Inquiry-Based Learning and Student Retention

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Inquiry-Based Learning and Student Retention

by

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Inquiry-Based Learning and Student Retention

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Chapter 1

Introduction

A. Statement of the Problem

Does inquiry based hands-on education engage students in their own learning and increase their retention of knowledge? Learning is a very personal and individualized experience for students who usually have to adapt to an educator’s pedagogy or strategy of teaching. During an introduction lesson in my sixth grade Earth Science class, I asked my students to tell me how they learn best. The majority of the students told me that hands-on activities help them to remember more information than they do through teacher-directed lessons and lectures.

The purpose of this action research study was to explore the challenges of teaching inquiry based hands-on learning that engaged learners and helped them retain the greatest amount of knowledge. My sixth grade students are experiencing science as a core subject for the first time in their educational careers. In elementary school, the science curriculum was often left until the end of the day. If the teacher ran out of time this was the first thing cut from the schedule. Several elementary teachers have stated that they were uncomfortable teaching science. They minimized their lessons or resorted to reading a textbook and completing fill-in the blank worksheets.

I introduced inquiry based learning to my sixth grade students by providing them with several classroom experiences using the scientific method. The initial exposure was through hands-on experiments that provided complete information and examples. I progressed with the students by gradually requiring them to develop parts of an experiment. Eventually my students developed a scientific method project that allowed
them to investigate a problem that they wanted to solve. The students produced a three-part project using the five steps of the scientific method. This consisted of a written report, a visual representation of the experiment, and an oral presentation that explained their findings to the class. Periodic check-ups occurred throughout the project. The homework check-ups gave students time to develop their ideas.

The students developed a question that contained a measurable outcome. From the approved question the students formulated a hypothesis stating what they expected to happen during their experiment. Ultimately, the student stated reasons why they proved or disproved their hypothesis. For the second and third parts of the evaluation the students developed a visual aid that was used to help the student present their scientific experiment to the class. Students were assessed on their preparation of their presentation. The students were also assessed for their presentation skills.

B. Background of the Problem

As a progressive thinker of the early 1900s, educational reformer, John Dewey, believed that learning occurred when students were solving real world problems in the community (School and Society, 1889). Sarker and Frazier took the idea of hands-on learning to another level. They claimed that place-based learning elevates hands-on activities to a meaningful level when the questions investigated come from students (2008). Hands-on learning is the process of acquiring knowledge through student engagement. Engaging students in their own learning through hands-on activities, internet and computer activities and simulations foster interest and encourages participation which ultimately results in the increased retention of the material learned.
The engagement of students in their own learning is important for all learners; some educators argued that hands-on learning is crucial for at-risk students to be successful. Bodzin suggested that inquiry-based, hands-on learning may be the answer to meet the needs of students with disabilities or students with special needs, which require modified education. The hands-on approach appeals to at-risk students, but especially to students with Individual Educational Plans (2007). Keffler also noted that contextual learning through hands-on programs can help students with disabilities showcase their skills while learning relevant core course material (2008). Hands-on activities allow the students the opportunity to apply the classroom learning to real-world situations.

Keys and Kennedy observed that students can also learn about real-world situations through inquiry-based learning. When the teacher allowed time for students to solve their own questions, they stretched their thinking, which made them excited about science and taught them the nature of science investigation (1999). The teacher found that students with special needs still had problems focusing, staying on task and ultimately completing activities. This is when the educator needs to determine the viability of inquiry-based learning. Would the students learn more while conducting the inquiry-based learning or would they have learned more during a traditional lesson? Will inquiry-based learning encourage the students to complete their assignments more than traditional learning would? I believe that it is important to stimulate and challenge students’ thinking. This increased interest improves the likelihood of assignment completion, and may increase their acquisition of knowledge.

The challenges that educators encounter while attempting to implement inquiry-based learning are numerous. Keys and Kennedy claimed that the district curriculum and
mandated concepts are often too abstract, making them difficult to teach through inquiry (1999). Adhering to mandates that are listed in a district curriculum was difficult for educators; fitting the district objectives to the inquiry model of teaching and learning was even more difficult. Keys and Kennedy continued to lay out the difficulties of teaching through inquiry-based education. Inquiry-based education requires students to experience the learning. They maintain that traditional lessons are easier for a teacher to plan. Inquiry-based hands-on activities require supplies and extra time to set up. Educators are restricted by limited funding for classroom activities and supplies are costly. Teachers try to adapt inquiry-based hands-on lessons around the supplies that are available to them. (1999). Classroom management is also necessary for successful inquiry, but can be very difficult to control due to the nature of the independent learning. I observed the students focus and effort while working independently. Then the student and I communicated about areas of weakness and how improvements could be made. Bodzin emphasized that educators needed to continually assess the quality of the learning through observation and student performance to determine whether the students were focused, paying attention, and participating in the instructional task (2007). According to Keys and Kennedy the most significant problem of teaching an inquiry based hands-on curriculum was setting identical inquiry outcomes for all students (1999).

C. Significance of the Problem

One of the greatest challenges an educator encounters is finding the time necessary to develop meaningful lesson plans. Educators are obligated to perform many
administrative duties and attend mandatory meetings that take away from the time that could be used toward developing engaging lesson plans. Hands-on inquiry based activities take time to set up and often require more time to perform. This time crunch often pushes educators to turn to the textbook to facilitate quick lesson planning.

Financing hands-on learning is also costly. During this time of economic challenges, school districts are trying to find ways to cut spending and balance the budget. Trips to museums or science centers are often the first programs cut from the curriculum. The biggest challenge I experienced was my limited knowledge of hands-on inquiry based activities. I was taught in a textbook manner and do not have the knowledge of hands-on inquiry based activities or ideas to institute into my lessons. Resources for hands-on training through staff development are not readily available to educators. By the end of the year my goal is for my students to love science, thus instilling knowledge and fostering a desire for lifelong learning in science. I know, from my own educational experience, that I was not excited by textbook learning. I do not want to become the kind of “boring” teacher that I experienced as a student. Teachers try to understand science teaching and learning in ways that they never have experienced or seen enacted (Campbell, 2009).

D. Rationale

Through hands-on education many students find success and a continued purpose for education. I believe students who are at risk for disciplinary issues or who are placed into special education may find a renewed interest in learning through hands-on programs. Several articles included in this study stress the importance of connecting
education to real world situations. Keffler stated, “Make education rigorous and relevant for all students. It does not matter if a student is special needs, gifted or general education” (2008, p. 6).

As a new educator and a life long learner it appears to me that hands-on teaching and learning is a successful way to engage and encourage my students in their own construction of knowledge. It also makes sense to me that the curriculum introduced during hands-on activities will be better retained and relevant to other situations in my students’ lives. My goal is to become a teacher who guides all students - regular education, at-risk, and special education, to acquire this life long learning style.

E. Definition of Terms

At-risk learners- students who are struggling to meet the basic curriculum requirements.

Students with Disabilities or special needs- are learners who have an IEP (Individual Educational Plan) and receive educational support specific to their individual needs.

Hands-on learning- is learning through the manipulation of materials. It is also referred to as kinesthetic learning.

Performance based science - is the process of learning by performing the behaviors required of hands-on activities such as manipulating the equipment or directing the activity.

Inquiry- is active learning based on students’ questions and investigations where students discover knowledge and not just memorize facts.
Placed-based learning- place-based learning elevates hands-on activities to a meaningful level when the student forms the question that is being investigated.

As previously discussed, the purpose of the study was to evaluate the benefits of inquiry based hands-on education, engage students in their own learning, and increase retention of knowledge. Research supports the connection between this process and the learning in a science curriculum. Four topics to be discussed in the following chapter are hands-on learning and inquiry-based instruction, hands-on learning beyond the classroom, at-risk learners and inquiry-based education, and challenges of teaching inquiry-based education.
A. Hands-on learning and inquiry-based instruction

Hands-on learning and inquiry-based instruction are important aspects of learning. This article shows an important connection between the process and a physics classroom. Campbell and Neilson (2009) believe inquiry-based, hands-on learning can be a great way to learn about friction. Scientific inquiry helps students understand concepts by experiencing the world around them and the way science happens in everyday life. While learning through scientific inquiry is beneficial to students, it is not always used due to the lack of experience teachers have in applying this strategy.

Campbell and Neilson discuss the importance of inquiry education through a quote by Mark Windschitl (2003) which states, “...For a science student, developing one's own question and the means to resolve the question suggests an inquiry experience that is profoundly different from the far more common tasks...of answering questions prescribed in the curriculum using methods also preordained in the curriculum or by the classroom teacher,” (Campbell and Neilson, 2009, p.16). The authors’ hope in sharing this inquiry-based science activity is that more science teachers will begin to apply this teaching style, and to a wider variety of instructional topics, encouraging students to better understand science and its processes.

Longfield (2007) investigated the question “Is science a set of facts or a process?” as she developed an inquiry-based science program for her elementary students. The author searched for a new way to teach her students when she discovered they could
memorize and reiterate scientific facts, but could not apply the processes, concepts, and skills they learned to other situations. Like most educators, she found that trying to change the way she taught was not an easy task. Longfield describes inquiry as a way to guide students to create questions about a topic. Then the students investigate resources to find the answers. Longfield learned that this requires teachers to answer a student’s question with another question. These resources allow students to determine in which direction a lesson will go. Using the inquiry-based method was difficult for her because she was so used to always being the one to provide answers, rather than allowing the students to discover information for themselves. The routine of providing is the norm for most educators.

The training to become a teacher of inquiry-based learners is time consuming and requires commitment. Longfield was trained in inquiry-based learning over two summers through the DASH program (Developmental Approaches in Science, Health and Technology) program. She found success through her commitment to the program. One challenge she encountered was how to conduct a hands-on, inquiry-based classroom, and at the same time, still cover all aspects and units of the curriculum. Incorporating real life situations, hands-on activities, and thought provoking tasks such as the use of KWL (What you know, What you want to know, What you learned) charts helped keep the students on track. This way of teaching led the students to be actively involved, excited, and even produced more creative solutions and ideas regarding how to solve a problem. For example, one student suggested the class build a wheel when working on an aspect of physical science. With parent permission, they did just that. This hands-on experience led
to a much greater understanding of science that the students would have gotten from a textbook.

Lehmann (2007) demonstrates the attempt to bring inquiry-based learning to an entire population of students. The Philadelphia School District opened an inquiry-based high school in 2006 called the Science Leadership Academy. The goal was to incorporate changes that reflect education in the new millennium. Most schools were built many years ago, and are in need of repair. This new school was equipped with up-to-date technology and equipment. Employed educators were trained in inquiry-based education. The new technology makes sure students are able to learn in an inquiry rich environment.

The Science Leadership Academy is committed to a project-based environment, inquiry, hands-on learning, and longer time periods for teaching and learning (Lehmann, 2007). The curriculum is built around essential questions that are generated by the students, fostering critical thinking skills while still maintaining high standards, and focusing on preparing the students for college and careers in the future. The idea behind the curriculum is that the world of communication has opened up immensely since the creation of the Internet. Learning needs to become open and interactive as well, even outside the school. Lehmann’s article allows the reader to take a glimpse into a creative, student-centered learning experience.

The goal of an educator is to engage students in the learning process. However, understanding what this looks like and how to effectively engage students can be unclear. Lord and Orkwiszewski (2006) describe learning in two very different ways. The traditional way of teaching is referred to as a “cookbook method”. This is a step by step process in which the students follow the teacher’s directions and fill in a given answer.
The information is presented in a safe and organized way. Most of the learning comes from textbooks and lectures.

The other method is inquiry-based learning. Lord and Orkwiszewski describe this as a way of teaching that engages students mentally and physically while leading to enduring understanding rather than passive tune out. Teaching in an inquiry-based setting is much more difficult for educators because it takes more planning, is more active, and may mean students are at different points in their learning. Lord and Orkwiszewski conducted a study to prove the benefits of inquiry-based learning compared to a “cookbook method”. The results favored the students involved in the inquiry-learning group. The students in a control group received assessment scores averaging 84.8%, while the experimental group scored 89.7% on the same assessment.

When these students were asked to respond to questions about their experiences and attitudes during the lesson, the control group responded to 31 of the questions positively and 17 of the questions negatively. The experiment-based group responded to 37 of the questions positively and 11 of the question negatively. Lord and Orkwiszewski discovered that the students in the experiment based group achieved higher scores, had better attitudes about the learning experience, and were better equipped to work at higher levels of critical thinking to solve science problems than the students in the step by step control population.

B. Hands-on learning beyond the classroom

Teaching science in the classroom is often done through the use of textbooks and bears little resemblance to the natural world (Ramey-Gassert, 1997). Her article is an
attempt to help educators realize that conducting hands-on experiments with simple everyday materials or visiting locations outside of school is a far better way to teach children science. She refers to these as out-of-school learning experiences. Science trips to museums are a worthwhile learning experience, but may be too costly for some lower-income schools. However, if a field trip to a science museum is possible, many of these museums offer hands-on, authentic learning that allows students to discover scientific concepts for themselves. This learning is more meaningful and students better retain the material.

Learning environments can be as simple as investigating a bug on the playground, or observing fish and other life in a pond near school. Other out-of-school learning opportunities or extended learning experiences can involve inviting in parents or community members with specific skills to share with the students, reducing financial concerns (Ramey-Gassert).

One way in which in- and out-of-school education varies is that learning in a non-classroom setting, such as a museum, relies less on verbal and written academic communication and language. This gives learners the opportunity to engage in hands-on learning, or make further connections without struggling through difficult texts or vocabulary (Ramey-Gassert, 1997). This could result in more meaningful learning for students who struggle with terminology and reading because they can actually see the scientific process or change and learn from the observation directly. Providing hands-on or visual aspects to the learning will deepen the students' understanding beyond what the textbook and vocabulary words can provide.
In one investigation Ramey-Gassert describes an out-of-school learning experience, where students recalled detailed information after visiting a museum. In addition to the acquired knowledge, many of the students were able to relate the information they learned to experiences in their own lives. On an assessment comparing students who experienced the hands-on museum tour to a control group who did not visit the museum, the out-of-school group developed a deeper and more complex understanding of the material presented. Visits to out-of-school destinations are difficult to evaluate, leaving some to question the quality of learning that takes place. The most important aspect of out-of-school experiences is to engage children in the world around them. This will result in higher interest, positive attitudes toward learning, and learning that will be facilitated and explored to a greater extent.

Pine et al. (2005) highlight the advantages of an inquiry-based, hands-on curriculum as opposed to textbook learning. Pine, et al. are trying to convince educators that inquiry-based science education is more stimulating for students' learning and continued interest in the curriculum and subject as opposed to textbook learning. The study consisted of 1000 fifth grade students in nine different school districts that spanned all socio-economic levels. The hypothesis of the study was that the majority of the students would find more success with hands-on, inquiry-based learning. The belief was that the students would prove to have many shortcomings such as performing the task and completely understanding the scientific process and the topic taught after traditional textbook learning. In the end, assessment scores did not show a significant difference between the learning acquired in the two types of programs. The average score attained by the students involved in the study was 45%. On the assessment questions that required
higher level thinking skills, the students only achieved an average score of 32%. In addition to the poor assessment scores, the study showed that there was not a significant difference in achievement in the hands-on learning compared to the textbook learning. The results of the various experiments were disappointing and involved many variables. One of the findings showed that the achievement scores of all students were at the same level, despite their socioeconomic status.

Pine, et al. (2006) suggest that educators may not be teaching hands-on, inquiry-based skills well enough for their students to achieve mastery levels on assessments. With unexpected results, the researchers attempted to revise their purpose of the study. Pine, et al. (2006) indicated the benefit of inquiry-based learning during one area of the experiment, not necessarily for the whole investigation. While the results showed that the students who were taught through inquiry-based learning did not perform at a higher level than those who were taught the material through traditional textbook strategies, the study was unable to prove whether the lack of difference between the text-based instruction and hands-on instruction was due to the tests, the curriculum, or the actual instruction.

C. At-risk learners and inquiry-based education

Bodzin, Waller, Santoro, and Kale (2007) suggest that inquiry-based, hands-on learning may be the answer to meet the needs of students with disabilities who require modified education. The hands-on approach appeals to many at-risk students, but especially those students with Individual Education Plans. This study looked at forty-eight ninth graders in two Applied Biology classes. Each class consisted of six students
with IEPs and was taught by a regular education teacher, a special education teacher, and a teaching assistant in the classroom as support. The teachers had worked together for several years, but were new to inquiry.

The study was closely observed and changes were put into place to meet the needs of the students with IEPs because the independence needed to successfully complete inquiry-based activities was often lacking in these students. Specific main ideas, guiding questions, and coaching helped these students. The inquiry-based programs raised the interest and focus of all learners; however, the students with special needs continued to have a hard time maintaining their focus when they were required to complete online web activities that required intensive reading.

Bodzin, et al. indicated that a decrease in the use of content vocabulary during hands-on experiments may have caused the increased resistance when asked to complete more traditional assignments. Interest waned and intervention was required for management issues of the students with IEPs. Instead of allowing each student to investigate the information and search the website on his or her own computer, the teacher demonstrated the web activity for the whole class by using an LCD projector (Bodzin, et al., 2007).

Despite the challenges of the new inquiry-based biology program, many students responded positively to a student attitude survey stating that the hands-on activities were very helpful, helpful, or somewhat helpful 79% of the time. Inquiry-based education needs to be carefully structured, ordered, and organized. This benefits inclusion students who learn best when they have structure, time, and assistance to learn through investigation (Bodzin, et al., 2007).
According to Keffeler (2008), because of hands-on learning and experiences with life skills, at-risk learners more effectively demonstrate their abilities and experience success in the classroom. Keffeler points out that these students can learn, they just need modifications, scaffolding, and assistance to succeed in the classroom. Succeeding in school is very difficult for students with special needs. Keffeler reveals some of the roadblocks these learners encounter, such as high dropout rates, lower employment rates, and even the lack of experienced special education teachers. It is important for teachers to be educated regarding how to work with students with special needs. These instructors should also pay attention to the needs and learning styles of these students. Students may be tested in alternative ways. Career counseling and technical education (CTE) are important parts of every student’s education at the secondary level. CTE is hands-on learning based on real life skills that will be useful in the job world. Some examples are portfolios, hands-on activities, and authentic assessments. Keffeler (2008) found that the use of CTE was beneficial with students with learning disabilities.

At-risk students often fall behind in education due to circumstances that are unrelated to a disability Emeagwali (2008.) They often struggle to fit into a rigid schedule, and expectations that may not align to their abilities, interests, or needs. Emeagwali (2008) introduces an alternative to the traditional high school setting. Chana High in California is a school for at-risk students who are in danger of dropping out of school. In this program, highly qualified educators work to meet the needs of 200 at-risk students through hands-on, performance-based learning, and a career and technical education program (CTE). The program gives the students a chance to start over in a small setting that accepts their differences and encourages them to learn in a manner that
best meets their educational needs. The program meets all graduation requirements using small group instruction, fitting the lessons to the students' needs, and providing ample help, encouragement and guidance from teachers. The students feel a connection to the teachers and are engaged and interested in the learning because of the hands-on approach and real life involvement. One student at Chana High School described the teachers as “friendly, kind and straightforward,” (Emeagwali, 2008, p 15). All of these attributes encourage these otherwise low-performing students to succeed. The Chana program also provides some career and technical training, which gives the students a positive step toward their employment possibilities and future success.

D. Challenges of teaching inquiry-based education

Trying to engage the disconnected learner is one of the biggest challenges an educator experiences during their career. Brackett (2006), a carpentry teacher at SUNY Delhi, explains the challenge of finding a way to engage hands-on, kinesthetic learners during vital classroom lectures. The instructor looked for ways to assist the hands-on learner with the traditional paper and pencil book work, realizing that the learner is not where the problem necessarily lies. It is the educator’s responsibility to work with the students to determine what can be done to ensure their success in understanding information provided in the lecture as well as the hands-on laboratory work.

Brackett (2006) had an interesting hypothesis which suggested that students that do well in the classroom would also do well in the laboratory. Likewise, it suggested that students who did not do well in the classroom would not do well in the laboratory. The results of the study did not support the stated hypothesis. The results showed that the
majority of students, both high and low performers, achieved lower scores in the lecture portion of the program than they did in the laboratory hands-on portion of the program. Overall, only nine of the sixty-eight students who completed the program performed better on the lecture assessment than on the laboratory assessment.

Brackett affirms that he realized that one type of learning style was not superior to another. Students have a variety of strengths and various ways of showing their abilities academically. This is something teachers must be aware of in order to tailor lessons and activities to the learning styles and needs of the students. If a student is engaged, encouraged, invested in the learning, and given the opportunity to apply their understanding, the learning will be balanced and the students will be more likely to succeed (2006).

Inquiry education in science classrooms is once again becoming more popular; however, it is not always used correctly or to its full potential due to a lack of knowledge on the part of the teacher regarding how best to implement this strategy, according to Keys and Kennedy (1999). Even when mandated, inquiry education is not always implemented, or is done differently depending on the teacher. Teachers have also stated they have trouble teaching with this method due to issues with supplies, behavior, and a fear that actual facts will not be learned. One potential solution cited from Lijnse (1995) states that adjustments must be made in the way inquiry teaching is presented based on the students’ needs, the school, and the unit being taught.

Kennedy (1999) focuses on a study done in a fourth grade class in which inquiry-based learning was added to the lesson in a number of forms. One way was simply to allow students to ask questions during lessons. However, rather than just answering
student questions, the teacher allowed the students to find out the answers through hands-on activities and inquiry. Another way Kennedy implemented inquiry was by allowing the students to have more say in how things were run in their lab or project groups, rather than assigning the same jobs and procedures to all. The teacher also used student-created data in her lessons. This is an example of inquiry education because it shows the students that activities they do and information they learn is actually just as valuable and useful as the information in a textbook. It keeps them interested and engaged, because they are evaluating and analyzing something they actually took part in creating. Finally, Kennedy had her students make predictions based on their prior knowledge in science, then work to learn whether or not they were correct through inquiry and hands-on learning.

Through this study, Kennedy found three main problems with the inquiry model. One problem was that there was not enough time, another was the fact that she found it difficult to address student questions without simply answering them, and finally, she ran into some items in the curriculum that she did not believe could easily be taught through inquiry such as the topics of fronts, pressure systems, and wind cycling in the weather unit. She did have to find a way to balance these issues, and make sure the students both benefited from inquiry-based learning and learned the curriculum by giving more time to some activities than others, and directly teaching some of the more abstract concepts (Kennedy, 1999). This is a great example of a teacher making inquiry work for her based on the needs of the students and the demands of the content. She made adjustments to the process so that inquiry-based learning could still take place in her classroom successfully.

The performance-based science classroom is the preferred style of teaching for many educators and most students; however, the hands-on experiences may not favor
boys and girls in the same way. Jovanovic and King (1998) examined the effects of the inquiry-based science classroom on the attitudes of learners after a full year in an intensive, hands-on environment. The purpose of the study was to figure out why girls’ perceptions of their own ability in science decreased, while their actual performance in science increased. The authors give many environmental factors that may contribute to the lack of confidence in young women. Many of the variables Jovanovic and King suggest go back to the playroom and the toys children are given to play with. In addition, there is a deeply ingrained perception by teachers and society that boys are better at science than girls. Less exposure to science-based activities for girls help fuel these beliefs. The study was carefully set up to ensure consistent treatment of all students, and age, male or female, and student achievement were important aspects considered among the students that were selected to be observed. The teachers were screened and selected for the study based on their technique for teaching through inquiry, as well as their being well trained, experienced, and supported by their district (1998).

The other major consideration when choosing which classrooms would be included in the study was the social status of the students. In the end, the authors realized that they did not include factors such as a student’s interest in science and how that interest factored into the student’s success, and whether they were male or female.

Overall, the study did reveal that boys were active leaders during the hands-on experiments and girls were more likely to be passive assistants. The girls were often ignored by the boys when they tried to input information or manipulate the materials. This often resulted in the girls having a learning disconnect in the hands-on activities. When the researchers looked at the performance of the students, girls scored just as well
as the boys on standardized assessments, although the girls believed that their performance had decreased.

There was a significant difference in the students’ task value beliefs. Task value is defined as “the degree to which an individual believes that a particular task is able to fulfill personal needs and goals” (Jovanovic and King, 1998, p. 479). In this measure the girls showed a significant decrease in their task value belief. One factor that was not considered during the study was the impact of active learning. If a student, boy or girl, took an active role in learning science, he/she was more likely to learn and do well. If they did not take an active role, they were less likely to learn the concepts and did not do as well. The active learners and leaders in the science classrooms also had a more positive perception of science and their own ability in the subject.

Frazier and Sarkar (2008) argue that hands-on and inquiry-based learning that is forced and not authentic will not lead to a positive impact on a student’s ability to solve scientific problems. Using place-based investigations can help the students really understand the usefulness of learning through inquiry. Frazier and Sarkar go back to Dewey’s thought that true learning came from involvement with the real world. Place-based inquiry focuses on a place that the student already has ties or interests because it engages them and helps put the scientific information into a meaningful context. This can be applied to tasks in many different science curricula, including physics or chemistry.

Students express excitement when they get to learn in this way because they actually make real connections between their lives and their education. It is also beneficial because the teachers get involved in the inquiry process. Students are shown that learning is happening all the time, even for adults (2008).
In order to assess the process of learning through inquiry, students keep notes, analyze data, as well as take a pre-test and post-test on the concepts and information targeted in the unit. They also present and share their findings with the teacher and their classmates in creative and interesting ways. Unfortunately, restraints due to time, money, school schedules, behavior, and student needs do not allow all schools to teach through this method. However, Frazier and Sarkar (2008) provide some ideas on how to work around such issues. Solutions such as giving fewer questions if time is a problem, staying on campus if field trips are not allowed or can not be afforded, and setting up strict expectations ahead of time for potentially unruly students can allow modified versions of inquiry-based learning to take place, with the results still being very beneficial.

In their article Clifford and Marinucci (2008) discuss a Canadian school called Glendale, which is committed to inquiry-based teaching and learning. In order to truly run an inquiry-based classroom, the teacher must be able to recognize opportunities for research and questioning. To arbitrarily set-up inquiry-based activities is not authentic and does not teach the students to apply these strategies to life. Inquiry-based learning focuses on questions, but what type of questions should be asked? Who should ask the questions? Do the questions fit the learning? These are issues that arise for many teachers.

The inquiry-based activity outlined in this essay came from a true situation. In the wake of the Indonesian tsunami, the students wanted to know why water and purification techniques needed to be brought in. According to Clifford and Marinucci, the students also wondered why they could not drink the salt water that was all around. The questions asked do not need to be overwhelming, just intriguing and open. Another unique facet of
inquiry learning is that students may find different parts of the process or pieces of information intriguing. Each student wants to focus their own learning in that direction (2008). This is different from conventional education, where all learning and products end up being very similar. The question of water purification led to a variety of other debates and questions, which keeps the process engaging. The inquiry process also involves many students learning and discovering knowledge together, as opposed to the usually individual style of conventional education. (Clifford and Marinucci, 2008).

If done correctly, inquiry-based learning will probably lead to the need for information and expertise outside the classroom. Some teachers shy away from this, worried that they will lose the image of the all-knowing teachers. (Clifford and Marinucci, 2008). However, those who welcome new information end up learning with the students. Another misunderstanding of this type of learning is that no actual learning is done. As a result, the academic standards are lowered. This style of learning teaches students to sort through information, find what is necessary, and determine the next step. They are also taught how to overcome barriers such as mistakes, misconceptions, or problems in research, rather than quitting and feeling as though they failed because they had to reconsider some aspect of their work. According to Clifford, et al. “Students trained in the habits of inquiry have much less fear that making a mistake reveals their own personal ignorance and are much more interested in the quality of their thinking,” (Clifford and Marinucci, p. 684).

Many teachers also fear that inquiry-based learning will move away from the curriculum and that certain information that may be tested will not be taught. Teachers who have mastered inquiry-based teaching have learned that there are ways to apply
students' interests and questions to aspects of the curriculum. Learning something without the textbook does not mean that it was not learned. The students in this class in Canada learned the mandated chemistry objectives, but did so though a hands-on, student centered class project. By the time the whole project was completed, the multitude of questions, detours, and other discoveries that took place ended up covering even more learning and objectives than originally anticipated.

In summary, inquiry-based learning is beneficial, but comes with challenges. This method of teaching gives students more ownership over their learning, is hands-on and includes a variety of learning styles, and teaches students how to reason and draw conclusions through information. One of the challenges is time. Many teachers are required to teach a rigorous curriculum that may not seem to allow time for inquiry-based teaching. However, according to this review of literature, some teachers have successfully incorporated inquiry-based teaching into existing lessons. Another challenge is ensuring that the students still learn all the required information. This can be remedied by still providing some direct instruction, and providing specific guidelines for hands-on, or lab based work.

These articles also show that inquiry-based learning helps nontraditional learners, such as those who have special needs or those who are at-risk. This is because traditional textbook teaching is not always easy for these types of students to relate to, and hands-on inquiry-based activities, or those involving questioning, may be more suitable. While the research is not completely conclusive on the benefits of inquiry-based teaching, more often than not, based on this review of literature, it seems to create meaningful and in-depth learning for all types of students.
Chapter 3
Applications and Evaluations

A. Introduction

This project was an initial exploration of the effectiveness of teaching inquiry-based hands-on learning in science. The purpose was to improve student motivation and increase retention of material learned. The goal of the project was to improve memorization and ease implementation of the five steps of the scientific method. The five steps include thinking of an idea, researching the topic, planning and conducting the experiment, collecting and recording data, and coming to a conclusion. The objectives were to further advance a desire to investigate a topic of choice through independence, self determination, and a sense of accomplishment.

B. Participants

Participants involved in this study were sixth grade suburban middle school students in an earth science classroom. There were eleven boys and ten girls in the class. The educational ability of the students was mixed. Some students needed step by step support throughout the process. The sixth grade students were new to this upstate suburban school. This was their first year in a formalized science program. All of my sixth grade students were responsible for completing this project as a final assessment of the Scientific Method Unit. Participants selected for this research project were from one of my science classes. I used a class that included an equal number of participants below, at, and exceeding standards. All students in that section were my participants.
C. Procedures of the Study

My students developed and investigated a scientific project of interest to them. The students produced a three part project using the five steps of the scientific method. In the first part of the project, students wrote a science experiment report which needed to include a hypothesis or an educated guess stating what was expected to happen in the experiment. They also prepared a step by step plan for doing the actual experiment. While performing three trials, the students carefully collected and recorded data. Depending on the reliability of the data, the students may have needed to do additional trials. Each of the students were required to analyze the data that was collected and compare that information to the hypothesis made earlier in the process. Finally, the students needed to state whether they proved or disproved their hypothesis. The students were provided with a rubric which provided the requirements of the written report.

A visual presentation of the experiment was developed by each student for their classmates and teacher as the second part of the project. The students were given a visual aid rubric with the specific requirements. The type of visual aid used was determined by the students and could be in the form of a poster, video, Power Point, or a demonstration. The visual aid needed to be neat and large enough for all to see.

For the third part of the project, the students had to use the visual aid to explain their research and the results of the data collected. The students were assessed on preparation, organization, and quality of the presentation based on the oral presentation rubric.
D. Instruments for Study

The following instruments of study were provided to the students throughout the Scientific Method Project. Those included a parent/guardian permission form to make families aware of the project requirements as well as safety awareness and possible costs, if any, of their child’s experiment (see Appendix A). The students also received a detailed rubric stating the requirements of the Written Report (see Appendix B). The students formulated a question, a hypothesis and a step by step plan. These three components were required as homework assignments as project check-ups (see Appendix C). This ensured all students were meeting the initial requirements of the project. After the three check-up assignments were completed the students received an outline listing the requirements of their conclusion (see Appendix D). They also received a visual aid rubric (see Appendix E), and an oral presentation rubric (see Appendix F) which stated the requirements of these components of the scientific method project. At the culmination of the project, students completed a scientific method project survey (see Appendix F). This survey helped me determine the effectiveness of each part of the project. I also used the survey information to improve the project for future students.
Chapter 4

Results

A. Scientific Method Project

Assessing a student’s level of learning is important for me to determine the quality of classroom instruction. As a teacher, I needed to know how well my students are learning the material that I presented to them. Does inquiry-based hands-on education engage students in their own learning and increase retention of knowledge was the question investigated. For the purposes of this study, I collected data from 19 students. One student moved out of the district before the project was completed. Another student was not included in this study. He was involved in a compacting unit for gifted and talented students. The relevant data that I collected was from an inquiry-based hands-on assessment. The information was from an end of unit scientific method project based on a topic of the student’s choosing. The project had three separate and required parts which were graded on an individual basis. The required standards of the project were clearly stated and the numbers of possible points for each component were provided to the students in a project rubric.

Table 1, found on the following page, displays three project scores for each student. These are the written report, visual aid, and oral presentation. A final grade also appears.
### Table 1: Scientific Method Project Scores

<table>
<thead>
<tr>
<th>Student</th>
<th>Written Report</th>
<th>Visual Aid</th>
<th>Oral Presentation</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
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<tr>
<td>1</td>
<td>100</td>
<td>90</td>
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<td>2</td>
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<td>100</td>
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<td>3</td>
<td>90</td>
<td>100</td>
<td>70</td>
<td>88</td>
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<td>4</td>
<td>35</td>
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<tr>
<td>Averages</td>
<td>82</td>
<td>88</td>
<td>93</td>
<td>85</td>
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</tbody>
</table>

The written report had five categories that the students were required to address. They were: the question, hypothesis, step by step plan of the experiment, data collected, and conclusion. The grades that the students earned for all portions of the project are listed in Table 1. The written report was worth 35 total points. Twelve students received a grade of 80%-100%. Seven students received a grade below 80%. Two of those students received failing grades of below 65%.

I also collected data from a visual aid and oral presentation. Each of these requirements was worth ten points. For the visual aid requirement of the project seventeen students earned a grade of 80%-100%. One student obtained a grade of 70%--
79%. One student received a failing grade of below 65%. For the oral presentation 18 students earned a grade of 80%-100%. Only one student received a grade of 70%-79%.

The final grade for this scientific method unit project was the end of unit assessment which was averaged into each student’s quarterly report card grade. The test/project grade counts as 25% of this quarterly grade. Fourteen students received a grade of 80%-100%. Five students obtained a grade below 80%. One of those students failed with a grade below 65%.
B. Check-up Assignments

I also collected data from the students through three classroom check-ups. These assignments gave the students the opportunity to develop the individual parts of the scientific method as they applied to each student’s project. The three classroom check-ups were for the question, hypothesis, and step by step plan of the experiment. Each student earned a homework grade for each of these check-ups. If a student completed the assignments, according to the classroom homework policy, a grade of 100% was

<table>
<thead>
<tr>
<th>Student</th>
<th>Check-up 1 Question (%)</th>
<th>Check-up 2 Hypothesis (%)</th>
<th>Check-up 3 Step By Step Plan (%)</th>
<th>Parent/Guardian Permission (%)</th>
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<tr>
<td>1</td>
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<tr>
<td><strong>Average</strong></td>
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<td><strong>100</strong></td>
<td><strong>88%</strong></td>
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</tbody>
</table>
received. If the students did not complete any one of the three check-up assignments a zero for the homework grade was earned.

However, more importantly, the check-up assignments allowed me to assess which students were meeting the vital objectives to be on task with their project. The students also had the opportunity to work with a peer to present preliminary information and make necessary improvements to these components of the project. All students in this study did receive a grade of 100% for all three check-up assignments.

All students were responsible for communicating project ideas and subsequent supplies that would be required to perform the experiments. The students were required to turn in the signed parent/guardian permission before they could start the project. All students received a homework grade for this assignment. The students lost 25 points for each day the parent/guardian permission form was late. Five students lost points for this assignment. One student received a 75% for the assignment being one day late and four students received 50% for the assignment being two days late. All of the check-up assignments and the parent permission were averaged into each student’s quarterly report card grade. The homework grade was 40% of this quarterly grade.

C. Student Surveys

After the students completed all of the components of the scientific method project I asked them to complete a survey. The student survey was meant to give me insight as to how well this project met the needs of the students and whether this project format allowed them to show what was learned during the unit. The survey gave me
information about the usefulness of the project check-ups for the question, the hypothesis, and step by step plan.

The students were required to hand in three check-up assignments and had the opportunity to edit these components with a peer. I asked the students if these assignments were helpful to them in completing the project. For the question check-up, 18 students said that the check-up assignment was helpful to them. One student said the check-up was not helpful. For the hypothesis check-up, 16 students said that this assignment was helpful. Three students said that this assignment was not helpful to them. For the step by step plan, 15 students said that the assignment was helpful to them. Five students said that the step by step assignment was not helpful to them.

For the students who said the check-up assignments were helpful, rationale fell into three categories: quality, organization, and responsibility. Ten students said that the assignments helped them improve the quality of the question. Eight students felt that the check-ups helped them improve the quality of the hypothesis. Another six students claimed that the check-up assignment helped them improve the quality of the step by step plan. Organization was another area students believed was improved upon due to the required check-up assignments. Five students believed that their thoughts were more organized for the question. Five other students felt that the check-ups helped them organize the hypothesis. Another five students believed that the check-up assignment improved the organization of the step by step plan. The students stated responsibility as a third area of improvement because of the required check-up assignments. Four students said they did not procrastinate on starting the project due to the required assignment. Three students said that the check-up helped them to complete the hypothesis. Finally,
five students claimed that the check-up assignment help them complete the step by step plan. For the students who said the check-up assignments were not helpful, they stated that the assignments were repetitive or that they did not need support on the project.

I asked the students what the most challenging and least challenging parts of the project were for them and why. Understanding the most challenging and least challenging parts of the scientific method project was important for my analysis of the project as an assessment tool. In response to my question, “Which was the most challenging part of the project for you?” the students responded in five ways. The challenging categories were the check-ups, organization, the written report, the visual aid, and the presentation. One student found the check-up assignments the most challenging part of the project. This student felt as if the check-up assignments slowed him down. He knew what he needed to do and wanted to get the project done. Three students conveyed that organizing the project was the most challenging for them. The general problem was putting the parts of the project in order and arranging the information to match the rubric. The written report was a challenge for five students because of the length of the report. Some students said it was hard to type the report because they type slowly. The visual aid was the most challenging for two students. These students stated that they were concerned about their lack of creativity and how the final product would look. Eight students responded that the most challenging part of the project was the presentation. This was due to their anxiety of presenting in front of a group.

The responses for the least challenging parts of the project were similar to the most challenging responses with a few changes. The responses that were the same were the written report, the visual aid and the presentation. Some students also found that
conducting the experiment and writing the conclusion were the least challenging part of the project for them. Four students found that conducting the experiment was the least challenging part of the project. They enjoyed doing the trials and collecting the data. Additionally, four other students said that the written report was the least challenging aspect for them. They were able to use the rubric as a guide to include all of the information required. Writing the conclusion was the least challenging section of the project for one student. This student said that this was due to the conclusion outline I distributed to the students. Preparing the visual aid was the least challenging aspect for three students. They stated that they found it easy to organize and display the information from their experiment. Eight students found presenting the project to the teacher and their peers as the least challenging part of the project. Each of these students said that they felt confident and comfortable in front of a large group of people.

I also asked the students if there was some other support I could have provided to assist them in the completion of the project. Modifying this inquiry-based assessment so that students can best convey their learning may be necessary. The student’s input is an integral part of considering improvements. In order to do so, I needed to know what other support I could have provided to my students to assist in their completion of the assessment. The students’ responses fell into five categories: assign a topic, add additional check-up assignments, provide more support for the written report, and give additional class time to work on the project. Four students said that they had a hard time choosing a scientific method experiment and would have preferred me to assign them one. Four other students said that they would want addition check-up assignments during the project. Five students expressed needing additional support with writing the report.
Additionally, two students said that they would have liked to have more class time to work on the project. Ten students replied that they did not need any additional support to complete the project.

Finally, I asked the students if they felt they were able to demonstrate their learning and ability to apply the scientific method through this project format, or if they felt that they would have conveyed their learning better through a written test. I will use the information collected to make improvements to the project and adjustments to the evaluation. I wanted to know whether the project as a final assessment was the best way for them to convey what was learned. The last question I asked the students was “were you able to show me what you learned in this unit by doing the project or would you rather have taken a test?” The project was preferred by 17 students. Another two students said that they would rather have taken a test. One student wanted a different alternate assessment and one student said that they did not want to do either type of assessment.

I asked the students to explain the reason why each preferred one type of assessment rather than the other. The responses were divided into four categories. Six students said that the experience of producing the scientific method project allowed them to learn the process being assessed. Five other students replied that the project allowed them to “show what they learned.” The project was preferred by three students because it was “interactive”. Another four students responded that they “don’t like to take traditional tests.” Lastly, two students said that they preferred traditional tests to the inquiry-based hands-on projects.

Based on my analysis of the data and the information collected from this study, I will draw conclusions, recommendations, further analysis and make suggestions about
the usefulness and reliability of this inquiry-based hands-on method of evaluating student’s achievement in the next chapter.
Chapter 5
Conclusions and Recommendations

A. Discussion and Conclusions

The inquiry-based scientific method authentic assessments were to give the students the opportunity to take an established method of solving a problem and then apply it to a question or problem they selected. Were the students able to display and convey their obtained knowledge better through a long term project or through a typical pen and pencil exam? The three categories in which the students were assessed were a science experiment written report, a visual representation, and an oral presentation. The overall average for the 19 students in the study was 85%.

The students did fairly well on the written portion of the project with an overall average of 82%. The students did very well on the visual aid portion of the project scoring an average of 88%. The overall average for the presentation was 93%. I was very impressed with the students' presentation skills and this early stage in their education. When I broke the data down into typical daily performance groups, the data revealed the usefulness of this type of assessment. The seven students who had been classified as being gifted and talented and participated in an Enrichment Program had an overall average of 89%. This score is not remarkable for a group of students who should be performing at a distinguished level of 90% or higher. In addition, none of these students received a perfect score on the project.

The largest group of students who fell into the average range also broke down into sub groups. The overall average for the students who did not have IEP’s and did not
attend project enrichment was 78%. Even more impressive was the average for a group of
students who worked very hard on a regular basis and who were very conscientious, but
seldom achieved at an exemplary level. These hard working students scored an average
of 86% on the three parts of the project. This average is comparable to the average for
Gifted and Talented Enrichment students who achieved an average of 89%. On the down
side, there was also a group of students who did not put forth the effort to achieve an
acceptable grade. This group of under achievers consisted of five students whose grades
on the project did not match their academic ability seen throughout the year. This sub
group of low and middle level learners received an average of 67%. For the most part,
the low scores were due to work being handed in late or missing required components of
the project.

The analysis of the data for this inquiry-based authentic assessment revealed a
great deal of information. At first glance, the data collected was actually disappointing
because with a hands-on project I expected the grades to be higher. The major part of the
project which was based on the Scientific Method Report had an overall average of 82%.
However, after breaking the grades down and looking at smaller sub groups, it was
apparent that the overall grade was pulled down by a small group of students who
received low or failing grades. This surprised me because I thought that the students
would complete all parts of the project and turn them in on time. I also thought the
students would be more invigorated by a project rather than a test. When the overall
average of the report grade was reconfigured without the low grades the total average
went up by six percentage points to 91%. The Visual Aid grades went up by five
percentage points to 93%. The Oral Presentation grades went up by two percentage points
to 95%. This was a much more acceptable outcome. These exceptional grades in the 90’s, showed that the majority of the students learned the material. I was pleased with the majority of the students’ work. The breakdown of the sub groups confirmed to me that the inquiry-based authentic assessment project was a success. The inquiry-based authentic assessment was a beneficial evaluation for my students. This data confirmed the knowledge gained.

The results of the survey were very interesting. I asked the students to tell me if three project check-ups were helpful to them to achieve their final goal. The majority of the students said that the check-ups were helpful even if they received a zero for one or more of the assignments. A small percentage of students said that the check-ups were not helpful. The students were not required to put their names on the survey, but most did. It was not a surprise that the majority of these students who thought the check-ups were unnecessary were the students in the Gifted and Talented Enrichment students. The question check-up was the most helpful for many of the students. While working with a peer to edit their plan, many students realized that they needed to add several steps to the plan in order for another person to recreate the experiment. As suspected, the majority of the students found the report to be the hardest part of the project and the visual aid to be the easiest part of the project. Finally, I asked the students if I should continue with this project as the final assessment or return to a traditional pen and paper test. All but two of the students said that I should continue with the project. Many stated that it was still hard to do a project, but they enjoyed being able to pick their own topic and doing the experiment were fun. The majority of these students said that they learned the scientific method better because they had to use it in the experiment.
B. Recommendations

The limitations of this project were numerous. First were the limitations of myself as a new teacher. I did not have a bank of proven assessments to pull from a file. I had to rely on my own experiences as a learner and a test taker during my own education. I knew that I panicked when I was told there was going to be a test. I remembered feeling helpless when I knew the information learned in the unit, but still failed the exams. Now, as a teacher I had the choice to provide my students with an alternative way to prove their acquisition of knowledge.

The project was extremely time-consuming and difficult to fit into the curriculum as a new teacher. Other educators have struggled with the problem of having time to implement inquiry-based learning as well. In *A dash of inspiration* by J. Longfield (2007), she stated that, “Mentally, I was convinced that the inquiry was good and necessary, but practically I wasn’t convinced that the inquiry was an effective use of my limited time” (p.27).

I felt like this many times throughout the project. I often wondered if I had made a mistake by taking on such a large task. This was especially stressful when I did not get through what I had intended on doing by the end of a class period. I had to set up a time table for the entire unit, including the project. This was difficult because I had to actually plan the end of the unit first and then set up the unit using a backward design. I had to plan for enough time to teach the unit, introduce the project, include the check-ups in my lesson plans, and provide time for the students to present their projects to their peers. Finally, I had to grade all of the projects and enter the grades.
Secondly, many of my students were not used to being challenged. Several students had a hard time developing a question in which to base their experiment. This was due to their lack of experience applying choices to the learning. This was an intimidating experience. I had to guide several students to think about something of interest to them. Each student needed to ask a question leading to a discovery using the scientific method. Then the students developed a project around this interest.

Another limitation for my students was following their project through to the end. It was difficult for these new science learners to maintain focus on a science experiment that has this many components. The students had to follow the five steps of a scientific method experiment and obtain data. This is where many of them thought they were done with the experiment. Having to interpret the data and apply it to their hypothesis was a new skill that caused anxiety for many students. I had to gently guide them to apply their own inquiry skills and trust their interpretation of the data.

Another limitation I experienced was from the parents of my students. Each student had to have a parent permission signature before they could start their project. The purpose of the permission was to communicate to the parents the amount of time the students would need to invest in the project. The parents also had to agree to provide any supplies needed for the project their child chose. The parents may have needed to assist their child with performing the experiment. A few parents required their child to change their project idea entirely due to the expense or because the project created too much of a mess. The other challenge I encountered with some of the parents was that they were too involved and probably did more on the project than they should have. Other parents did
not assist their child at all. These students were the ones who tended to have trouble
staying on track with responsibilities and turning some parts of the project in late.

The mindset of the parents was another limitation that became apparent after the
projects were graded and returned to the students. I got several phone calls from parents
who thought that their child deserved a better grade than they had earned. The majority of
these calls came from the parents of the students in the Gifted and Talented Enrichment
program. Their justification was that I should have based the student’s grade on the fact
that they are “good students”. Dealing with parents that expected me to grade their child
on the quality of their character rather than the quality of the project was extremely
frustrating. I thought that the assessment was clear, based on the rubric. The interaction
with some of these parents was unpleasant. At one point I was so frustrated with these
interactions that I considered eliminating the project and returning to a pen and paper test.
However, reading the surveys made me realize that the inquiry-based authentic
assessment was the best way to assess my students’ learning.

The concern I had going into this project questioned which type of assessment
would best allow my students to apply and convey the knowledge learned during a unit
based on the scientific method. I could have chosen to give a pen and pencil test or a
project-based assessment where students had to apply the knowledge learned to a topic of
their choosing. The pen and pencil test would have been “quick and easy” to administer
and grade. The production and presentation of the project-based assessment was time-
consuming. I had to justify the extra time consumed by the inquiry-based project
compared to the traditional method of a pen and paper exam. Lord & Orkwiszewski
(2006) described this as a way of teaching that engaged students mentally and physically while leading to enduring understanding rather than passive tune out.

C. Future Considerations

This action research project was much more of a challenge for me than I had expected it to be. The frustrations were numerous and I was not sure I was doing the right thing by using an inquiry-based project as the final assessment for the Scientific Method Unit. The students were unsure of their ability to come up with an acceptable project idea and develop a question right from the presentation of the assignment. There were plenty of frustrations as I guided the students through the first few steps of the project check-ups. However, we did get to a point where the students started to realize that I was not asking them to do something that they were incapable of doing. They started to realize that their ideas were suitable for the assignment and they could successfully get through the project. My stress and aggravation turned to hope. I was proud of my students for producing a project that was developed from start to finish. More importantly, I was proud of them for not giving up. In the end, they were proud of themselves for the final product they produced.

In the future, I think I need to introduce inquiry-based assignments on a smaller scale to give the students the practice needed to attempt the project. This will allow my students to develop confidence in their own inquiry-based skills, and to trust their ideas as participants in their own learning.

Inquiry is a difficult skill for me as an educator as well. In the research about inquiry-based education, the articles dealt more with, what is inquiry-based learning rather than how to teach inquiry-based learning. The problem I discovered was that the
information available did not teach me how to implement inquiry-based teaching. This information, however, was useful in developing my ideas of pedagogy and what is important to me as I work to become the best educator I can be.

The few articles I did find that were based on implementation showed that the inquiry-based assessments were not very successful. In *Investigating the Use of Inquiry & Web-Based Activities with Inclusive Biology Learners*, two educators, a biology teacher of 37 years and a special education teacher of 10 years joined forces to design an inquiry-based biology program for low level regular education students. Twelve students had IEP’s and several of the students were unmotivated. The educators were seasoned teachers, but they were never trained in inquiry-based investigations for the laboratory setting. The teachers discovered that the way they were implementing the inquiry-based learning often left the students on their own. The teachers worked with small groups or individual students to determine their level of learning from the activities. The lack of structure on a grand scale led to students being off-task and unable to maintain their attention which then required more time to complete their report writing. Many of the students expressed a preference for the hands-on learning. They felt like they were able to apply the acquired information and also thought they had learned more from the inquiry-based activities. The teachers also expressed a preference for the inquiry-based learning, but also noted the increased amount of time it was taking to get through the laboratory experiments.

The enthusiasm shown, the quality of work produced and the independence displayed by my students tell me this is a good way to teach. However, I had some reservations and reflections. I felt like there had to be an approach to balance the
demands of a curriculum with the benefits of inquiry-based teaching. I will continue to incorporate inquiry-based activities, assignments, and assessments into my teaching. I will need to continue my research to find a more efficient way to utilize this important pedagogy in order to further the quality of education for my students. This initiative must parallel meeting the demands of implementing the required curriculum.
References


Appendix A

Name_________________________  Class Color_________________________

Scientific Method Project

Parent Permission

You are becoming a fantastic scientist! Have you been wondering about and questioning the world around you? This is your opportunity to show that you are a fine detective of science by investigating your question using the scientific method.

This is an AT HOME project. You will need to discuss your choice with your parents/guardians before you begin for safety reasons, and so that they are aware that you do not need to spend money to successfully complete this project. The project consists of a written report of each step of the scientific method, an oral presentation to the class as to what you did, and a visual aid to help in the explanation.

Choose your question from the examples from class, ones found in the books in our room, or one you come up with on your own.

__________________________________________________________________________

__________________________________________________________________________ (question to be investigated)

__________________________________________________________________________ (parent signature)

Question due date: __________________________

Project Due Date: __________________________

Materials needed to complete your experiment:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Appendix B

Name__________________  Class Color______________

Part 1 – Scientific Method Project

Written Report Rubric

A written form of the Scientific Method is to be handed in. Your report will be at least five paragraphs.

**Question:** This should be the purpose of your investigation that is stated in the form of a question. It must be something you can determine through experimentation. Your question must be approved. (+3)

<table>
<thead>
<tr>
<th></th>
<th>Yes (+1)</th>
<th>No (+0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the form of a question</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Question is clearly stated with specifics</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Your question was approved</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hypothesis:** This is a sentence telling what you think is the answer to your question. You must use the words “I think... because... or If...then...” (+2)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you use the words</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>“I think... because” or “If...then...”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you state what you expect the answer to your question to be?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Experiment:** This is the part where you develop a step by step plan. You need to describe your set up so that someone else can recreate it. (+10 total)

0 missing 1 some 2 complete

1. You need to keep everything the same and test the one difference.

0 1 2

2. Be specific-brand/quantity when listing materials and giving directions.

0 1 2

3. You must list the steps using numbers and complete sentences.

0 1 2

4. Include what will be recorded for your data in the form of numbers. (Ex. the height of the bounce)

0 1 2

5. Include the number of trials you need to do the experiment to get accurate results.

0 1 2

Total

51
**Data:** Your data needs to be an organized record of the information required to answer your question. It must be presented neatly in the form of a table. (+10) You can use Excel if you choose.

<table>
<thead>
<tr>
<th></th>
<th>0 missing</th>
<th>1 some</th>
<th>2 complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of ruler</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Labeled</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Title</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Neat</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Total ____________

**Conclusion:** This is a paragraph proving the answer to your question by referring to your data. (+10)

<table>
<thead>
<tr>
<th></th>
<th>0 missing</th>
<th>1 some</th>
<th>2 complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paragraph form</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Answered the question</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Used facts to support</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Noticed things</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(discoveries, disappointments, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis accuracy</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Total ____________

**Total points for Experiment Report**

\[
\text{Total} / 35 = \_
\]
Appendix C

Name_________________________ Class Color __________________

Scientific Method Project

Check-up Assignments

Check-up 1

Question: This should be the purpose of your investigation that is stated in the form of a question. It must be something you can determine through experimentation. Your question must be approved.

Check-up 2

Hypothesis: This is a sentence telling what you think is the answer to your question. You must use the words “I think... because...” or “If... then...”

Check-up 3

Experiment: This is the part where you develop a step by step plan. You need to describe your set up so that someone else can recreate it. You need to keep everything the same and test one difference. Be specific, tell the brand and the quantity when listing materials and giving directions. You must list the steps using numbers and complete sentences. Include what will be recorded for your data in the form of numbers. Include the number of trials you need to do the experiment to get accurate results.
Appendix D

Scientific Method Project

Conclusion Requirements

1. Tell me what you did in your experiment.

2. Repeat your hypothesis from the second paragraph of your report (don’t forget to change the verb to past tense)

3. Tell me what actually happened when you did your experiment. This is a general statement about the data collected.

4. Compare your data to the hypothesis. Did you prove or disprove your hypothesis?

5. Final statement about the experiment. This could be what surprised you, disappointments of the experiment or discoveries you never expected.
Appendix E

Name_________________  Class Color ___________

Part 2 – Scientific Method Project

Visual Aid Rubric

Make your visual aid interesting by using a poster, Power Point, video, a demonstration of your project, etc. The visual aid should be:

<table>
<thead>
<tr>
<th></th>
<th>0 missing</th>
<th>1 some</th>
<th>2 complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neat</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Large for all to see</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Explained</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Helpful for explanation</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Used during presentation</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Total points for Visual Aid

___________________________________________/10 = _________
Part 3 – Scientific Method Project

Oral Presentation Rubric

You need to present your findings to your peers and teacher. You will be graded on how clearly you present your project. The presentation should be:

<table>
<thead>
<tr>
<th></th>
<th>0 missing</th>
<th>1 some</th>
<th>2 complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practiced for organization</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Loud enough for all to hear</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Practiced using eye contact</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Well paced</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Able to answer questions</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Total points for Visual Aid

_____________________________ /10 = _______
Appendix G
Scientific Method Project
Survey

1. You were required to hand in three check-up assignments. Were these check-ups helpful? Please explain.
   a. Question

   b. Hypothesis

   c. Step by Step Plan

2. What was the most challenging part of the project for you? Why?

3. What part of the project was the least challenging for you? Why?

4. Was there other support that I could have given you to assist in your completion of the project?

5. This project was the final assessment for this unit. Were you able to show me what you learned in this unit by doing the project or would you have rather taken a written test. Please explain your response.