matter is all around them, since matter is anything that takes up space. I displayed pictures of houses made from various items. From these pictures, the students could see that matter could be anything from wood and plastic to bricks and metal.

This lesson provided the students with a good introduction to matter, but it did not fully answer their inquiry. This unit would certainly be different than the others and I hoped I could provide the students with experiments and activities that would answer the question, “What is matter?”

Let’s Discover

Once it was time to actually start the matter unit, I began with a lesson on paper and cloth. I felt these were two materials the students would be comfortable working with to start looking at matter. In addition, the students were probably most familiar with paper and cloth compared to other matter materials I planned on using.

The students were displaying signs of excitement in regard to science as we started the unit on matter. Brad seemed to speak for the class with his eager question, “Can you tell us now?” They were all anxiously waiting to find out what our science experiment would be for the day’s lesson. Once they were settled in their science groups, I informed the students that we would be playing with paper and cloth and comparing the two types of matter. The students worked in their groups and created a list describing a piece of paper and a piece of cloth. These lists were then shared with the whole class to compare the various descriptors that were used for each type of matter. The following figure is one group’s paper and cloth description list.

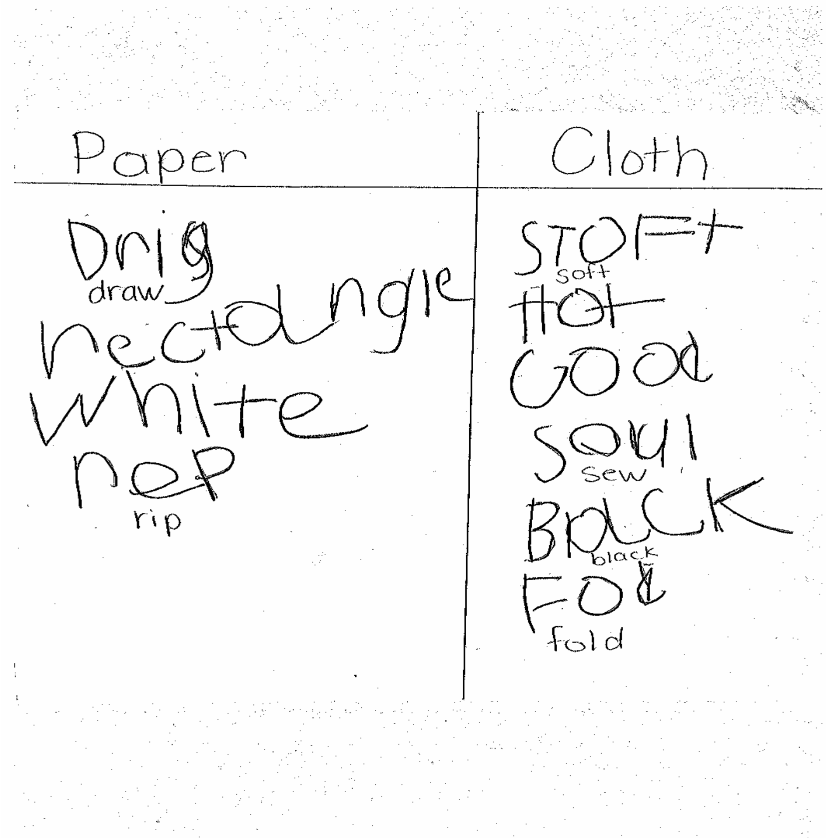


Figure 12. Student sample of paper and cloth description list.

As the lesson continued, the students had the opportunity to compare paper and cloth by working with each material to determine what could be done with both types of matter. As we worked with paper, the students determined that they could fold it, rip it, and crumble it. As we discussed each thing that could be done with the paper, the students manipulated their piece of paper to fold, rip, and crumble it. Connor also commented that we could make paper airplanes and puzzles from paper.

We then worked with cloth in the same manner as we had the paper. Once again, each student had a piece of cloth to manipulate as we discussed what could be done with cloth. The students discovered that they could make knots, stretch cloth, and fold it. As the students were playing with the cloth, they also made the observation that cloth can be used to wash their bodies. At this comment, several students pretended to wash themselves with their piece of cloth.

Once the students were refocused on the task at hand, we continued with the next part of the lesson. The students had to complete a worksheet comparing the two matter materials. For this worksheet, they had to determine if it was easy or hard to fold, bend, tear, cut, and draw on both the paper and the cloth. They continued to use their sample paper and cloth to discover the answer to each worksheet question. As we began the worksheet, Connor said that “maybe some will be hard.” Thomas however felt that it would not be hard and that I should just “circle easy for each one.” As we moved through the paper, Thomas found that they were not all easy and had to double check his work to make sure he had every answer correct. The students had the paper and cloth to use as manipulatives to complete this worksheet and were able to get through it quickly.

The lesson concluded with our experiment. For the experiment, we made recycled paper. The next part of Connor’s layered story shows his perspective of the experiment.

Connor's Story, Part 4

I thought we were going to make smoothies but Mrs. Benulis said we are going to make paper. I don't know how this is going to happen. We have to rip up paper and put it in the water. This is fun. I bet when it's all done, the paper will be blank white. Ooh, as Mrs. Benulis is mixing it, it looks like a gray tornado. Mrs. Benulis, are you sure this is going to work?

It's all blended now and it looks like baby puke. This is gross. She is putting the mush on a screen and putting the screen between newspaper. It don't look like paper to me. She told us that when it dries it will be paper. I still don't believe it.

Well, I guess she was right. We let the mushy stuff dry for a day and now Mrs. Benulis is peeling it off the screen. It doesn't really look like paper. Wow, she just wrote on it. Now we get to touch it. It feels a little hard but it does feel like paper. I guess she was right. That was cool.

My Story

Connor saw the blender and thought we were making smoothies. That is funny. I do not think I knew what a smoothie was in kindergarten. Anyway, we are making paper today. Connor seems really intrigued by this experiment. He is making predictions and observations as we progress through the experiment. However, he is unsure as to how it will work. Honestly, so am I as I have never done this before. It is a learning process for everyone.

Connor has quite the opinion about what he is observing the mush to look like. His description may not be the most appealing but it proves he is focused.

He is amazed that it actually worked. Sometimes the teacher actually knows what she is doing. I wrote on it to show them that it was actually paper. Connor really seemed to learn quite a bit from this experiment. Sometimes the unexpected does happen. I am beginning to get the impression that the students are beginning to understand what matter is and what can be done with it.

Figure 13. Part 4 of Connor's layered story.

The next two materials we worked with in the matter unit were wood and metal. I began the lesson by having the students walk around the classroom to find things that are made from either wood or metal. I wanted them to realize that, just like paper and cloth, they are surrounded by wood and metal objects. They identified some objects such as the doors, the edge of the whiteboard, my desk, the chair legs, and even the thermostat. Similarly, we looked at a picture that displayed items made from wood and items made from metal. What was most interesting to the children was the pictures of the man cutting the wood with a saw compared to the man cutting the metal with a welding machine. I explained to them that the machine melts the metal so it could be cut.

Since we did such an elaborate experiment for the previous week's lesson on paper and cloth, I wanted to keep this lesson's experiment fairly simple. For our experiment on wood and metal, we used the Touch Box. I put four items in the box: a stapler and paper clip, which were metal, and a pencil and block, which were wooden. The students had to try to guess what the items in the box were as well as what they were made from, wood or metal.

Once all the students had a turn and made their guesses as to the box's contents, we gathered on the carpet. At this point, I revealed the items in the box. The students cheered for themselves whenever I displayed an item they had correctly guessed.

Let's write it up. When the students began to work on their notebook entries for this lesson, I was impressed with the effort put forth by Brad as he completed his entry. To begin with, he not only shared supplies, such as erasers and crayons, with his group members, but also shared ideas as to what to put in their notebooks.

As Brad worked on his entry, I noticed he would occasionally flip back to previous entries in his notebook. Upon further observation, I realized he was checking the spelling on words he used to make sure he spelled them correctly in this entry. I was really impressed that he made this effort and even that he thought enough to do it. During his work time, he wanted to check the name of the Touch Box or the items in it, so he walked up to the box and items to check his work and make sure he included everything. His drawing would be his way to indicate that he had gained something from the lesson and he was making sure he included all aspects of the lesson. The drawings in the notebook are a way for the students to communicate the knowledge they have gained and is a form of "child speech" (Vygotsky, 1978, p. 112). When he began coloring, he opened all his crayon boxes in front of him to make all colors easily accessible.

I was amazed at Brad's management skills, even at such a young age. He was well prepared to do his work and had all necessary tools readily available. When he was unsure of something, he knew where to go to get the needed information. He was organized, which allowed him to produce a notebook entry that included all necessary elements to indicate learning, as can be seen in the figure below.

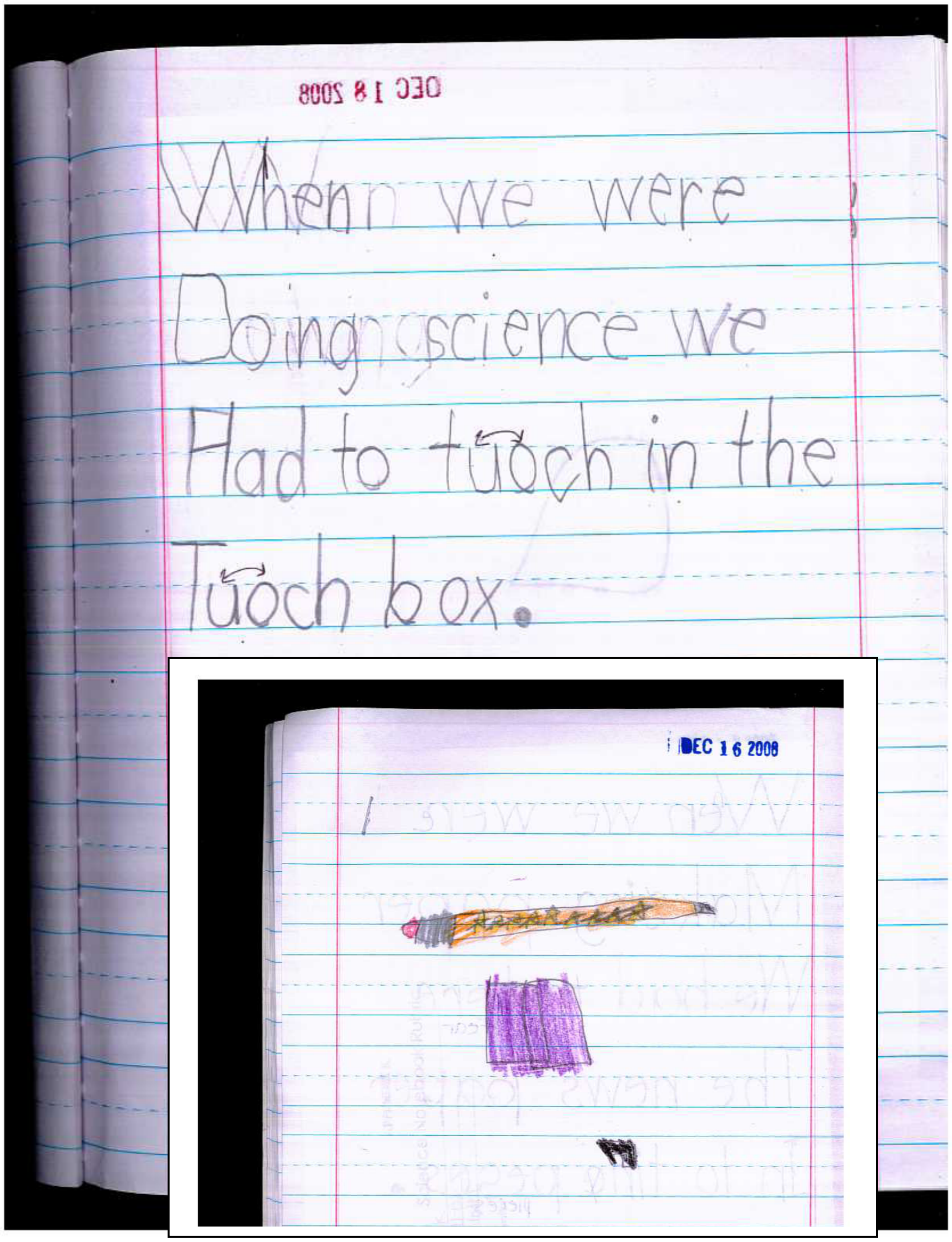


Figure 14. Student notebook sample from wood and metal lesson.

The States of Matter

As the time to end the study neared, I wanted to present a lesson on the three states of matter: liquid, solid, and gas. The best way I knew to do this was to use water. The students had to identify the item in each of three small containers which contained water as one of the states of matter. They did well with this because I briefly explained this concept in our introductory matter lesson.

In order to allow the students to see how matter can move from one state to another, our experiment involved observing an ice cube over the course of a 24 hour time frame. The students observed and made predictions at 10 minute, 20 minute, and one day intervals.

When the class observed the ice cube at both 10 and 20 minutes, they noted that the ice was melting and, as Allie commented, "it's gonna turn to water 'cuz ice cubes are made of water." I asked the students what they thought would happen to the ice cube after one day. Allie predicted that "it's going to be all melted and there's not even gonna be one piece that's hard."

Unfortunately, we were not able to observe the ice at the one day interval because the next day was a snow day which was then followed by the weekend. However, when the students returned to school on Monday they could see that the cup was now empty. I reviewed with them the three states of matter we had discussed the preceding week. We recalled that we had seen the water as solid in the form of ice and liquid when it melted to water. I then explained to the students that the water in the cup had evaporated and turned to gas. I would have liked to conduct the experiment again; however, this was not possible do to the time constraints of the fast approaching Christmas holiday break. Fortunately, this allowed the students to get a better understanding of the three states of matter as the ice had gone through all three stages. It was an unplanned turn of events that taught the children more than they would have learned had the lesson gone according to the original plan.

The Heart of the Matter: What It All Means

After three weeks of hands-on activities and experiments, the final lesson of the matter unit was upon us. I could only hope that I had done enough to explain to the class what matter is and answer their only inquiry.

We began the lesson by completing the KWL chart. The students had more to share about what they learned than they had when we started the chart 3 weeks ago. The following pastiche displays some of the things the class learned during the matter unit.

We Learned About Matter

You could build stuff with it.

WE KNOW HOW TO CUT WOOD.

We know how to cut metal.

We learned how to fold paper.

We know how to make paper.

WE LEARNED HOW TO RIP AND CUT PAPER.

We learned that if something breaks up put it back together again.

We learned how ice melts.

We learned that water goes up to the clouds, it falls & turns to rain and if it's cold it turns to snow.

Figure 15. Pastiche showing what the students learned during the matter unit.

Next, the class had to complete their assessment on matter. As I began passing out the assessment sheets, Connor said, "I know what we're gonna do."

Connor's Story: Part 5

I know Mrs. Benulis is passing out our test. I'm a little nervous about it. We learned a lot of things but I don't know if I know it. I hope I do good. Oh, this first one is easy, it's solid. Hey, this is all easy. But why is she calling us up? What!! I don't know what types of matter there are. Does she mean like liquid and gas or does she mean the things we played with? I'm not too sure about this part. I hope I did good.

My Story

Connor is obviously paying attention. He is aware that it is test time. He seems a little unsure, but he is doing fine. Who would have thought that test anxiety could begin to set in as early as kindergarten? He did well throughout the unit so I am sure he will do well on his assessment. But I want to add another part to the test. We worked with several types of matter and I want to assess the students on this. As I ask Connor to name three types of matter he is not very quick to answer. It seems that he is getting the types of matter and the states of matter a bit confused. I will have to quickly review the difference. Overall, he did very well. He got the entire first part correct. He did only name one type of matter when I asked for three, but at least his mind was on the topic of matter. Connor has really come along way. Not that he never performed well, but he has really shown an interest in science and a display of the knowledge gained in every unit.

Figure 16. Part 4 of Connor's layered story.

As the rest of the students completed the matter assessment, they seemed to perform in much the same manner as Connor. They did very well identifying what the different items were made from or what stage of matter was pictured on the paper-and-pencil part of the assessment; however, when I asked them to name three types of matter that we learned, they got confused between types of matter and stages of matter. Overall, they did not do as well as the previous two assessments, but they did still do well. They following graph displays the results of their final unit assessment.

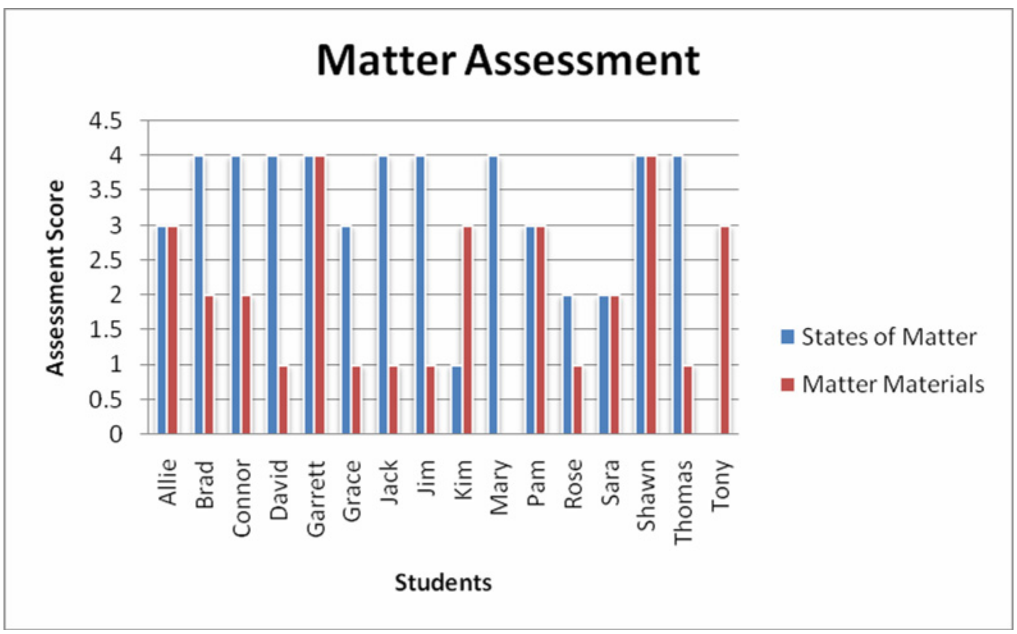
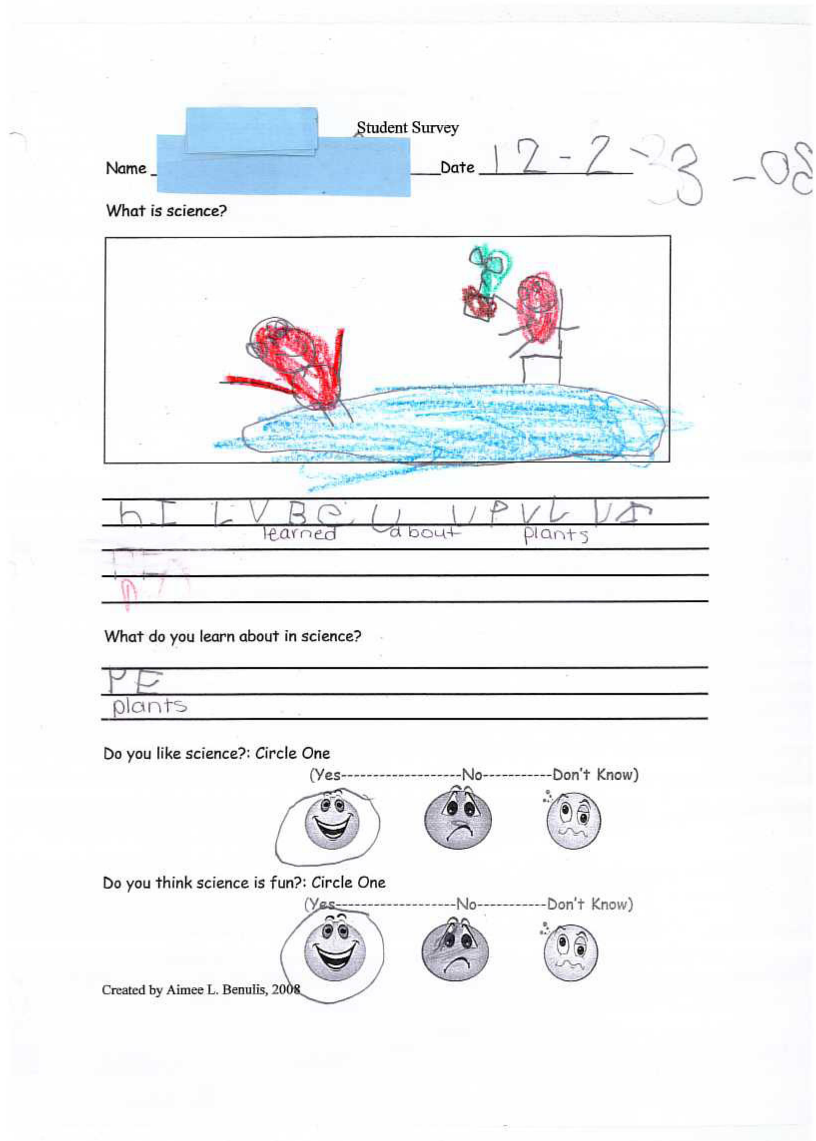


Figure 17. Matter Assessment results.

Our Final Thoughts

"The more active an attitude men and women take in regard to the exploration of their thematics, the more they deepen their critical awareness of reality and, in spelling out those thematics, take possession of that reality" (Freire, 2003, p. 106).

Before concluding the unit, the students completed the post-survey. The survey was identical to that which they completed at the start of the study. I was curious to see if and how their thoughts and attitudes towards science had changed since the study began over 3 months ago. The following figure is a sample post-survey entry. The student who completed the pre-survey in Figure 1 also completed this post-survey.



Student Survey

Name ________ Date 12-23-08

What is science?

learned about plants

What do you learn about in science?

PE

plants

Do you like science?: Circle One

(Yes-------------------No-----------Don't Know)

Do you think science is fun?: Circle One

(Yes-------------------No-----------Don't Know)

Created by Aimee L. Benulis, 2008

Figure 18. Post-survey student work sample.

Based on comparison from Figure 1 to Figure 16, the students now had a better understanding of what science is and what is learned in science. The attitudes of the students also changed, which is seen in Table 2.

Table 2

Student Post-Survey

Do You Like Science?	**Yes**	**No**	**Don’t Know**
	12	1	3
Do You Think Science Is Fun?	**Yes**	**No**	**Don’t Know**
	13	0	3

The students’ comments regarding science had changed since the study began back in September. Based on their comments from the post-survey, the students thoughts were more related to science concepts. The following pastiche displays the responses from the students on the post-survey.

What is Science, Part II?

I learned about plants

Writing

Volcano

Plants

Moving

Celery

We learn about mixing stuff

Doing fun experiments

Celery experiment

Making paper

Two flowers growing

Ice melts into the water, it goes into the clouds

Experiments

FLOWER GROWING FROM A SEED

Putting a penny in vinegar, pull it out and its clean

Rocket science

Figure 19. Pastiche showing student responses from post-survey.

As we finished this study, I asked the students "What is Science?" Here is what they said.

"You learn about stuff."

"Science is a kind of thing with stuff and you could get seeds and put them in water for one day and cut it open and look inside with a magnifying glass."

"We taste, hear, smell, feel, look."

"We work about experiments."

"We made paper, we made our own plants. I like making paper."

"It's cool because we get to do fun stuff like making experiments."

"It's something you can do like experiments and making stuff."

"I like to do it because it's fun."

"When we're doing science, we are learning a lot."

"I like everything about science."

Figure 20. Student comments.

The students expressed what they learned about science and their feelings about science. They all said they liked science and shared things they learned, which is evidence that they gained knowledge during the study. I was very pleased with how receptive the students were to science and how much they have grown since I began this study in September.

This is a journey the students and I will not soon forget.

DATA ANALYSIS

In order to determine the results of my study, I had to analyze the data I had collected during the four months I conducted my inquiry study. According to Wolcott, analysis "follows the standard procedures for observing, measuring, and communicating with others about the nature of what is 'there,' the reality of the everyday world as we experience it. Data subjected to analysis are examined and reported through procedures generally understood and accepted in that everyday world, among social as well as not-so-social scientists" (2009, p. 29). As I analyzed the data, I looked at each element out of the flow of sequence to examine it more closely (Ely, Vinz, Downing, & Anzul, 1997). By examining each piece of data, I could see how it fit into the puzzle of my story and how I could best present it to tell my story.

As I analyzed data I collected, I used a variety of approaches. The largest piece of data I used was my field log. As I progressed through the study, I began coding my field log. This process continued throughout the study as I often went back to re-code or find similar codes at various points in the log. As I went through the coding process, I tried to make interpretations from the data I collected. As Ely, Vinz, Downing, and Anzul point out, "interpretation means drawing meanings from the analyzed data and attempting to see these in some larger context. Interpretations arise when patterns, themes, and issues are discerned in the data and when these findings are seen in relation to one another and against larger theoretical perspectives" (1997, p. 160). I looked for similar themes and patterns that began to emerge in my study. I looked at these themes to determine the findings of my study.

While working on my field log, I also completed reflective memos. As I conducted my study, I read the work of four educational philosophers: Dewey (1997), Freire (1970), Delpit (2002), and Vygotsky (1978). As I read each philosopher, I found key phrases, quotes, and theories that were related to my study. I used the theories I gained from these philosophers to look at my data through their eyes in order to see my data from a different perspective. It allowed me to make philosophical connections to the daily events of my classroom.

At the mid-point of my study, I completed a methodological memo to determine what I had accomplished and what I hoped to accomplish as I completed it. Through this memo, I could see what data sources I already used and what other sources I needed to use to get a well-rounded look at what was occurring in my classroom. In addition to looking at my research question, I was able to see sub-questions that were beginning to emerge and needed to be answered.

I also obtained data from the students. This included worksheets, assessments, and notebook entries. I analyzed student notebook entries using a rubric (see Appendix M). The rubric looked at how well the picture and write-up explained the lesson and the activity as well as the students understanding of the science content.

Furthermore, I interviewed the students to determine their thoughts on science, what they liked and did not like about it, and their favorite experiment and activity (see Appendix M). This information was further obtained through a pre- and post-study survey completed by the students (see Appendix E). The surveys enabled me to see if and how their thoughts and perceptions changed over the course of the study. This survey was a comparison from week 1 to week 12 on the students' thoughts about science.

Based on student comments, observations of students, and students' thoughts and ideas pertaining to science and inquiry activities, I created pastiches, layered stories, and skits. I used these to depict the students' feelings and reactions throughout the study. I also created graphs to display the attitudes towards science as well to show the results of the assessments they took on each science unit.

As I examined all the data I had collected, I also triangulated the data to increase the validity of my study. I triangulated by looking at the data through multiple perspectives: observations, interviews and surveys, and student work. I looked for patterns in each of these areas and compared the patterns that emerged in each area to find similar themes throughout the study.

As I coded my field log, I created bins to show similar patterns and themes that emerged in my study. The following graphic organizer displays the patterns that were present in my field log. The theme statements summarized these bins to indicate the findings of my study.

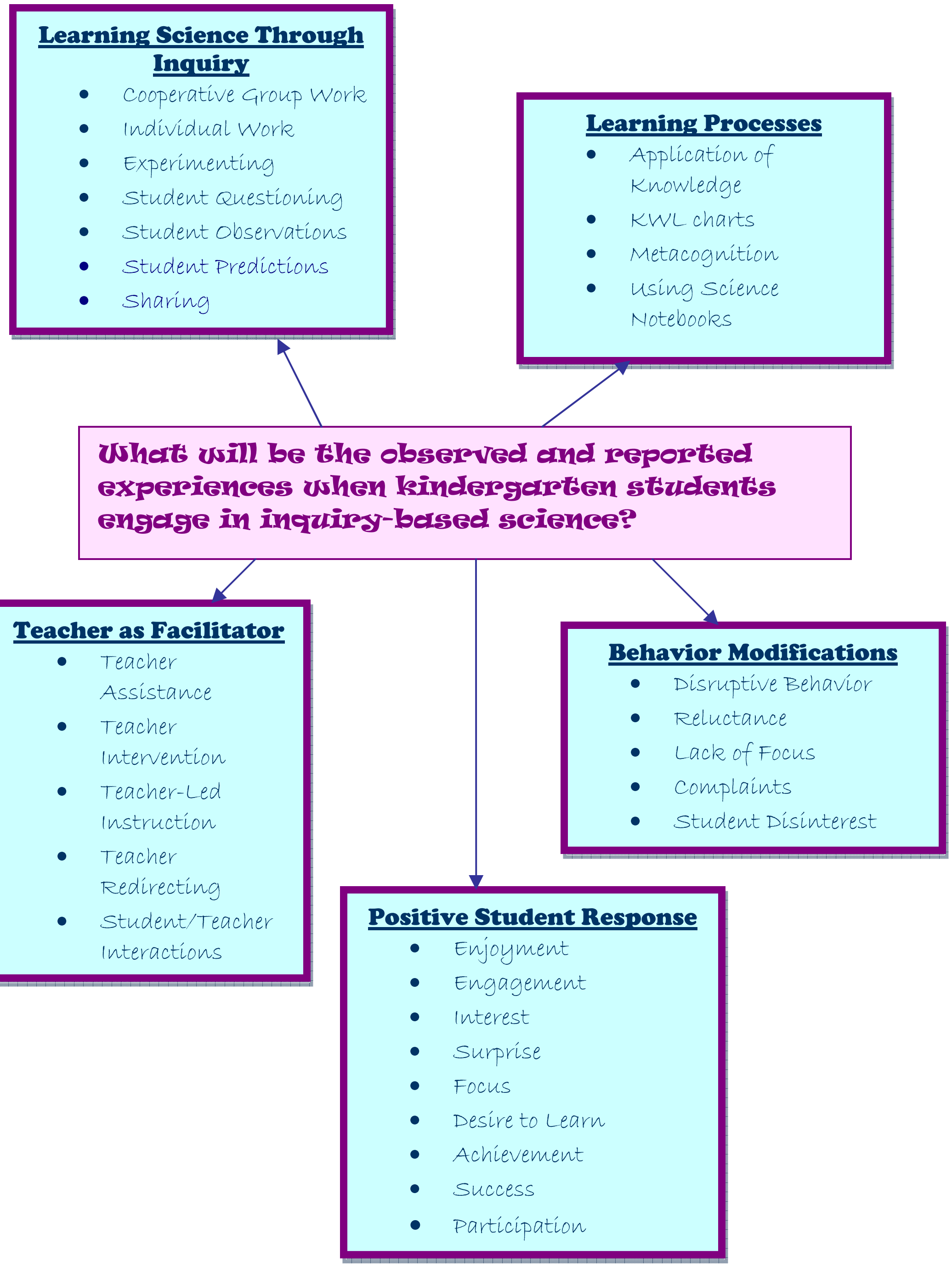


Figure 21. Themes and Bins.

Theme Statements

* As the kindergarten students *learned science through inquiry*, they were working with groups and individually, making observations, questioning, predicting, experimenting, and sharing, as they learned science in an authentic manner.
* The students used a variety of *learning processes* as they developed an understanding of multiple science concepts. They were able to apply the knowledge they gained through science notebooks, KWL charts, and metacognitive thinking processes.
* Through the process of learning science via inquiry, the *teacher* removed herself as instructor and functioned *as facilitator* who guided the students' learning processes and redirected students into participating.
* Through inquiry-based science activities, the students were more actively engaged and focused on their learning and displayed a *positive response* to learning science.
* *Behavior modifications* were required as students displayed disruptive behavior, reluctance, and lack of focus; however, the students were easily refocused to the task at hand.

FINDINGS

My goal of this study was to observe and report experiences when inquiry learning and hands-on activities were incorporated into science instruction. My findings from this study focused on learning science through inquiry, learning processes, teacher as facilitator, positive student responses, and behavior modifications.

Learning Science Through Inquiry: **As the kindergarten students learned science through inquiry, they were working with groups and individually, making observations, questioning, predicting, experimenting, and sharing, as they learned science in an authentic manner.**

Throughout the course of my study, I focused on developing lessons and experiments based on the inquiry of my students. I set out to get them involved in their learning to understand science concepts in an authentic way.

Hinrichsen and Jarrett describe inquiry learning as a method that "transforms science learning from watching and listening to doing" (1999, p. 6). I found this statement to describe my classroom. Everyone was involved in science learning. The students were engaged and actively participating in each activity and experiment. They asked questions and were excited to get answers, as is depicted in part 2 of Connor's story (Figure 6). As part of each lesson, the students were required to make predictions about the outcomes of experiments and make observations during the course of the experiments. Furthermore, their questioning lead to the development of the experiments because the focus of inquiry learning "is on the active search for knowledge or understanding to satisfy a curiosity" (Haury, 1993, p. 2).

As part of each lesson, the students completed activities both individually and with cooperative inquiry groups. "Pupils, through individual and small group work, should be encouraged to speculate freely on the nature of objects and phenomena" (Hunn, et al., 1998, p. 8). As the students took part in inquiry lessons and activities, they did question things around them to develop a stronger understanding of these science topics. The students completed worksheets, assessments, and their notebook entries individually; however, many activities and experiments were done in cooperative groups.

"Cooperative learning is a pedagogical technique that involves students working in small groups to accomplish shared learning goals and to maximize their own and each other's learning" (Johnson, Johnson, & Smith, 1998, p. 24). The students worked together to conduct experiments and complete activities. They would help each other along the way so that everyone was involved and everyone was learning. In the beginning, the cooperative inquiry groups struggled with how to work together (Figure 6). Eventually, the students learned how to work together and help each other during inquiry activities, as they completed notebook entries, and during experiments. "Good inquiry-based science teaching provides powerful literacy-learning experiences through small-group interactions"

(Pine & Aschbacher, 2006, p. 313). As a result of the cooperative inquiry groups, the students not only learned the science concepts, but also the value of teamwork.

A key component of inquiry learning is experimentation. These experiments were designed to answer the students' own questions. Because the students were taking part in experiments, they were actively involved in their own learning. In addition, they were better able to understand the science concepts as they proceeded through the experimentation process. The experiments were a way for the students to answer their inquiries. They were interacting with their learning to develop an understanding of science concepts. Furthermore, they were learning more about the topics in science that interested them and that they wanted to know more about.

I have found that the students are better able to understand science concepts when they are take part in inquiry-based lessons. Through experimentation, questioning, and hands-on activities, which are all pieces of inquiry-based lessons, the students were able to "develop a better understanding and appreciation of both the history and nature of science" (Thompson, 2007, p. 32). "That is, if students are taught science in the context of inquiry, they will know *what* they know, *how* they know it, and *why* they believe it" (Ruiz-Primo & Furtak, 2006, p. 206).

Inquiry learning required the students to ask science questions, conduct experiments to answer these questions, and share their findings with others. I found that as the students moved through these steps each week, they were able to make more predictions and observations and, as a result, developed a better understanding of the science topics. Based on the results of the assessments in each unit, the students finished the unit with a solid understanding of the topics presented (Figures 5, 10, and 15). They have built a solid foundation for future science education.

Learning Processes: **The students used a variety of learning processes as they developed an understanding of multiple science concepts. They were able to apply the knowledge they gained through science notebooks, KWL charts, and metacognitive thinking processes.**

As the kindergarten students progressed through the science units, they used multiple learning processes to learn the science content. With each learning tool that was used, the class was able to display the knowledge they gained.

A KWL chart, which is designed to show the students' background knowledge, what they want to learn, and what they did learn, was completed for each unit. As the students shared their previous knowledge on a topic, they expressed basic understandings. However, their questions for each unit were quite varied. The students had quite a few inquiries for the topics of plants and the five senses. As we began the matter unit, the students had one inquiry because of their limited background knowledge of this science topic.

The students became passionate about their inquiries and were eager to have them answered. Connor's story displays his excitement to have his inquiry answered (Figure 6). Throughout the plant unit, he stated that he was "dying to know" how a plant comes out of a seed. When we finally completed the experiment to answer his inquiry, he was focused, inquisitive, and interested in the results.

At the completion of each unit, the students were able to recall the knowledge they gained as we progressed through the lessons. They applied the knowledge they acquired to complete their KWL charts. Likewise, they recalled experiments and activities and what was learned in each one pertaining to the lesson topic. Pastiches show what the students learned in the units on plants and matter (Figures 4 and 13).

"There should be brief intervals of time for quiet reflection provided for even the young. But they are periods of genuine reflection only when they follow after time of more overt action and are used to organize what has been gained in periods of activity in which the hands and other parts of the body beside the brain are used" (Dewey, 1997, p. 63). The students in my class used their science notebooks for this period of reflection on what they learned. These notebooks were a compilation of observations, experiments, and experiences related to the science instruction the students received each week (Ruiz-Primo, et al., 2002). The science notebooks were a way for the students to communicate with others "about their investigations, findings, and conclusions" (Reid-Griffin, et al., 2005, p. 4). While the KWL charts allowed the students to share what they learned during the entire unit, the notebooks allowed each student to share what they learned in each lesson and experiment. Connor was able to record his observations in his notebook and share with others what he learned (Figure 7).

The science notebook kept the students engaged in their learning. It required them to metacognitively think about what was done in each lesson and what they observed during the experiments. The science notebook was a weekly tool in which the students had to apply what they learned. When the students used the science notebooks, they were more focused on the lesson so they could record their observations (Klentschy & Molina-De La Torre, 2004). In addition, "science notebooks give learners opportunities to engage in inquiry based experiences and to develop higher order thinking skills" (Reid-Griffin, et al., 2005, p. 4).

The use of learning tools, such as the KWL charts, and science notebooks, were ways to keep the students focused and engaged as they were able to metacognitively think about what they learned and the purpose of each experiment. Furthermore, they applied the knowledge gained in the KWL chart and science notebook to share with others what they learned in each science lesson.

Teacher as Facilitator: **Through the process of learning science via inquiry, the teacher removed herself as instructor and functioned as facilitator who guided the students' learning processes and redirected students into participating.**

The teacher is the most important component to any educational setting. In an inquiry-based science classroom, the teacher no longer serves as instructor, but rather as facilitator. Inquiry learning allowed the students to take control of their learning while the teacher served as a guide to the students' learning (Hinrichsen & Jarrett, 1999). As Hapgood, et al., state, the teacher supported the students' learning and motivated them as they conducted experiments to answer their inquiries (2004).

Teacher-led instruction was a part of each inquiry lesson. In order to explain or define the science topic being taught, the lesson had to have some element of direct instruction. However, this portion of the lesson was minimal. The students would lose focus when the direct instruction was too long because they were not interacting with the lesson. Nonetheless, this was a necessary part of each lesson to ensure the students understood each science topic.

Even though teacher-led instruction was an essential part of each lesson, the greater portion of the lesson was student-centered. Despite the fact that the lessons were student-centered, I was still an integral part of the learning. I assisted the students with lessons and experiments to guide their inquiry learning. For instance, I intervened when a group was not successful with an activity. I needed to intervene and get the group back on track. The intervention also occurred during discussion, as seen in And So It Grows. I had to redirect their thoughts to help them identify the elements a plant needs to survive. With my assistance, the class was successful in this part of the lesson and gave them the knowledge they needed to continue with the experiment.

Each lesson also included an element of student-teacher interaction. “Teacher talk and student talk are essential components that determine the quality of learning in the classroom” (Delpit & Dowdy, 2002, p. 147). When the class had the opportunity to interact and discuss science topics, they were able to get a better understanding of the science topics that were addressed. Also, through this student-teacher interaction, both parties are responsible for the learning that occurred and worked together to develop methods for understanding (Hinrichsen & Jarrett, 1999).

The student-teacher interaction not only benefited the students, but the teacher as well. As a result of the dialogue that took place, “the teacher is no longer merely the-one-who-teaches, but who is himself taught in dialogue with the students, who in turn while being taught also teaches” (Freire, 2003, p. 80). I was able to learn what the students knew about each topic and what they wanted to know. I was also able to look at each experiment’s results through their eyes as they shared their observations. Based on their inquiries, I also learned new things about the science topics, just as I learned what a plant looks like in a seed (Figure 6).

On the negative side, I did need to redirect students who had lost focus or were causing disruptive behavior. These occurrences were minimal and, through my redirection, the students were able to refocus on the lessons and experiments.

As a result of the patterns that emerged, I found that the students were able to control their learning if the teacher facilitated them with the tools and knowledge they needed to learn. There were points in each lesson when I had to be instructor or needed to intervene and redirect the students. Throughout the course of each unit, I assisted and guided the students as they answered their science inquiries. I have found that when the teacher serves as facilitator, the students performed better (Figures 5, 10, and 15). They were able to progress through their inquiry lessons, answer their questions, and develop a solid foundation in science education with the guidance of the teacher.

Positive Student Response: **Through inquiry-based science activities, the students were more actively engaged and focused on their learning and displayed a positive response to learning.**

As I have noted already, the students were focused and engaged when they were involved in inquiry lessons. The students were involved in the lessons and thus involved in their learning. Because the students were engaged in their science learning, they were more easily able to master the subjects they were learning about each week (Bybee & Van Scotter, 2006/2007).

As a result of the inquiry lessons, the students had a desire to learn and experiment each week. Connor was “dying to get an answer to his question,” and many times on science day, the students would ask repeatedly what we were doing in science (Figure 6). They expressed an interest in science because they were asking questions, showing a desire to learn more about each topic.

The hands-on activities kept the students focused on the lessons. Because they were actively involved, they had little time to cause a disruption or lose focus on the lesson. As Sivertsen noted, “teaching with hands-on activities is demanding but everyone is involved, eager, and active, and participants remember what they have done” (1993, p. 6). I found that the students were really interested in each experiment and were surprised at what they observed. In the example of the sense of sight activity, the students expressed enjoyment at watching each other walking around the classroom “blind.”

The students displayed success in each science unit (Figures 5, 10, and 15). The majority of the class received high scores in all areas of each assessment, which displayed an understanding of the science content by the students. Also, the pastiches on the plant and matter units are evidence of what the students learned in each of those units (Figures 4 and 13).

In looking at the post-survey, the students learned a great deal about science (Table 2 and Figure 18). The majority of the students responded that they liked science and they thought science was fun.

I found that, as a result of the inquiry lessons, the students were "learning science, actively engaged in science, and having fun doing science" (Radford & Ramsey, 1996). They were eager to learn and looked forward to science. They expressed a desire to learn and were successful in the activities they participated in for each lesson. They remained focused when actively engaged and enjoyed the activities and experiments. Overall, as a result of their positive student response, they were able to learn the science content in an enjoyable and interactive manner.

Behavior Modifications: **Behavior modifications were required as students displayed disruptive behavior, reluctance, and lack of focus; however, the students were easily refocused to the task at hand.**

While this study proved successful because the students came to understand the science concepts through the inquiry lessons, it is not to say it went without any problems. While the students were engaged in the lessons and experiments, there were occasions that disruptive behavior or student disinterest occurred.

One problem that was present during teacher-led instruction or discussion was lack of focus. Rose was one student who would often lose focus during the lesson. Many times she was not following my directions and was "fading into

[her] fantasies" (Delpit & Dowdy, 2002, p. 155). Instead of working with her group, she was playing and talking (Figure 3). I often found myself having to redirect her back to the lesson. When I did redirect her, she was then able to focus on the lesson and participated in the discussions. I would continually reach out to her, and all the students, to insure that they did learn something.

Another occurrence of disruptive behavior was Allie's behavior during the sense of sight activity. She purposely bumped into tables and desks as a way to do "anything for attention" (Delpit & Dowdy, 2002, p. 6). While it was fun and entertaining and did serve to show the importance of our eyes, the entire class needed to be redirected to the lesson at the conclusion of the activity. Nonetheless, her disruptive behavior did help to teach the objective of the lesson.

Other issues that occurred were student reluctance and disinterest. While these incidents were rare and only limited to a small number of students, they were still issues that needed to be addressed. Likewise, the complaints expressed by the students were minor and easily corrected. The complaints expressed were that another student gave them the answer to a question during discussion, they got their paper last, or they could not see the picture or item on display. Even though these complaints are not necessarily a factor of the study, they did cause a disruption to the flow of the lesson. These disruptions distracted students, causing them to lose focus or cause further disruptions with their behavior.

The unacceptable student behavior primarily occurred when the students were not actively involved in the lesson. Based on this pattern, I found that it is important to keep the students involved throughout the entire lesson or as much as possible. This helps to prove that the hands-on activities were a source of learning for the students. During this time, the students were actively learning, focused on the lesson, and participated in discussion. I found that the more involved the students were, the more focused on the lesson they were as well. Likewise, if they were focused, they were going to gain more from the lesson and were able to develop a better understanding of the science concepts.

WHERE DO WE GO FROM HERE?

After the positive effects of teaching science using an inquiry-based approach, I know that this is a method that I will continue to use to teach science. Inquiry-based science motivates the students to want to learn because they are actively engaged in their learning. In addition, I look forward to teaching science and answering their questions. Furthermore, the science notebook was a valuable learning tool for the students to reflect on their learning.

I would like to continue presenting the science concepts in much the same format; however, this is a time consuming approach. So, to ensure adequate time for the students to experiment and record observations in their science notebooks, I need to present the lesson in a shorter time period.

As we continue to use science notebooks, I want the students to more fully explain what they learned in the lesson through their pictures and writing. The science notebook is a way for the students to communicate with others “their investigations, findings, and conclusions” (Reid-Griffin, et al., 2005, p. 4) so it is important that the students know how to present their findings and observations in a more comprehensive manner. This may require more modeling on my part as well as more time to review what was learned before the students begin their notebook entries. I may consider approaching the notebooks as Nesbit, et al., did where the notebook entries are done as whole class until the students have a clear understanding of how to complete them. Then, the whole class entry would eventually be replaced with the students recording their entries individually (2004). Ultimately, the students would know what is expected of them and be able to clearly explain each week's observations and findings.

The goal of my lessons is to answer the students' inquiries; therefore, I will make sure that I have a variety of lessons for each unit. I feel that the activities and experiments I used for this study allowed the students' inquiries to be answered; however, future classes may have different questions. While an experiment may be useful to answer questions year after year, not all experiments will serve this purpose. Thus, I am open to finding new experiments and activities to answer future inquiries that may arise. In addition, I want to try to develop activities for all lessons that require each student or group to experiment on their own as opposed to whole class activities and experiments.

Even though my study is over, the students will continue to explore scientific concepts using the same inquiry-based approach. They will also continue to share their findings in their science notebooks. The students enjoy being able to conduct experiments, make predictions and observations, and complete their notebook entries to share what they did and learned in each lesson. I truly believe that they are better able to understand science concepts in this manner. My students have developed a solid foundation in science that they can build on as they continue through school.

THE END OF THE ROAD

As I look back on this journey, I realized that it was well worth all the work, time, and effort. The students and I have both grown a great deal as a result of it. Not only have I come to enjoy teaching science, but I have come to appreciate the value of science education as well.

As we began science at the start of this school year, no one really knew what to expect. The students had no prior knowledge on what science was and I had no idea what would be the result of inquiry-based science lessons. However, I think the results speak for themselves. The students have gained a considerable wealth of knowledge in the science topics that were covered in each unit as well as in terms of science in general.

The students were successful in science and I have come to enjoy the subject of science. Now, the students look forward to our weekly science lessons and I am always trying to find interactive experiments and activities to include the students in their learning.

While I was apprehensive when I began this journey, I do not regret having taken it. I have learned a lot about science and research and know my students have also learned a lot during this process.

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APPENDIX A

MORAVIAN COLLEGE

August 18, 2008

Aimee Benulis
[redacted]

Dear Aimee Benulis:

The Moravian College Human Subjects Internal Review Board has accepted your proposal: "The Effects of Inquiry Science Activities in Kindergarten." 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 ([redacted]) or through e-mail ([redacted]) should you have any questions about the committee's requests.

[redacted]
Chair, Human Subjects Internal Review Board
Moravian College
[redacted]

APPENDIX B

MORAVIAN COLLEGE
A SMALL NATIONAL TREASURE
1742

Department of Education
1200 Main Street
Bethlehem, Pennsylvania 18018-6650
TEL 610 861-1558
FAX 610 861-1696
WEB www.moravian.edu

Dear [redacted]:

I am completing a Master of Education degree at Moravian College. My courses have enabled me to learn about the most effective teaching methods. One of the requirements of the program is that I conduct a systematic study of my own teaching practices. This semester, I am focusing my research on Science inquiry. The title of my research is *The Effects of Inquiry Science Activities in Kindergarten.* My students will benefit from participating in this study because they will develop a stronger understanding of scientific concepts through the use of hands-on activities.

As part of this study, students will be asked to participate in hands-on, inquiry-based activities and lessons related to Science topics. They will complete surveys, write up weekly lesson descriptions and observations in science notebooks, and complete formal assessments at the conclusion of each unit. There are no anticipated risks involved in this study. The study will take place from September 1, 2008 to December 24, 2008.

The data will be collected and coded, and held in the strictest confidence. No one except me will have access to the data. My research results will be presented using pseudonyms – no one's identity will be used. I will store the data in a locked cabinet. At the conclusion of the research, the data will be destroyed.

A student may choose at any time not to participate in this study. However, students must participate in all regular class activities. All students will be participating in science lessons, activities, and completing notebook entries. In no way will participation, non-participation, or withdrawal during this study have any influence on any aspect of the class.

I thank you for granting me approval to conduct this study. Any questions you have about the research or about the process for withdrawing can be directed to me, Aimee L. Benulis, [redacted], [redacted], or my advisor, [redacted], Education Department, Moravian College, [redacted] Any questions about the rights of research participants may be directed to [redacted]s, Chair HSIRB, Moravian College, Bethlehem, PA 18018, [redacted].

Sincerely,

Aimee L. Benulis

Aimee L. Benulis

I am the school principal and I understand the research project that will be conducted by Aimee L. Benulis. She has my permission to conduct her study as described. I have read and understand the consent form and received a copy.

[redacted] 9-10-08

Principal's Signature Date

APPENDIX C

MORAVIAN COLLEGE
A SMALL NATIONAL TREASURE
1742

Department of Education
1200 Main Street
Bethlehem, Pennsylvania 18018-6650

TEL 610 861-1558
FAX 610 861-1696
WEB www.moravian.edu

Dear Parent/Guardian:

I am completing a Master of Education degree at Moravian College. My courses have enabled me to learn about the most effective teaching methods. One of the requirements of the program is that I conduct a systematic study of my own teaching practices. This semester, I am focusing my research on Science inquiry. The title of my research is *The Effects of Inquiry Science Activities in Kindergarten.* My students will benefit from participating in this study because they will develop a stronger understanding of scientific concepts through the use of hands-on activities.

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A student may choose at any time not to participate in this study. However, students must participate in all regular class activities. All students will be participating in science lessons, activities, and completing notebook entries. In no way will participation, non-participation, or withdrawal during this study have any influence on any aspect of the class.

We welcome questions about this research at any time. Your child's participation in this study is voluntary; refusal to participate will involve no penalty or consequence. Any questions you have about the research or about the process for withdrawing can be directed to me, Aimee L. Benulis, [redacted], [redacted] principal, or my advisor, [redacted], Education Department, Moravian College, [redacted], [redacted] Any questions about your rights as a research participant may be directed to [redacted], Chair HSIRB, Moravian College, Bethlehem, PA 18018, [redacted]. Also, if a student experiences any distress as a result of this study, the student/parent can contact [redacted], principal, or [redacted] school psychologist, [redacted], [redacted], or the school nurse, [redacted], [redacted]

Sincerely,

Aimee L. Benulis

Aimee L. Benulis

APPENDIX D

KWL Chart

Topic: ___________________________

K	W	L
What We Know	What We Want To Know	What We Learned

Created by Aimee L. Benulis, 2008

APPENDIX E

Student Survey

Name ______________________________________Date ____________________

What is science?

What do you learn about in science?

Do you like science?: Circle One

(Yes------------------No-----------Don't Know)

Do you think science is fun?: Circle One

(Yes------------------No-----------Don't Know)

Created by Aimee L. Benulis, 2008

APPENDIX F

KWL Chart

Topic: Plants

K
What We Know

They grow.
After plant seed, grow big, beautiful flowers.
They have roots.
They have leaves.
They have flowers.
They grow by the root.
They grow big.
They have stems.
Seeds.
They grow nice & big.
They're big.
They grow leaves on the side of the stem.
Plant them, feed them water, sometimes food.
They need the rain.
They have soil.
The have petals.

W
What We Want To Know

About flowers?
About plants?
How do just little seeds with only rain & sunshine grow?
How does rain make the flower grow?
How do they drink water really slow?
Grow?
How can petals fall off the plant?
How do flowers & seeds come out?
How do they grow seeds & split open & make little roots?
I want to learn all about it.

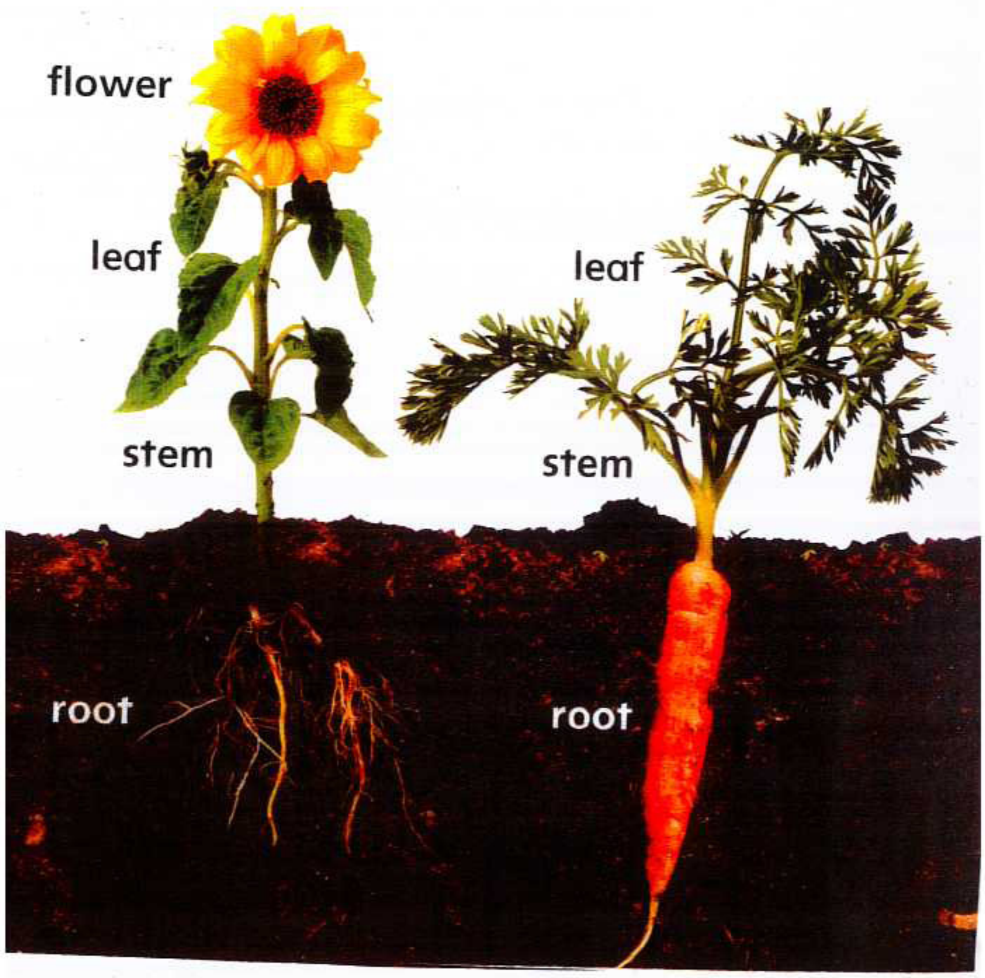
L
What We Learned

They drink water up like a straw.
They need air.
Water goes in the roots.
They have seeds.
The are in the dirt.
They grow-when you put seeds in & give it water it grows.
The need sun & have roots.
They need water (rain).
The need soil/dirt.
They grow from seeds.
They have a stem so the flower can stay straight.
The leaves catch the rain & help make food.
They grow flower petals.
Lose leaves by not getting rain; they turn brown.
The wind blows the leaves off.
Someone picks off leaves.
Seeds grow more flowers.

Created by Aimee L. Benulis, 2008

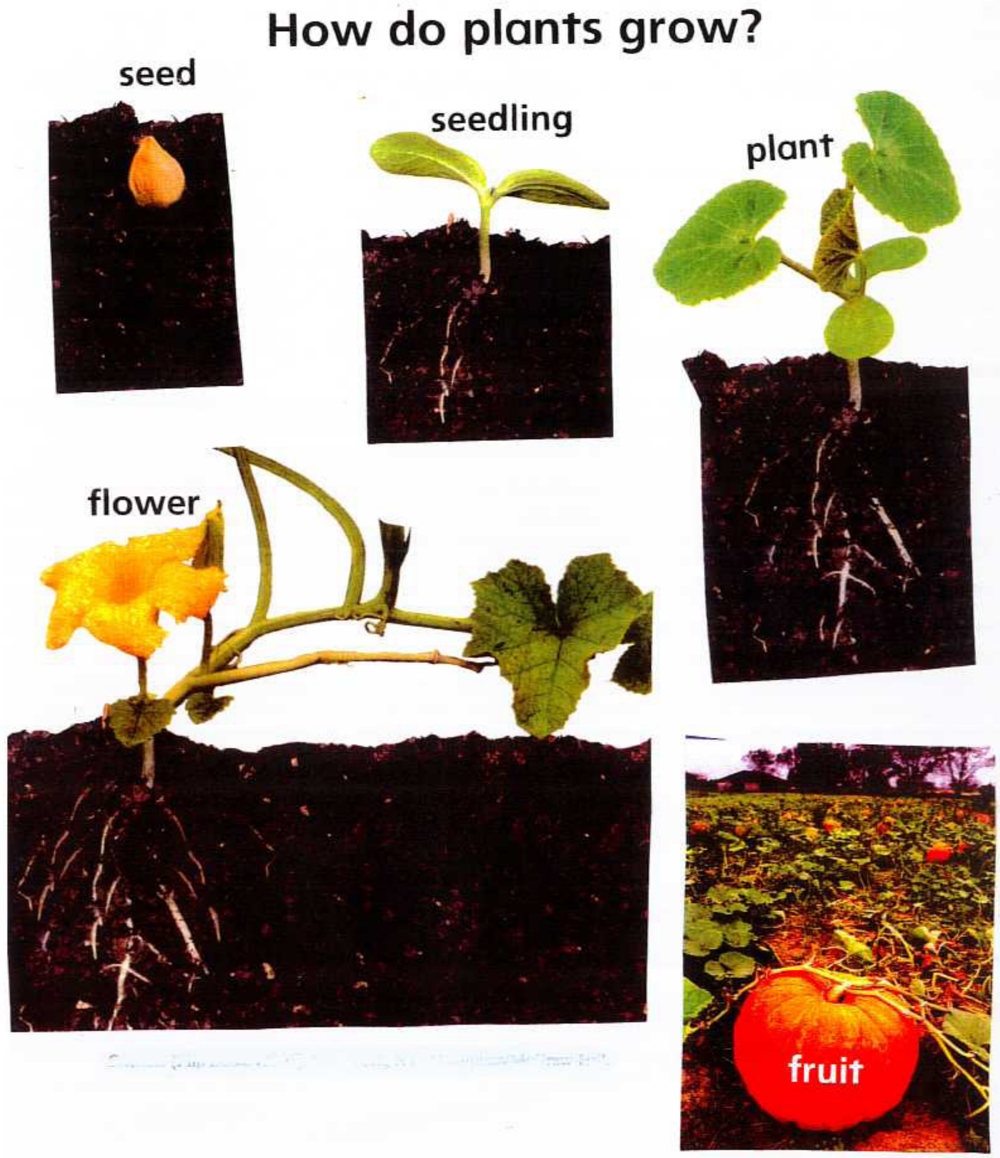
APPENDIX G

What are the parts of plants?



APPENDIX H

APPENDIX I



APPENDIX J

Name____

Seed in the Bag Experiment

Week 1	Week 2
Week 3	Week 4
Week 5	Week 6
Week 7	Week 8
Week 9	Week 10

Created by Aimee L. Benulis & Makayla E. Boyle, 2008

APPENDIX K

Plant Assessment Rubric

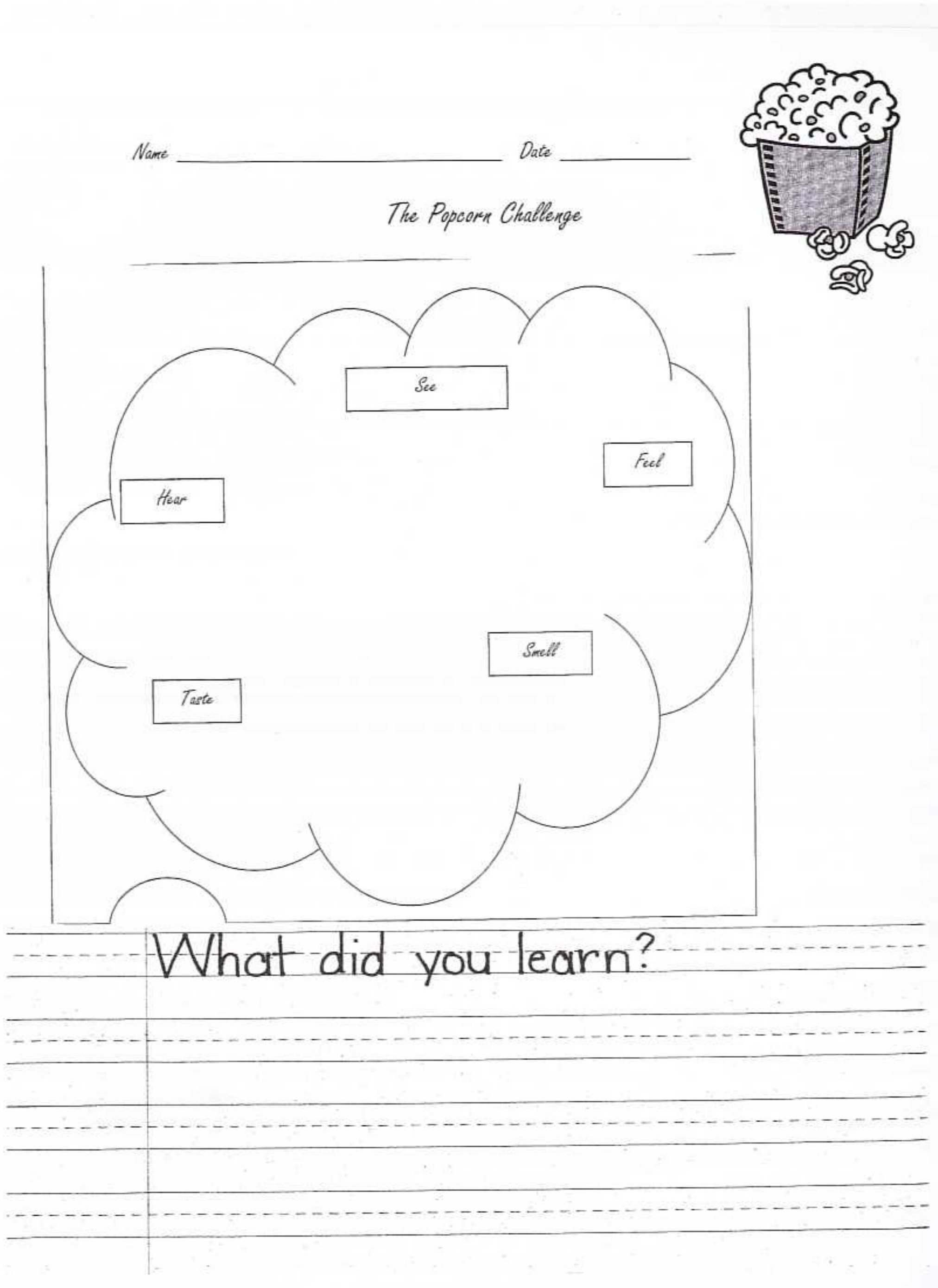
Name ____ Date___________________________

Plant Parts: roots, stem, leaf, flower
Things Needed to Survive: water, sunlight, air, soil

4	Student identified all four parts of a plant	Student knows all four things a plant needs to survive
3	Student identified three parts of a plant	Student knows three things a plant needs to survive
2	Student identified two parts of a plant	Student knows two things a plant needs to survive
1	Student identified one part of a plant	Student knows one thing a plant needs to survive

Created by Aimee L. Benulis, 2008

APPENDIX L


Name
Date
The Popcorn Challenge
See
Feel
Hear
Smell
Taste
What did you learn?

APPENDIX M

Student Interview Questions

1. Pretend we have a new student in our class and they say to you, "what is science?," What would you tell them?

2. What do you like about science and why?

3. Is there anything you do not like about science and why?

4. What was your favorite science experiment and why?

5. Is there anything else you would tell this new student?

APPENDIX N

Science Notebook Rubric

Name ____

Date_______________________

Topic ________________________________

Necessary Elements:

date, lesson title, picture (colored), writing description

	4	3	2	1
Picture-Display	Picture shows all elements of the lesson/ activity	Picture shows most elements of the lesson/ activity	Picture shows some elements of the lesson/ Activity	Picture shows few or no elements of the lesson/ activity
Writing-Description	Writing explains all elements of the lesson/ activity	Writing explains most elements of the lesson/ activity	Writing explains some elements of the lesson/ Activity	Writing explains few or no elements of the lesson/ activity
Picture-Understanding	Picture shows complete understanding of lesson topic	Picture shows understanding of most of lesson topic	Picture shows understanding of some of lesson topic	Picture shows understanding of little of lesson topic
Writing-Understanding	Writing displays complete understanding of lesson topic	Writing displays understanding of most of lesson topic	Writing displays understanding of some of lesson topic	Writing displays understanding of little of lesson topic
Presentation	Notebook is neatly and organized and contains all necessary elements	Notebook looks nice and contains most necessary elements	Notebook is good and contains some necessary elements	Notebook is not very nice and only contains a few necessary elements

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