Teaching Middle School Science Lessons Using Inquiry-Based Methods

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Teaching Middle School Science Lessons

Using Inquiry-Based Methods

by

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Teaching Middle School Science Lessons
Using Inquiry-Based Methods

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Chapter I

Introduction

A. Background

Inquiry-based teaching is a relatively new method of teaching in the classroom. Teachers provide students with materials and support in order for students to teach themselves the concept of the inquiry-based lesson at hand. Because of the amount of discussion and the thoroughness of inquiry-based lessons, some teachers hesitate to incorporate inquiry-based teaching into their classroom for fear that they are being wasteful with their class time (Newman, Abell, Hubbard, McDonald, Otaala & Martini, 2004). Because of the recent increased standards for all students in the United States (Manzo, 2006), it is important for teachers to use their time as efficiently as possible. Time saved within the classroom can be time used to teach to these new benchmarks. Using thematic units that have some inquiry components to their lessons is one strategy that teachers have used in order to expose students to a magnitude of curriculum in a short amount of time (Garner, Wissick, Schweder, and Canter, 2003).

Education has evolved since the days of the one room schoolhouse. Rose and Campbell’s research on historical schoolhouses and what is commonly referred to as “The Prairie Years,” explains how the earliest teachers had schoolrooms of students that varied in age and skill. These teachers had limited materials and taught students using the lecture or traditional method (1997). This is one of the many models of teaching that is still used in classrooms today (Wheeler, 2006).
Traditional science lessons are the reason Lunetta (2004) feels that students are not as engaged in science. She suggests that the amount of factual information they have to memorize takes away from their personal connection to the curriculum being presented. Lessons that are more hands on require less memorization and demonstrate increased retention of new content. Lunetta’s research suggests that science lessons should be reconstructed to engage more students. Making lessons applicable to everyday life, while still making them interesting, engages more students. Teaching has evolved and the traditional method of teaching is not the only way to instruct students. Although teaching traditionally still is used often within the classroom, there are other instructional methods that have developed since “The Prairie Years” that Rose and Campbell reminisced about in their research (1997).

Inquiry-based teaching is one method that teachers are using more in their classrooms (National Science Teachers Association, 2006). Ross, Skinner, and Fillippino date the inquiry approach back to the early 20th century when interdisciplinary thematic instruction was introduced (2005). Patrick and Yoon identify inquiry as asking questions about the world and then seeking answers to those questions (2004). Inquiry-based teaching encourages students to learn as much as they can from the lessons that their teachers prepare. Students take the materials and construct their own knowledge. Inquiry teaching encourages students to develop and answer their own curiosities.

Ross et. al. suggest that because inquiry teaching requires hands on application and the manipulation of materials, the lessons can sometimes take longer
than lessons that are taught the traditional way. They explain that when teachers do not have a firm grasp on teaching, the lessons can be misinterpreted and scientific myths can arise (2005). Without proper structure and guidance throughout a lesson, students can misunderstand scientific concepts and actually reinforce scientific myths. It is imperative for teachers to be informed and trained on how to implement the inquiry method of teaching into their classroom (Maroney, Finson, Beaver, & Jensen, 2003).

With the time constraints that teachers face, the question is whether to use an inquiry or tradition approach when teaching science. Students learn at different levels and at different rates. Is teaching using the traditional or the inquiry approach more advantageous to teachers with a limited amount of time to teach a specific concept? Gardner introduced the idea that students have different learning styles. His latest research adds that students’ learning styles may or may not be attributed to the social and economic conditions that they come from (2003). Each classroom environment and each group of students has diverse needs that may lend to different styles of teaching. It is necessary for teachers to know their students well and recognize what learning style works for each individual student.

Learning using the inquiry method is kinesthetic and many students benefit from kinesthetic learning (Gardner, 2003). Does traditional or inquiry methods of teaching cater to more learning styles in classrooms? There are numerous questions that surround these two specific methods of teaching, but in this paper, the focus question was which teaching method, inquiry or traditional, provided better
assessment results, created more enthusiasm for science, and increased the confidence of students so they verbalized and applied their newly acquired knowledge?

B. Statement of the Problem

Science teachers have a limited amount of time to teach and have recently been required to reach different benchmarks (Wheeler, 2006). Many teachers know that using a traditional approach when teaching is not always the most engaging, but they use it because they can go through the curriculum faster. According to Newman, Jr. et. al. (2004), teaching, using inquiry-based instruction, takes increased teacher knowledge about the scientific concept being taught and is more time consuming. I believe some teachers are hesitant to use this method for fear that it is not efficient. In this study, I have compared the results of pre- and post-assessments, student surveys, and student interviews to identify which method of instruction produces better assessment results, and evokes a more enthusiastic attitude towards science for sixth grade special education students.

C. Significance of Problem

The curriculum that science teachers are required to cover can be challenging because of the depth of it (Manzo, 2006). Teachers have to determine the important pieces of the curriculum in order to plan what to spend a significant amount of time on. Staying on pace and getting through an entire year of curriculum can be difficult, and inquiry-based lessons are more time consuming that the lessons that are taught
traditionally (Newman, Jr. et. al., 2004). Producing research that might suggest that inquiry based teaching provides better assessment scores may help teachers justify the amount of time they spend on inquiry-based lessons.

D. Rationale

As a fourth year teacher, I am still looking for best practices to use in my lessons. In my classroom, I am responsible for maintaining basic skills developed in previous grades, and increasing the background knowledge of my students so they can retain more content taught in their grade-level core area classes. Without a set curriculum, there is flexibility in my teaching schedule. The district does advise me to teach strategies that will increase the amount of material that my students will comprehend when they read. Teaching thematic units has been one way that I can teach material that broadens background knowledge while still meeting the district’s expectations for content. Because of this, I bring a lot of science units and lessons into my classroom and teach a variety of reading comprehension and writing skills within these science units. My students do not comprehend as much of the science material as I would like them to understand. I hope my research suggests that inquiry-based teaching increases the amount of retention that students have at the conclusion of the water cycle unit. Research is limited in regards to science and inquiry-based teaching and I have provided one example of how successful the inquiry method of teaching was in my classroom.
My action research involved seventeen students who had been taught a unit on the water cycle. Using my two learning lab (resource room) classes, Group A, consisting of nine students, was taught using the inquiry approach. Group B, consisting of eight students, was instructed using the traditional approach. Both groups were given the same pre-test to assess background knowledge about the topic. In addition, both groups were assessed with the same test at the conclusion of the unit to determine the amount of information retained.

Because the inquiry-method of teaching is relatively new compared to other methods of teaching, the research in science classrooms is limited. Researchers are concerned about the lack of knowledge that teachers have in science and question whether or not a teacher with limited scientific knowledge is capable of teaching the inquiry-method successfully. When teachers are qualified and have the appropriate knowledge, the inquiry method has proven to be successful in classrooms.

The following review of literature uncovers considerable research related to inquiry-based instruction.

E. Definition of Terms

**Traditional Method of Teaching:** a method that is teacher-centered where the teacher presents information to students using lectures and worksheets. Information is presented to the whole class, and the student is responsible for constructing their own learning based on this method.
**Inquiry Method of Teaching:** a student-centered model of teaching where students construct their own knowledge using the materials provided by the teacher. Students are guided through lessons in order to solidify their knowledge and alleviate misunderstandings. Teachers circle and monitor student groups to make sure that specific content is covered, but simply guide students through content so students construct knowledge on their own.

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Chapter II

Review of Literature

Social constructivism and instructional methods

Theories and practices in education have evolved since the time of the one-room school house. Ross and Campbell’s research about the earliest education suggests that historically all students of different backgrounds and ages were grouped together in a classroom to learn. Students were usually first through eighth graders, and class sizes ranged from six to forty or more students. All subjects were taught with an emphasis on reading, writing, and arithmetic, but history, physiology, and geography were touched upon throughout the year. These school houses contributed to the literacy of the nation (1997).

As schools progressed, they became more targeted to the age and ability levels of students. Jean Piaget’s research suggested that the study of science needed to be appropriate for the individual student’s stage of intellectual growth (as found in Hall, 2000). It is Isaac’s research that began the idea of inquiry-based methods when she detailed how important it was for students to develop their own knowledge about the scientific world around them. Isaac believed that students of all ages could develop their own knowledge based upon their own curiosity. Piaget used the example of children not understanding the quantity of a liquid when it was transferred between containers to explain that the intellectual level of students needed to be considered when teaching them about the world around them (as found in Hall, 2000).
Science education shifted as a result of a combination of Piaget’s and Issac’s research. The inquiry-method of teaching was developed because of Isaac’s philosophies on how children can inquire about the world around them, but with the notion that they need to be monitored in order to assure that they are learning and developing correct scientific knowledge that is appropriate for their intellectual stage of development (as found in Hall, 2000).

Because students are going through physical, emotional, and academic changes during their middle school years (Patrick and Yoon, 2004), the National Science Teachers Association, in 2003, stressed the importance of capturing the interests of these students in order for students to embrace scientific concepts and phenomena. Creating a safe environment that allows students to inquire and answer their own scientific questions is the responsibility of the middle level science teacher (National Science Teachers Association, 2003). Teachers of middle level science have the responsibility of recognizing the struggles that middle level students have, in regards to their physical, emotional, and academic changes, and restructuring lessons to accommodate those changes (NSTA, 2003).

One way that teachers can restructure their lessons is by using thematic units. Thematic units can help a multitude of learners, including students with disabilities and general education students. Thematic units view learning holistically and focus on one scientific concept, while the reading, math, and social studies lessons also focus on that scientific concept. This has proven effective in classrooms and allows students to make connections between subject areas, and demonstrate how
interconnected science is with the real-world (Gardner, Wissick, Schweder, and Canter, 2003).

When interdisciplinary units are taught, students ask a lot of questions and make meaningful connections to the curriculum being presented. Gardner, et. al., suggest that a holistic approach is similar to the interactive world that we live in and that students with disabilities benefit from thematic units (2003). Organizing instruction in this manner benefits students by encouraging them to seek answers for their own questions and develop a broad range of knowledge in regards to a specific concept.

With interdisciplinary units, literacy and science make a solid connection. Reading within the content area allows students to make gains in the problem-solving process (Creech and Hale, 2006). The focus of incorporating science content and literacy is to build knowledge about a specific science topic, while practicing skills that make students better readers. The interdisciplinary nature of thematic units provides the opportunity for skills and content to be taught in a short period of time.

Ten years ago, educators, scientists, and parents developed a plan for students to encourage scientific literacy at different grade levels. This was called the National Science Education Standards (NSES, 2000). The organization released the importance of hands-on activities and structured learning experiences. During the development of NSES, states decided that the best way to encourage a science curriculum was to standardize it, but it was important to develop assessments and produce a set of standards that would help curriculum development at each level.
These assessments and standards have guided states into creating a curriculum that is focused, consistent, and appropriate for students at the elementary, middle, and higher levels. The standards are worded to encourage hands-on activities, and inquiry-based teaching (NSES, 2000).

Inductive learning is another form of inquiry-based teaching that is motivating for students. It takes student learning styles into consideration and has shown results in the classroom. Prince and Felder’s research suggests that inductive learning encompasses inquiry-based instruction because students are presented a challenge and then guided through their learning so that the appropriate information is acquired (2007). Students feel responsible for their own learning, and their enthusiasm is demonstrated in their increased contribution to discussions and activities that follow the lesson.

Prince and Felder’s research (2007), coupled with the National Science Education Standards (2000), and Patrick and Yoon (2004) indicate that the inquiry method of teaching is beneficial for students. Other research by Prince and Felder (2007), and research by Newman, Jr., Abell, Hubbard, McDonald, Otaala, & Martini, (2004) discusses the amount of planning time that is required for inquiry-based lessons and how some teachers hesitate to incorporate these lessons into their classrooms. These teachers are afraid of the extra work and planning that is involved with setting up an inquiry classroom. Teachers that incorporate cooperative learning activities into their classroom are more apt to teach inquiry-based science because students have to rely on the strengths of their group mates and are more apt to work...
with one another (Prince and Felder, 2007). Using the strengths of the group is
drawing upon the different learning styles that students have.

Knowledge about learning styles and Howard Gardner’s concept of Multiple
Intelligences can assist teachers who are developing an inquiry-based classroom.
Gardner’s research explains how people learn best when information is presented
appropriate to their learning style. The different learning styles include: linguistic
intelligence, logical-mathematical intelligence, spatial intelligence, musical
intelligence, intrapersonal intelligence, bodily-kinesthetic intelligence, interpersonal
intelligence, and naturalist intelligence. Using knowledge about students’ primary
intelligence can help teachers build groups that are well rounded (Armstrong, 2007).
Lectures that expect students to take notes appeal to students that are linguistic
learners, and math lessons would be easy for the logical-mathematical learner
(Armstrong, 2007). Considering these intelligences while grouping students is
important for teachers that are developing their inquiry-based classroom.

Benefits of teaching inquiry

The Weizmann Institute of Science performed research in Israel that identified
benefits of teaching using the inquiry method. Students in 11th and 12th grade in
Israel, under the research of Hofstein, Navon, Kipnis, and Mamlok-Naaman, were
presented chemistry curriculum two different ways. One group of students was
presented the curriculum with a focus on the inquiry method and the other group was
presented the chemistry curriculum in lecture format with notes. Research suggested
students asked more scientific questions when information was presented using the inquiry method of teaching (2004).

Students that were in the inquiry group asked both higher level questions and lower level questions. Students in the control group asked less questions, and the quality of the questions was lower (Hofstein, et. al., 2004). Hofstein, et. al., suggested that learning was more meaningful for the students in the inquiry group and, because students connected with more of the information that they were being presented, they had more questions that furthered their understanding of the curriculum (2004).

All students that participated in this research were asked to read a scientific article about the chemistry content they had just learned. When questioned about the article, students in the inquiry group answered more questions correct and were more thorough than students in the control group. Students in the inquiry group also spent more time on the questionnaire, in comparison with students in the control group. This research indicated that chemistry teachers in Israel were given time to develop and implement an inquiry-oriented program in order for students to make more connections to the curriculum (Hofstein, et. al, 2004).

Improving student attitudes and fostering more interest in activities affects student success in the curriculum. The attitudes that students had towards science improved when students participated in laboratory activities (Hofstein and Lunetta, 2002). Students had more social opportunities and engaged in cooperative activities, which improved their attitude towards science curriculum. Students that are
motivated by their own curiosity retain more information and are more successful on assessments (Wilhelm, 2007).

Building upon what students already know is the foundation for a successful inquiry lesson. The teacher, in Wilhelm’s research, had students develop Lego cars and provided a rubber band to see if they could get the car to move. While setting up the inquiry lesson on potential energy, one fourth grader discovered how energy transfers from one Lego car to another. The boy, without any direct instruction, commented, “…but you can’t use the energy unless you connect it somehow to the axle or the wheels on the car. You have to, like, transfer it—the energy, I mean—to the car,” (Wilhelm, 2007, p. 45). The teacher’s responsibility, during this portion of the lesson, is just to listen and guide students towards acquiring their own knowledge. The teacher is not concerned about every student learning exactly the same information, but is mindful of the process that students go through to develop their own understanding.

One example of an inquiry-based curriculum experiment that was researched at the middle grade level was a project called Chemistry That Applies (CTA). Scaling Up Curriculum for Achievement, Learning, and Equity Project (SCALE-uP) was the research organization that funded the investigation of inquiry-based curriculums with different middle schools in the Maryland area. The CTA curriculum was effective with students with disabilities when compared with other programs (Lynch, Taymans, Watson, Ochsendorf, Pyke, & Szesze, 2007).
In the CTA program, students with disabilities demonstrated the same amount of growth as general education students. Special education students were still below general education students’ level of performance, but they made the same amount of gain as their general education peers. In other programs that were funded by SCALE-up, special education students did not see the same increase in growth as general education students (Lynch, et. al., 2007). This was a success for the CTA program and researchers credited the responsibility that students were required to demonstrate while they investigated the curriculum (Lynch, et. al., 2007).

Another curriculum program that is similar to the inquiry-method by focusing on the process that students take to acquire their own knowledge is the Learning By Design program. It is tailored to the middle school science classroom. Teachers who participated in the Learning By Design program reported that students consistently learned science content as well, or better, than students who were not involved in the program (Kolodner, Camp, Crismond, Fasse, Gray, Holbrook, Puntambekar, & Ryan, 2003). The curriculum project encourages all students to participate in their own learning and fashions a learning environment that motivates students to investigate scientific phenomena. Students, in the process of answering their own curiosities, increase their cognitive, social, learning, and communication skills (Kolodner, et. al., 2003). The program’s ritualized activities that are also sequenced, allow teachers who are unfamiliar with certain scientific concepts to teach lessons with confidence. Kolodner, et. al’s research shows a significant amount of gain with students that are
the most socio-economically disadvantaged and that tested the lowest on the pre-tests conducted at the beginning of the study (2003).

In addition to the results with socio-economically disadvantaged students, the Learning By Design (LBD) program’s results indicate that it is highly motivating for girls in the middle grades. In pre-tests, girls, on average, scored lower than boys. Post-tests indicated that girls performed equal to or ahead of boys as a result of the inquiry-based program (Kolodner, et. al., 2003). The LBD program had results that were encouraging for teachers and school districts, but especially for districts with a high number of students considered socioeconomically disadvantaged.

Limitations in teaching using the inquiry method

As mentioned in Hofstein’s research (2004), inquiry-based laboratory work is only successful if students have the opportunity to connect to the curriculum. They also must discuss and reconstruct their own knowledge during the lab. If students perform a technical task without making a connection to it and do not have the opportunity to perform a meta-cognitive activity to go along with it, then the laboratory has not been a good use of time (2004).

Teaching inquiry lessons can be time consuming. Newman, Jr. et. al., discussed in their research that limited planning time did not allow teachers to correctly develop inquiry lessons and that when a lesson was hastily planned, students can misunderstand the content being presented. Students may waste valuable class
time on investigating a less important content strand and miss the specific content that was supposed to be acquired (2004).

Newman, Jr. et. al., also addressed one major problem when presenting a lesson using the inquiry format: What happens when students just do not understand the concept that they are supposed to be investigating? Frustration and doubt can occur when students become overwhelmed with the scientific content, and that can result in wasted class time and a negative attitude about science and science curriculum. The researchers also explained that differentiation is possible when teaching using inquiry, but requires a lot of teacher/aide support, which is not available in all schools (2004).

Research by Heppner suggests that inquiry is the superior method of teaching but, that there are factors that must be considered (2006). He explained the possibility that when extra attention is paid to subjects, the experiment produces favorable results and that the method is not the variable that is causing students to perform better (2006). Although Heppner believed that results could be swayed based on the extra attention that students are provided, he further clarified that students’ increased enthusiasm is enough to support the inquiry method being implemented into classrooms (2006).

Newman, et. al.’s research asked students to keep a journal about their learning. These college undergraduates expressed concerns about not learning specific science content and that the activities were more of a social interaction versus content that was learned. The researchers were concerned that if college level
students did not take some of the activities seriously during investigation time, possibly middle and high school students would struggle as well (2004). Future teachers of inquiry that have limited experiences with learning using the inquiry method alarmed these researchers. If these future teachers have not learned using inquiry, will they be sufficient at teaching using the method itself? If not, then how much will elementary, middle, and high school students learn?

Preparing teachers to teach the inquiry method

Universities implemented course work into teacher education programs that highlighted the inquiry method of teaching science. Because special education students and general education students perform better on assessments when presented material using the inquiry method, teacher certification programs focus on preparing future teachers on teaching using the inquiry method (Maroney, Finson, Beaver and Jensen, 2003).

Colleges found that students in certification programs were not familiar with the inquiry method, and first needed to observe the inquiry method, in action, during a science class. Afterward, college students were required to reflect on their observations and identify how their observed classroom was different than science classrooms they were used to (Maroney, et. al., 2003). This research explained how teachers need inquiry skills themselves before they can teach students how to inquiry about the world around them. In addition, inquiry-based lessons are time consuming and difficult to prepare for, and students in teacher certification programs need
instruction on how to manage their planning time and create inquiry lessons (Newman, Jr., et. al., 2004).

Inquiry classrooms must be set up at the beginning of the year and should allow students to ask questions comfortably, and encourage the sharing of opinions and observations (Maroney, et. al., 2003). Classrooms that are fit for the inquiry method are supportive, and have teachers in them that are always encouraging students, yet rarely providing evaluative comments that may dissuade students from furthering their investigation. This balance must be maintained and practiced before a teacher is fully prepared to teach using the inquiry-method (Maroney, et. al., 2004). Universities that have embraced the inquiry method provide future teachers the opportunity to practice in classrooms with students, only after a significant amount of observation time with a teacher versed in the inquiry method.

Although the inquiry method is beneficial to a wide range of students, it is not always the best fit. Manrubang expressed that teachers should be prepared with a variety of strategies and teaching methods based on the needs of the students, the curriculum, and current events (2004). Also important in Manrubang’s research, is the idea that future elementary science teachers should have some background in science.

Education in life science, physical science, earth science, and scientific reasoning would benefit future elementary science teachers and better prepare them to use the inquiry method in their classrooms. Because inquiry lessons evoke detailed, higher level questions, future teachers need this background to answer questions accordingly. The Full Option Science System is one module that universities can
adopt to provide their future teachers with the necessary background knowledge in science (Manrubang, 2004). When students have time to practice during their student teaching practicum and they have the background in science, they are better prepared for their own classroom when they are hired for their first teaching position (Manrubang, 2004).

When teachers are not taught how to inquire themselves, they cannot teach their students how to inquire during a science lesson. Teachers that are expected to use the inquiry method should receive professional development and support in order to use the method effectively in their classroom. Manrubang discussed that teachers who are not fresh out of college should be provided additional support to assure they fully understand the inquiry method and its components (2004). Beginning teachers that have observed the inquiry method and practiced it are better prepared to teach using it when they have their own classrooms. These teachers create classroom climates that foster investigation, cooperation, and higher-level thinking (Manrubang, 2004).
Chapter III

Methods

Introduction

The main objective for this action research study was to examine whether or not students performed better on assessments and were more enthusiastic during interviews when a water cycle unit was presented to them using the inquiry-method of teaching. This method was contrasted with the traditional lecture-based method. This research helped develop impressions about inquiry based learning within the inclusive classroom.

Participants

The members of the target group for this specific action research paper were sixth grade special education students in a rural school district located forty-five minutes from Rochester, New York. This study included seventeen sixth grade students in two different classes and one special education teacher. There are about 600 students in the school, which is the only middle school in the district. Based on the number of students that receive free and reduced lunch, the poverty rate is about thirty-five percent. The two classes that participated in this study, represent a population that is more impoverished than other classes in the school. Of the seventeen students, sixteen are Caucasian, and one is a racial minority. In this study, the class that attends learning lab first during the day is referred to as Class A, and the second group is referred to as Class B.
Procedures

Students that attend learning lab are taught lessons that are focused on math concepts and English concepts, but are taught cross-curricularly. Students in Class A and Class B were taught a unit on the water cycle, focusing on vocabulary words and the verbal/visual vocabulary strategy. Both classes took the same pre-test and post-test that would determine their acquisition of knowledge of vocabulary terms throughout the unit. Both classes focused on the following vocabulary words: condensation, precipitation, collection, and evaporation. Both Class A and Class B were required to write the life story of a waterdrop. In addition, both classes were interviewed by the teacher at the conclusion of the unit to discuss components of the unit.

The vocabulary words and concepts that were taught during Class A’s unit were taught using the inquiry method of teaching. Condensation was taught using frozen cardboard and holding it over boiling water to see the water beads that form. Precipitation was taught using the same lesson from condensation, but actually letting the beads fall onto a piece of tissue paper under the cardboard. Collection was taught with a cup of soil, letting precipitation fall onto the dry soil until a puddle appeared. Evaporation was taught by taking the beginning measurement of water, letting it boil for ten minutes and letting it cool, and then measuring it again. Students also watched movies on www.brainpop.com, reviewing the previous day’s vocabulary term. Students completed Verbal/Visual worksheets that served as notes during the
lesson (see Appendix A). Students in Class A were also given a packet with definition of the vocabulary words on it (Appendix C).

Students in Class B were instructed using a lecture-based method of teaching. Students used worksheets that explained the different vocabulary words with pictures (see Appendix B). The teacher drew pictures on the overhead, made reference to the weather outside, and lectured students while they took notes in the traditional notes packet. Students reviewed the previous day’s vocabulary word by discussing it, and drawing a picture on the whiteboard. All students in Class B filled out the same Verbal/Visual worksheet, but did it in addition to the worksheets that they took notes on during instruction. Class B was presented the same material in the same amount of time, but without inquiry activities.

Instruments of study

At the beginning of the action research project, both groups of students were required to take a pre-test, which asked students for the vocabulary word, the definition, a picture, and a personal association with the word (verbal/visual worksheet) (refer to Appendix A). This worksheet was again used at the end of the unit with both groups as a post-test. All of the assessments were scored by the participating teacher. The teacher prepared the table of results in Microsoft Word.

Both groups of students were asked to fill out the survey to assess their feelings during the unit (see Appendix D). Those results were added to the table
created in Microsoft Word. Students filled out the chart independently, with a teacher there only to read the questions.

Students were also interviewed by the participating teacher and asked a series of questions to determine how the perceived the water-cycle unit (see Appendix E). Students were asked how they felt during the unit, whether they felt that they learned a lot during the unit, what activities they did during the water cycle unit, if they enjoyed the unit and the activities in it, and if there was anything that they felt the participating teacher should change before teaching the unit next year. Both Class A and B’s student responses to these interview questions were written down on the interview sheet and analyzed qualitatively to perceive the students’ feelings and enthusiasm during the unit.

Results of the surveys, assessments, and interviews can be found in the following chapter.
Student Achievement

Students in Class A and Class B were taught a unit on the water cycle, focusing on vocabulary words and the verbal/visual vocabulary strategy. The vocabulary words and concepts that were taught during Class A’s unit were taught using the inquiry method of teaching. Students in Class B were instructed using a lecture-based method of teaching.

Students in both Class A and Class B were required to take a pre-test at the beginning of the unit. The purpose of this pre-test was to determine how much background knowledge each student had on the water cycle at the beginning of the unit. This test was the same assessment that was used at the conclusion of the unit.

Both groups of students were also given a post-test to determine the information retained during each unit. The results of the pre-test and post-test are reported in Table 1, found on the next page.
According to Table 1 above, the eight students that took the pre-test assessment in Class A obtained an average of 55%. The highest score on the pre-test in Class A was 67%, which was achieved by three students. The lowest score on the pre-test in Class A was 42%, and was achieved by two students. The nine students that took the pre-test assessment in Class B produced an average of 45%. The highest score on the pre-test in Class B was 67%, which was achieved by one student. The lowest score on the pre-test in Class B was 25%, which was attained by one student.

The eight students that took the post-test assessment in Class A earned an average of 81%. The highest score on the post-test in Class A was 100%, which was achieved by a single student. The lowest score on the post-test in Class A was 67%, also attained by a single student. Class B, with nine students, earned 74% on the post-test. Two students achieved the highest grade of 83%, while three students earned the lowest grade of 67%.

<table>
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<tr>
<th></th>
<th>Class A Inquiry Unit</th>
<th>Class B Traditional Unit</th>
</tr>
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<tbody>
<tr>
<td>Pre-Test Verbal/Visual Average</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>Highest Grade</td>
<td>67%</td>
<td>67%</td>
</tr>
<tr>
<td>Lowest Grade</td>
<td>42%</td>
<td>25%</td>
</tr>
<tr>
<td>Post-Test Verbal/Visual Average</td>
<td>81%</td>
<td>74%</td>
</tr>
<tr>
<td>Highest Grade</td>
<td>100%</td>
<td>83%</td>
</tr>
<tr>
<td>Lowest Grade</td>
<td>67%</td>
<td>67%</td>
</tr>
<tr>
<td>Growth shown between Pre- and Post-test</td>
<td>26%</td>
<td>29%</td>
</tr>
</tbody>
</table>
On average, Class A showed 26% growth between pre- and post-test scores. The highest grade on the pre-test for Class A was 67%, while the highest grade on the post-test was 100%. Class B showed an average of 29% growth, with the highest grade on the pre-test being 67%, and the highest grade on the post-test being 83%. Both classes showed growth between the pre- and the post-test assessment, with Class B, the traditional group, showing 3% more growth between pre- and post-test assessment scores.

Student Attitude

At the conclusion of the unit, students in both Class A and Class B were given a survey that asked about the different activities in the water cycle unit (see Appendix E). The following survey terms expressed the ease of the activities: easy to accomplish, made me think, was difficult, and was too hard. The following table shows how the perception of ease varied with the method of teaching that was used for each unit. The average scores of the student survey questions are reported on the following page in Table 2.
The survey results indicate that 100% of students in Class A and 89% of students in Class B felt that the water drop story was easy to accomplish. The surveys for Class B also indicate that 11% of students felt that the story was difficult to accomplish.

Survey results for Class A indicate that 63% of students felt that the notes page, referred to as Inquiry Notes Packet (Appendix C) was easy to accomplish. The rest of the group, 37%, felt that the worksheet made them think. Class B’s surveys report that 44% of students felt that their notes page, referred to as Traditional Notes Packet (Appendix B), was easy to accomplish. In addition, 44% of Class B felt that the same worksheet evoked thought, while 11% felt that it was difficult to accomplish.

No surveys in Class A or B indicated that students felt learning the vocabulary was difficult. Class A’s data indicates 25% of students felt that the vocabulary
component of the unit was easy to accomplish, while 75% felt that it evoked thought. Class B’s data from the survey shows that 44% of students felt that learning the vocabulary during this unit was easy, while 55% of students felt that the vocabulary part of the unit was difficult.

The same pre-test was given to both groups of students. No students in Class A felt that the pre-test was easy to accomplish, while 70% felt that it evoked thought and 30% of the class thought it was difficult. Class B’s survey results for the pre-test reported that 56% of the class felt that the pre-test was easy to accomplish, while 44% of students in Class B felt that it evoked thought. No students in Class B indicated that they felt that the pre-test was difficult to accomplish.

Student responses on the survey indicated whether or not they felt each activity was enjoyable. Table 3 shows the variance between student perceptions of enjoyment level of activities based on the teaching style that was used for each unit. The following survey terms indicated students enjoyed the activities: fun to do, I didn’t mind it, I enjoyed it. Students also had a choice between the following selections that indicated that the activities were displeasing: I didn’t enjoy it, it was frustrating, it made me angry. The average scores that indicate whether students felt the unit activities were enjoyable or displeasing are reported on the following page in Table 3.
The survey results for Class A indicate that 25% of the students felt that the pre-test was enjoyable, while 75% felt that it was displeasing. All students in Class B felt that the pre-test was enjoyable.

All students in Class A reported that all other unit activities were enjoyable. Class B’s surveys indicate that 78% of students felt that learning the vocabulary during the unit was enjoyable, while 22% felt that it was displeasing. The surveys for the Traditional Notes Packet (Appendix B) report that 67% of students felt that was an enjoyable activity, while 33% felt that it was displeasing. The survey results for Class B show that 89% of the group felt that the water drop story was an enjoyable activity, while 11% felt that it was displeasing.

Students in both groups were interviewed at the completion of the water cycle unit. Each student was asked the same four questions: Did you feel that you learned a lot during the unit? What activities did you do during the water cycle unit? Did you
enjoy the water cycle unit and the activities in it? Is there anything that you think I should change before I teach the unit next year? (see Appendix F).

Responses to these questions varied between groups. Three quarters of students in Class A responded that they felt like they learned a lot during the unit. In Class B, 55% of students indicated during the interview that they felt like they learned a lot, where 45% answered that they did not feel that they learned anything new. The second student interviewed in Class B said that he already knew all of the information that was presented and that the unit was boring.

Students were asked “What activities did you do during the water cycle unit?” Out of seven activities, students in Class A mentioned four on average. All students in Class A mentioned the water drop story, with the individual experiments being the next most mentioned activity. One student in Class A said, “When we boiled the water to make the frozen cardboard rain, it was awesome!” The second student interviewed in class A responded, “I loved how the water evaporated when we boiled it, and when we made the cardboard precipitate. You should have used snow instead of cardboard though.” No students in Class A mentioned either the pre-test or the post-test.

Students in Class B responded differently to the question “What activities did you do during the water cycle unit?” Every student in Class B mentioned either the pre-test or the post-test. Three students mentioned both the pre-test and the post-test. One student in Class B responded, “I don’t remember anything except the notes packet and the tests.” Another student in Class B remembered the life of the water
drop story, and commented, "the water drop story was the best but I hated taking notes...I guess the notes helped us learn about the cycle a water drop goes through though." The notes packet was the most mentioned after the pre- and post-test. On average, five activities were mentioned during the interviews with Class B.

The third question that students were asked during the interview was whether or not they enjoyed the unit. One student in Class A said that they did not enjoy the water cycle unit, while the rest of the group said that they did. One female in Class A said, "I wish that we would do more experiments like the ones we just did during learning lab. This is the best thing that we have done so far!" In comparison with Class B, 55% of the class enjoyed the water cycle unit, with 45% responded that they did not enjoy it. The second student interviewed in Class B, responded to this question, "The notes packet is like everything else that we do in every other class. I usually think your class is more fun, but when we did this unit, it wasn’t."

The question on the Interview Response Sheet (Appendix F), "Is there anything that you think I should change before I teach the unit next year?" was asked to see if students felt connected enough to the unit to suggest on how to make it better. As reported in Chapter II, students that embrace the inquiry method of teaching feel their suggestions and comments are beneficial to teachers of inquiry. Fourteen suggestions were given during interviews with Class A. Seven of the suggestions indicated that the teacher should create more experiments and activities. The other seven suggestions referred to the pacing of the unit, i.e. "provide more time for the story," and "don’t spend as much time on evaporation." Students in Class B
gave a total of five suggestions. One of the suggestions offered was that "the whole unit should be changed because it is boring." The other suggestions offered were to eliminate the notes packet, and to "just have kids write the story because that was the only good part."

Conclusions and recommendations based on this data are provided in the following chapter.
Chapter V
Conclusions and Recommendations

Conclusions

The purpose of this thesis was to compare an inquiry-based science unit to a lecture-based science unit in terms of student attitudes towards learning and student achievement. I wanted to be able to justify spending extra time teaching inquiry units, rather than teaching lecture based units that take less time. I enjoy teaching inquiry units because I like the enthusiasm that students have during the units. I also like that students teach themselves at their own pace, but because the units take longer to teach and plan for, I needed justification for spending this extra time. This research would help me see which method of teaching provided better assessment results, and, if either unit influenced the attitude that students had towards learning science. By reviewing the results of the pre-test, post-test, surveys, and interview responses, I have formed some conclusions about the efficiency and success of the inquiry-based unit.

When comparing the pre-test results and the post-test results, it was evident that both groups of students increased their knowledge about the water cycle. Although not expected, the traditionally taught group of students (Class B) had 3% more growth between pre- and post- test scores than the inquiry taught group of students. However, students in Class A started with a higher percentage correct when they took the pre-test. This could account for why Class B showed more improvement. Class A’s post-test results (88%) indicate increased mastery when
compared with Class B’s post-test results (74%). The data suggests that students in Class A constructed deeper understanding of unit content and were able to demonstrate that on the post-test assessment.

When analyzing the survey results, several interesting interpretations can be made. Class A felt that the pre-test evoked thought and was difficult. The majority of Class B responded that it was easy. I believe that while filling out the survey, students in Class A compared the hands on activities of the inquiry unit, to the pencil and paper pre-test, which may have caused them to mark that the test evoked thought or was difficult. In comparison, they believed that learning the vocabulary and filling out the Inquiry Notes Packet (Appendix C), was easier than the pre- and post-test, as reported in the survey. This is why they marked those activities as easier.

Students in Class B may have thought that the pre-test was easier than taking notes during the lecture-based lessons. Their responses on the survey suggest that they may have indicated that the pre-test was easier, while the vocabulary component of the unit and the worksheets that went along with the daily activities evoked thought or were difficult. The interview responses from Class B indicated that the notes packet was boring, and many survey responses indicated that the notes packet was difficult. Based on that, I think that students in Class B found that the format of the pre- and post-test was more enjoyable than the note taking involved in the daily activities, which is why they indicated that on the surveys.

The difference in survey results for each group that indicate whether or not unit activities were enjoyable suggests that Class A’s inquiry unit had activities that
were more enjoyable than Class B’s traditionally taught unit. It is clear that students in Class A felt that their unit activities were more enjoyable than Class B’s unit activities. This indicates that units taught using the inquiry method are more pleasing to students.

Based on the survey results, the water drop story was clearly the most enjoyable activity for both groups of students. The post-test results show that students in Class A had a more solid understanding of unit concepts. Therefore, that group of students went into the water drop story with more knowledge and the activity was easier for them. Although, the majority of students in Class B felt that the water drop story was an easy activity, one student felt that it was difficult. This could be because that student traditionally struggles during writing activities, or because that student did not fully understand the water cycle and because of that, had a difficult time writing the story.

The interview results show that students in Class A really thought the water cycle unit was fun and interesting. Students in Class A felt that they learned a lot and expressed that during the interview. This indicates that students finished the unit thinking that they had a solid understanding about the water cycle, and in actuality, they did demonstrate significant knowledge about unit content on assessments given.

The survey question that asked students to tell about the unit activities was asked to see what activities were memorable. The activities that they really enjoyed, or they really disliked were mentioned, and I was curious which activities were mentioned for each group. Of the seven activities, it was interesting that Class A only
remembered four activities, on average. The majority of students in Class A remembered the vocabulary notes packet, each experiment that taught them the different stages of the water cycle, and the water drop story. No students in Class A mentioned the pre-test or the post-test. To them, that was not a memorable activity. They remembered lessons.

In comparison with Class B, all students listed either the pre-test or the post-test as one of the activities. The two other activities that were mentioned were the water drop story, and the vocabulary notes packet. Students in Class B remembered the assessments, instead of the lessons that were supposed to teach them the content.

The final question asked students to provide suggestions on how to improve the unit. It prompted 14 suggestions in Class A, and five suggestions in Class B. One interpretation of this data is that students in Class A felt that a lot needed to be changed in the unit, especially when compared to the lack of suggestions in Class B. Another interpretation of this data is that students in Class A felt more “in charge” of their learning, when constructing their own knowledge about the water cycle, and therefore, felt that their suggestions had more worth. This goes along with research that was cited in Chapter II of this project. When students are more connected with their learning, as in inquiry lessons, they are more apt to provide suggestions and comments as to how to make the lesson better.

Students in Class B chose not to contribute to this question, possibly because they did not feel connected to the unit and did not feel that their opinion was needed. When students in Class A were their own teacher, as in this inquiry unit, they were
more apt to provide suggestions on ways to make the unit better. When I lectured, students did not have specific ways to make the unit better, but did feel the need to comment that the unit was boring. The suggestions from Class A were significantly more positive and constructive than the responses from Class B, which also suggests that the inquiry unit created a more positive attitude towards learning when compared to the traditional unit.

Recommendations

Throughout my teaching career I have contemplated taking more time and teaching inquiry lessons in my classroom. They take a lot of preparation before hand, and a lot of class time, but I always wondered if students acquired more knowledge and had a better attitude towards learning when taught using this method. I wanted to know if inquiry teaching was, like most research suggests, worth it. By reviewing the literature on inquiry based teaching, and completing this action research project in my classroom, I found that there were many benefits to inquiry based teaching. These benefits included increased student performance, deeper understanding of content taught, and a more positive attitude towards learning.

When inquiry units are taught effectively, students construct their own understanding. They teach themselves the content that needs to be learned. It is acquired at their individual learning levels. Students that were taught traditionally learned the content that was taught, but students that were taught using the inquiry method demonstrated increased mastery of the water cycle curriculum. Research is
limited in the inquiry approach, especially at the middle school level with science curriculum. This specific research was one positive example of inquiry-based teaching with middle school special education students.

If I were to do this research again, I would open it up to general education students to see how they preformed. This research was specific to special education students, and it would be interesting to see the success that the special education students would have while integrated with their general education peers. This would determine how successful inquiry-based science lessons would be with different levels of learners. This research would also hint at whether or not differentiation was appropriate during inquiry-based lessons.

I would change the unit topic if I were to do this research again. The water cycle unit was something that some students had a lot of knowledge on, and some students had no knowledge on. This made it difficult to determine whether or not the actual unit was the reason for success or if students were just accessing background knowledge while taking assessments. If I was to redo the research, I would choose a topic that was out of the ordinary and was something that I knew students had exceptionally limited knowledge on. Being a special education teacher that is not required to teach science content, I would choose a science topic that was interesting and not previously taught.

Determining learning styles has always been something that I have done at the beginning of the academic year for my students. Comparing learning styles with success using the inquiry method of teaching is another area that I would explore,
given the chance to do this again. Now that school districts have assessments that
determine learning styles, it would be interesting to see if a certain style was more
successful or unsuccessful while using the inquiry method. Would students that are
kinesthetic learners be more successful using inquiry than students that are visual
learners? It would be interesting to determine the success that different learning
styles had using the inquiry method.

This action research project has provided the professional justification that I
needed to spend extra class time on inquiry-based lessons. Although there is an
increased amount of preparation that inquiry lessons require, this project has
motivated me to spend that extra time getting my classroom inquiry ready. I will
develop inquiry lessons that are appropriate for my students and focus on interesting
scientific content. Having students teach themselves was so much more effective
than lecture teaching. I felt that my students learned more from constructing their
own knowledge with little adult support, when compared with the group that I
lectured to. Because of that, I plan to develop more group work where my students
can rely on each others’ strengths to overcome their weaknesses. By using inquiry
often, my hope is that my students will continue to teach themselves and others, while
building confidence and demonstrating enthusiasm about science.
References


Name:

Directions: Label the parts of the water cycle

A – evaporation
B – condensation
C – precipitation
D – collection

Appendix A
Pre-Test Watercycle
Evaporation is when the sun heats up water in rivers or lakes or the ocean and turns it into vapor or steam. The water vapor or steam leaves the river, lake or ocean and goes into the air.
Water vapor in the air gets cold and changes back into liquid, forming clouds. This is called condensation.
Precipitation occurs when so much water has condensed that the air cannot hold it anymore. The clouds get heavy and water falls back to the earth in the form of rain, hail or snow.
When water falls back to earth as precipitation, it may fall back in the oceans, lakes or rivers or it may end up on land. When it ends up on land, it will either soak into the earth and become part of the "ground water" that plants and animals use to drink or it may run over the soil and collect in the oceans, lakes or rivers where the cycle starts all over again.
Evaporation is when the sun heats up water in rivers or lakes or the ocean and turns it into vapor or steam. The water vapor or steam leaves the river, lake or ocean and goes into the air. Make your own evaporation. With an adult’s help, heat some water in a kettle. Watch closely! Do you see the steam rising? That’s evaporation!
Condensation

Water vapor in the air gets cold and changes back into liquid, forming clouds. This is called condensation.

To see condensation in action, put a large (at least 8 ½ x 11) piece of cardboard (a book will work) in the freezer for about an hour. Now, take the boiling kettle of water and hold the cold book about 1 foot over the spout (right in the steam... wear oven mitts). Water droplets will form on the book. That's condensation!
Precipitation occurs when so much water has condensed that the air cannot hold it anymore. The clouds get heavy and water falls back to the earth in the form of rain, hail or snow.

If you continue the condensation experiment long enough, so much water will condense on the book that it won’t be able to hold it all. At that point, water will start dripping down from the book and you’ve created precipitation!
When water falls back to earth as precipitation, it may fall back in the oceans, lakes or rivers or it may end up on land. When it ends up on land, it will either soak into the earth and become part of the "ground water" that plants and animals use to drink or it may run over the soil and collect in the oceans, lakes or rivers where the cycle starts all over again.
<table>
<thead>
<tr>
<th>Vocabulary Word</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporation</td>
<td>Circle the part of the water cycle this word represents</td>
</tr>
</tbody>
</table>

**Visual**

- Circle the part of the water cycle that this word represents.

**Diagram**

- **A**: Evaporation
- **B**: Condensation
- **C**: Precipitation
- **D**: Collection

**Personal Association or Characteristic**
## Verbal / Visual Packet

### Condensation

<table>
<thead>
<tr>
<th>Vocabulary Word</th>
<th>Visual</th>
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<tbody>
<tr>
<td><strong>Condensation</strong></td>
<td>![Water Cycle Diagram]</td>
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</tbody>
</table>

- **Definition**: [Blank]
- **Personal Association or Characteristic**: [Blank]

**Circle the part of the water cycle this word represents**

- A - evaporation
- B - condensation
- C - precipitation
- D - collection

**Name:** ____________________

---

55
**Vocabulary Word**

<table>
<thead>
<tr>
<th>Precipitation</th>
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</table>

**Definition**

**Visual**

Circle the part of the water cycle this word represents

- **A - evaporation**
- **B - condensation**
- **C - precipitation**
- **D - collection**

**Personal Association or Characteristic**
<table>
<thead>
<tr>
<th>Vocabulary Word</th>
<th>Verbal/Visual</th>
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</thead>
<tbody>
<tr>
<td>Collection</td>
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</table>

**Visual**
Circle the part of the water cycle this word represents

![Diagram of the water cycle showing parts A, B, C, and D, with labels: A - evaporation, B - condensation, C - precipitation, D - collection.]

<table>
<thead>
<tr>
<th>Definition</th>
<th>Personal Association or Characteristic</th>
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<tbody>
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### Student Survey Questions

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<th>Easy to accomplish and fun to do</th>
<th>Easy to accomplish and I didn’t mind it</th>
<th>Make me think, but I enjoyed it</th>
<th>Make me think, and I didn’t enjoy it</th>
<th>Was difficult, and was frustrating</th>
<th>Was difficult, and make me angry</th>
<th>Was too hard, and I gave up</th>
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</tbody>
</table>

The pre test was:

- Learning the definitions of the words Condensation, Precipitation, Collection, and Evaporation was:
- Completing Water Cycle Note Packet was:
- Completing the Water drop story
Student Identification: ________________________________

Group:   A   B

How did you feel during the water cycle unit?

Did you feel that you learned a lot during the unit?

What activities did you do during the water cycle unit?

Did you enjoy the water cycle unit and the activities in it?

Is there anything that you think I should change before I teach the unit next year?