

EVALUATING DIFFERENT LEVELS OF INQUIRY
IN THE SCIENCE CLASSROOM

by

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Robert A. Moyer

July 2012

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INTRODUCTION AND BACKGROUND

Project Background

School Demographics

For the last three years I have been teaching seventh grade ecology at Snyder-Girotti Middle School. The school is located along the Delaware River in Bristol, PA. Bristol is 20 miles from downtown Philadelphia. The mean income of the community of Bristol is \$34,000. The demographics of the school are fairly diverse: 63.3% White, 19.2% African American, 17.2% Latino, and 0.4% other races (U.S. Census Bureau, 2008). The school is a Title I school, with 72% of the students receiving free or reduced lunch. The school climate is that of a small town, although it is located within a larger, congested urban-like region. The town is small enough that all of the students walk to school and our seventh grade consists of 120 students.

Teaching and Classroom Environment

The seventh grade curriculum is life science and environmental science combined. I teach five sections composed of 18-22 students in each class. The classes are not intentionally leveled, but there are higher and lower ability-level classes due to tracking in other classes. One section has 11 inclusion students who are accommodated by a special education inclusion teacher.

In the last five years the seventh grade life science classes at Snyder-Girotti Middle School have had limited inquiry-based educational opportunities. From 2005 to 2008, a book-only curriculum was utilized with no labs or investigations. Since 2008 the class has been moving in a more inquiry-based direction with labs, demonstrations, and

investigations. Inquiry-based labs allow the students more flexibility, while providing hands on activities that boost motivation and increase process skills. The goal was to evaluate five inquiry-based lessons to determine which level of inquiry is most effective. In addition the lessons and activities are taking the place of the current textbook lessons in the area of arthropods, classification, and life cycles.

Focus Question

Over the course of two weeks, five lessons were conducted; each lesson was designed with a different level of inquiry. The levels of inquiry ranged from completely student designed investigations, to completely book-driven lessons with little to no inquiry. The lessons and observations will focus on this primary question:

1. How does changing the levels of inquiry influence student achievement?
2. What is the effect of changing the levels of inquiry on student's attitudes towards science?
3. In what way does the use of a Scientific Investigation Matrix, which is used to aid in differentiating the levels of inquiry, improve the creation of inquiry based lessons?

CONCEPTUAL FRAMEWORK

In the 2011 *State of the Union Address*, President Barack Obama announced that our education system needs to have “a Sputnik moment”. This proclamation had a direct connection to science education in America. The President went on to describe the need for a talented work force that is trained in high levels of research and development, and stressed that the fields of biomedical research, information technology, and clean energy will provide the jobs of the future. To do these jobs, students are going to have to be strong critical thinkers with the ability to process scientific knowledge and devise innovative solutions (Their, 2000). Bruce Alberts (1996), president of the National Academy of Sciences from 1993-2005, writes that inquiry lessons, “provide a powerful general strategy for solving many problems in the workplace and in everyday life”(p. xiii). The National Science Educational Standards (National Research Council) (1996) have created guidelines that assist in the transition to more inquiry based science instruction and away from traditional direct instruction, which focuses on textbooks and rote learning to increase scientific literacy.

The NSES defines scientific literacy as “knowledge and understanding of scientific processes required for participation in civic and cultural affairs, economic productivity, and personal-decision making” (p. 22). In recent years there has been a push to teach science through an inquiry-based approach that forces students to become seekers of their own knowledge. It is not a new idea; as early as 1916, Dewey reported that students must create their own knowledge through the activation of prior knowledge. The majority of today’s science classrooms do not encourage students to ask their own questions and find their own answers. Sutman, Schmuckler, and Woodfield (2008) state,

“We have developed a science instructional approach that provides answers that do not provoke questions, especially effective science questions, and do not develop seekers of knowledge.” (p. 10). The move from a teacher-centered, textbook structured classroom can prepare students for the future and raise achievement levels (Von Secker, 2002).

Inquiry based classrooms are classrooms in which students are engaged, thinking critically and responsible for their own learning. Inquiry teaching has a principle theory of constructivism; however inquiry teachers have stronger hand in guiding the students through the learning process. (Llewellyn, 2002; Paget, 1970). Constructivist theories help drive inquiry lesson design and promote students to experience an environment first hand and create their own knowledge. In inquiry-based classrooms, students are active participants in the learning process, creating questions that spark discussions and produce experiments/activities to answer those questions. This type of investigation, or “active exploration”, as described by Douglas Llewellyn, encourages the students to become the finders of knowledge. The student’s role is a problem solver in an endless cycle of questions, answers, and predictions. The teacher’s role is to be the guide on the side that facilitates the desired goals or objectives, but not the exact route in which to reach them (Llewellyn, 2002).

This type of classroom is different than the traditional behaviorist type classroom, where the teacher is the focus and the students are passive learners with a defined goal, usually an assessment (Von Secker, 1999). In an inquiry based classroom the goal is to build upon prior knowledge with questions and answers that strengthen critical thinking skills (Sutman et al., 2008).

Interestingly, it has not been well supported that inquiry based instruction increase scores on standardized tests, or teaches scientific concepts more effectively than other methods of instruction. However many science teachers find inquiry lessons to be great ways to improve higher order thinking skills. In a recent study by (Coburn et al., 2010), it was found that inquiry instruction and direct instruction were both successful strategies in teaching scientific concepts when the lessons were expertly designed and engaging. In addition, the studies suggest that there is a need for more research that provides evidence for inquiry methods. However, there is a variety of data to support that inquiry-based instruction raises overall achievement, provides for better classroom management, and fosters positive attitudes towards science (Byers & Fitzgerald, 2002). Results from a study done by Von Secker (2002), found that on average, science achievement increased when the teacher placed more emphasis on inquiry-based lessons. Although the study focused on equity, these findings were associated with all students no matter the social context. These claims support the reforms recommended by the National Science Education Standards (1996).

Although starting the process of inquiry in the classroom can be time consuming, research shows that after the initial investment, classroom management becomes less intrusive and creative thinking becomes the norm. Inquiry-based classrooms allow for more differentiated instruction and students become more motivated because they are part of the process, requiring less supervision (Baker, Lang, & Lawson, 2002). In addition, Miller (2006) suggests that inquiry skills can strengthen reading comprehension. “Rather than teaching them to read, we are teaching them to learn from reading” (p. 32).

Even though scientific inquiry is commonly accepted as valid teaching method, a lack of knowledge and professional training is a road block (Grady, 2010). Most researchers of inquiry-based instruction would agree that there is lack professional development (Banchi & Bell, 2008; Byers & Fitzgerald 2002; Dias, Eick, & Brantley, 2001; Dolan & Grady 2010; Von Secker, 2002). This lack of professional development may require teachers to seek out inquiry lessons on their own and do the proper reflection and assessment that supports their findings.

One way for a teacher to reflect on the practice of inquiry is to use a matrix to assist in lesson planning and reflection (Grady, 2010; Llewellyn, 2002; Priestly et al., 1998; Smith, 2000). A proper matrix acts as a tool for reflection and allows the instructor the ability to self-assess the level of inquiry actually taking place in the lesson (Priestly et al., 1998). The Matrix for Assessing and Planning Scientific Inquiry (MAPSI) introduced by Dolan & Grady in 2010 analyzes both assessment of a teacher's current practices and the implementation of inquiry into new lessons. A simpler matrix proposed by (Sutman et al., 2008) provides a quantitative value and clearly shows the students' and teachers' roles in the learning process. Another level of inquiry matrix introduced by (Banchi & Bell, 2008) looks at four different types of inquiry, Structured Conformation Inquiry, Structured Inquiry, Guided Inquiry, and Open Inquiry.

Each level of inquiry puts more emphasis on what the students produces compared to the amount of guidance the teacher provides. A systematic approach to reflection can lead to the increase of complex scientific reasoning in lesson preparation (Grady, 2010). An inquiry matrix like the the Scientific Investigation Matrix (Figure 1)

will also assist in the ability to scaffold lessons as students' progress throughout the year (Smith, 2000; Sutman et al., 2008.).

The Scientific Investigations Matrix					
Level of Inquiry	Pre-Laboratory Experience		Laboratory Experience	Post-Laboratory Experience	
	Inquiry	Discovery			
	Proposes Problem or Issue for Inquiry	Plans Procedure to Be Used to Address the Inquiry	Carries Out Procedure to Address the Inquiry	Supplies Answers to the Inquiry	Considers How Discoveries Can be Applied or Can Lead to Other Inquiries
0	Teacher	Teacher	Teacher	Teacher	Teacher
1	Students	Teacher	Teacher	Teacher	Teacher
1	Teacher	Students	Teacher	Teacher	Teacher
1	Teacher	Teacher	Students	Teacher	Teacher
1	Teacher	Teacher	Teacher	Students	Teacher
1	Teacher	Teacher	Teacher	Teacher	Students
2	Students	Students	Teacher	Teacher	Teacher
2	Students	Teacher	Students	Teacher	Teacher
2	Students	Teacher	Teacher	Students	Teacher
2	Students	Teacher	Teacher	Teacher	Students
2	Teacher	Students	Students	Teacher	Teacher
2	Teacher	Students	Teacher	Students	Teacher
2	Teacher	Students	Teacher	Teacher	Students
2	Teacher	Teacher	Students	Students	Teacher
2	Teacher	Teacher	Students	Teacher	Students
2	Teacher	Teacher	Teacher	Students	Students
3	Students	Students	Students	Teacher	Teacher
3	Students	Students	Teacher	Students	Teacher
3	Students	Students	Teacher	Teacher	Students
3	Students	Teacher	Students	Students	Teacher
3	Students	Teacher	Students	Teacher	Students
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3	Teacher	Students	Students	Students	Teacher
3	Teacher	Students	Students	Teacher	Students
3	Teacher	Students	Teacher	Students	Students
3	Teacher	Teacher	Students	Students	Students
4	Students	Students	Students	Students	Teacher
4	Students	Students	Students	Teacher	Students
4	Students	Students	Teacher	Students	Students
4	Students	Teacher	Students	Students	Students
4	Teacher	Students	Students	Students	Students
5	Students	Students	Students	Students	Students

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Figure 1. The Scientific Investigation Matrix (Adapted from Smith, 2000).

Through the use of teacher training tools like an inquiry matrix, teachers can self-evaluate their curriculum, and create lessons that are truly inquiry based and provoke students to be active, engaged learners that are able to make their own decisions and then evaluate those decisions. Through these lessons, students will gain the experiences and critical thinking skills that will prepare them for an ever changing world. The future job market is going to require that workers be able to adapt and think creatively; these individuals are going to be vital in the creation of new technologies and the protection of our natural resources.

METHODOLOGY

Data triangulation throughout the study was done using observations, pre and post treatment surveys, student post lesson evaluations, student lesson task sheets, student interviews, and teacher reflections. For the project I created six inquiry specific lessons with different levels of student inquiry as shown in the Student Lesson Matrix (Figure 2). The lessons were numbered from 0-5, five having the most amount of student inquiry and zero having the least student inquiry, or most amount of teacher support. During the project I recorded my own personal daily outcomes and attitudes in a reflection journal.

To evaluate how different levels of inquiry affect classroom management, student's quality of work and students comfort level with the given lesson; six lessons were created and taught over a three week period. Each lesson was designed using The Scientific Investigation Planning Guide (Appendix A). The Scientific Investigation Guide is a rubric that was simply created to assist with the planning of lessons and to

allow me to designate a number value to a lesson with regards to inquiry. The guide also helps to clearly show what the teacher and students responsibilities are.

Student Lesson Matrix					
Lesson Level of Inquiry	Proposes Problem or Issue	Plans Procedure to Address Inquiry	Carries Out Procedure	Supplies Answers to Inquiry	Considers How Discoveries Can Lead to Other Inquiries
Level Zero: Introduction to Insects	Teacher	Teacher	Teacher	Teacher	Teacher
Level One: Insect Anatomy	Teacher	Teacher	Teacher	Teacher	Student
Level Two: Insect Biodiversity	Teacher	Teacher	Student	Student	Teacher
Level Three: Cricket Dissection	Teacher	Teacher	Student	Student	Student
Level Four: Insect Development	Teacher	Student	Student	Student	Student
Level Five: Life in Water	Student	Student	Student	Student	Student

Figure 2. Student Lesson Matrix.

Each lab/investigation had similar student task sheets and materials that varied in the level of support from the instructor. The student task sheets were scored to record the quality of work and the completion level during the lessons. To be considered a completed task sheet, the student must have answered all of the questions or completed the task, an example of a task may be drawing or measuring. When I collected the task sheets, I tallied up the number of completed sheets to get a completed percentage. A few

students from each class were randomly interviewed as a way to identify their attitudes towards the amount of support they received from the teacher. The interview questions asked the students how much support they received from the teacher and if they needed more support. Finally, I took notes outlining any changes in discipline and quality of work.

Each of the five classes received the same treatment. The lessons were designed to complement the current curriculum's unit on Mollusks, Arthropods, and Echinoderms. Below is a chart of the lessons in the order they were given (Table 1).

Table 1
Lessons and Experiences

Lesson Title	Experience
Level Zero-Introduction to Insects	Students read about insects in the textbook and answered questions.
Level One-Insect Anatomy	Students viewed a power point and took notes.
Level Two-Insect Biodiversity	Students compared a mowed lawn to a meadow habitat.
Level Three-Cricket Dissection	Students dissected a cricket.
Level Four- Insect Development	Students studied mealworms in various life stages.
Level Five- Life in Water	Students created their own research about organisms in pond water.

After each lesson the students were given the same Post Lesson Evaluation (Appendix B). The questionnaire asked the students to describe what they learned during the lesson while having them rate the classes' behavior, the amount of teacher support they received, and how successful they felt they were in accomplishing the goal of the lesson.

In addition, students' task sheet scores were compared in all the different types of lessons. Throughout the entire unit students' attitudes and motivation were detailed in the teacher reflection journal discussed earlier.

Finally a Pre and Post Treatment Survey (Appendix C) was created as a way to assess student attitudes towards insects, the natural world, and life science. Throughout the unit students were interviewed about their feelings towards insects and life science. The same survey was given as a follow up at the end of the unit to evaluate the students' changes in attitudes. During the course of the study a Triangulation Matrix was utilized to organize treatment methods (Table 2).

Table 2
Data Triangulation Matrix

Research Questions	Data Set 1	Data Set 2	Data Set 3
1. How does changing the levels of inquiry influence student achievement?	Student Lesson Task Sheets	Student Interviews and Pre and Post Treatment Surveys	Teacher Observations
2. What is the effect of altering the levels of inquiry on student's attitudes towards science?	Pre and Post Treatment Surveys	Student Interviews and Student Lesson Evaluations	Teacher Observations
3. In what way does the use of a Scientific Investigation Matrix, which is used to aid in differentiating the levels of inquiry, improve the creation of inquiry based lessons?	Teacher Lesson Guide	Teacher Observation	Teacher Reflection

Lesson Descriptions

For each lesson, data was collected through student evaluations, lesson task sheets, and field notes. Each student was given a post lesson evaluation after each leveled lesson and every lesson had a task sheet.

Level Zero Lesson

The first lesson was at level 0, meaning that the students really did not have much of a hands-on, or inquiry experience. The teacher proposed the inquiry and also supplied

the answer to the inquiry (Figure 2). During this lesson students read the first section in the textbook that dealt with an introduction to invertebrates. Next they watched a documentary about invertebrates and answered questions that went along with the video on their Documentary Task Sheet (Appendix D).

Level One Lesson

This lesson consisted of a twenty minute Power Point about the anatomy of insects and the biology of insects, in which the teacher gave all of the instruction and the students copied the notes down on their Level One task sheet. Then the students did research on the internet. During this lesson the only inquiry proposed to the students was, “How can the information you learned today be used to answer other questions?” The first part of the lesson went well and there was some complaining about the amount of copying that was being done, but, overall the students were well-behaved. When asked how they felt about the Power Point, “one student replied that they couldn’t believe how much they copied down!”

After the students finished the lecture, it was then their turn to do some inquiry. Their task was to utilize the internet to research and apply the information they learned from the lecture in order to study other organisms. This was again reported on the Level One task sheet. Most students were confused by the question. They wanted to know exactly what I wanted. One student said, “Can I look up what you already told us?” Another student replied, “Can I look up a shark’s anatomy?” This lead to students looking up all types of animal and human anatomy sites.

Level Two Lesson

The Level Two lesson consisted of an insect biodiversity study. The students studied biodiversity earlier in the school year, so this activity was a culmination of the two topics, thus requiring the students to have more background knowledge than previous lessons. The procedure was teacher planned. The students were to carry out the research and come up with the answer, however they were not asked to consider how their discoveries could lead to other inquiries. To begin the lesson the students reviewed their notes on biodiversity. The students were then asked the question, “what has more biodiversity in insects, an area that has been mowed or a non-mowed area?” The procedure was teacher planned, and the students were to carry out the research and come up with the answer, however they were not asked to consider how their discoveries could lead to other inquiries.

For the study we walked to a local park next to our school. The middle field of the park is mowed but there is an area that is not mowed. The students were split up into groups and they used plastic PVC square meters to delineate the area in which they were studying. During the study they compared the biodiversity of insects in the mowed and not mowed areas. They wrote their data down on their task sheet for this lesson created using the Scientific Investigation Guide. The Biodiversity Study Task sheet (Appendix E) included a drawing section, a write-it-out section, and an area to check off what they have found. They were also allowed to use their iPod's or phones to take pictures of anything they found interesting.

Level Three Lesson

During the Level Three lesson, students received a cricket specimen and a diagram of a cricket. They followed the dissection directions to remove and observe the legs, wings, and the head. They recorded their observations on the Cricket Dissection Task Sheet (Appendix F). They also had to draw all the mentioned body parts and answer questions. The last question of the assignment asked the students to take what they learned and apply it to a new situation. It asked students to go home and research entomologists and then to describe what they found.

Level Four Lesson

In the Level Four lesson, the students were given a container with *Tenebrio Molitor* (mealworms) at different life stages. The inquiry question for the students was, “How many different types of insects are present?” This activity was adapted from a mealworm curriculum I used the prior year. In this lesson, the students were given the question and they had to plan the procedure, list the resources they would use, and supply the answers to the inquiry question and carry out the experiment. Once again the student were to record their findings on their lesson task sheet.

Since we feed our class pet Fluffy, a bearded dragon, mealworms on a daily basis, the majority of the students have at least seen the larvae stage of a beetle. However, I have never received any questions about what the insects were, and knowing I would be doing this lab, I never pushed the students to investigate. To assist the students to better understand the stages of insect development and build upon previous lessons in classification, part of the procedure was to categorize the insects.

Level Five Lesson

First, the students were given a small bucket with freshly collected pond water. They wrote down ten questions they had about the water and described how they could possibly answer one of the questions. Next, they had to design a procedure to answer the question. Finally over the weekend they were asked to carry out the procedure. The students easily created ten questions related to the water, and about half of the students designed a procedure to answer their question. Most of the procedures involved using the microscope to look at objects more closely. Some students wanted to test the water to see where it was from, while other students wanted to separate the plants from insects (biotic) and soil (abiotic). It should be noted that since I knew this was going to be very difficult for our students to finish the task, I told them that the final actual experiment would only be worth extra credit.

DATA AND ANALYSIS

My research consisted of six specifically designed lessons given to five classes over the course of a two week unit. The lessons were integrated into existing curriculum covering insects and invertebrates. Initially, students' attitude towards inquiry and insects were evaluated through the use of a Pre-Treatment Survey (Appendix A).

Pre-Treatment Survey

The survey was anonymously given to 103 students, all five classes. The survey utilized four Likert style questions and two open ended questions. The same survey was given at the end of the project. The pre-treatment data showed that the students preferred hands on inquiry lessons over book driven lessons, with about 1% stating that they would

rather have book lessons. It was also evident in the student written responses, “Real life is better than pictures in books, hands on lessons are more fun, and usually during hands on lessons you can move around.” One student wrote that, “Hands on lesson are better, because you get an actual experience, and that experience makes you remember things better.” However one student wrote, “I like using the textbook, because I am not a visual learner and I can do the work on my own.”

In addition, the survey collected data on attitudes in regards to insects. This data varied more than their feelings towards hands on lessons. These questions asked if students were curious about insects and if they were afraid of insects. About 70% of the students said they were curious about insects and only about 15% admitted that they were scared of insects. When asked if they would ever want to be an entomologist, 90% said no, but on the survey, 64% said they thought it would be an interesting job. The reasons for not wanting to be an entomologist included interest in other occupations than science, while some thought working with insects was creepy and dangerous. Furthermore, some said they would want to work with other types of animals instead of insects (Figure 3).

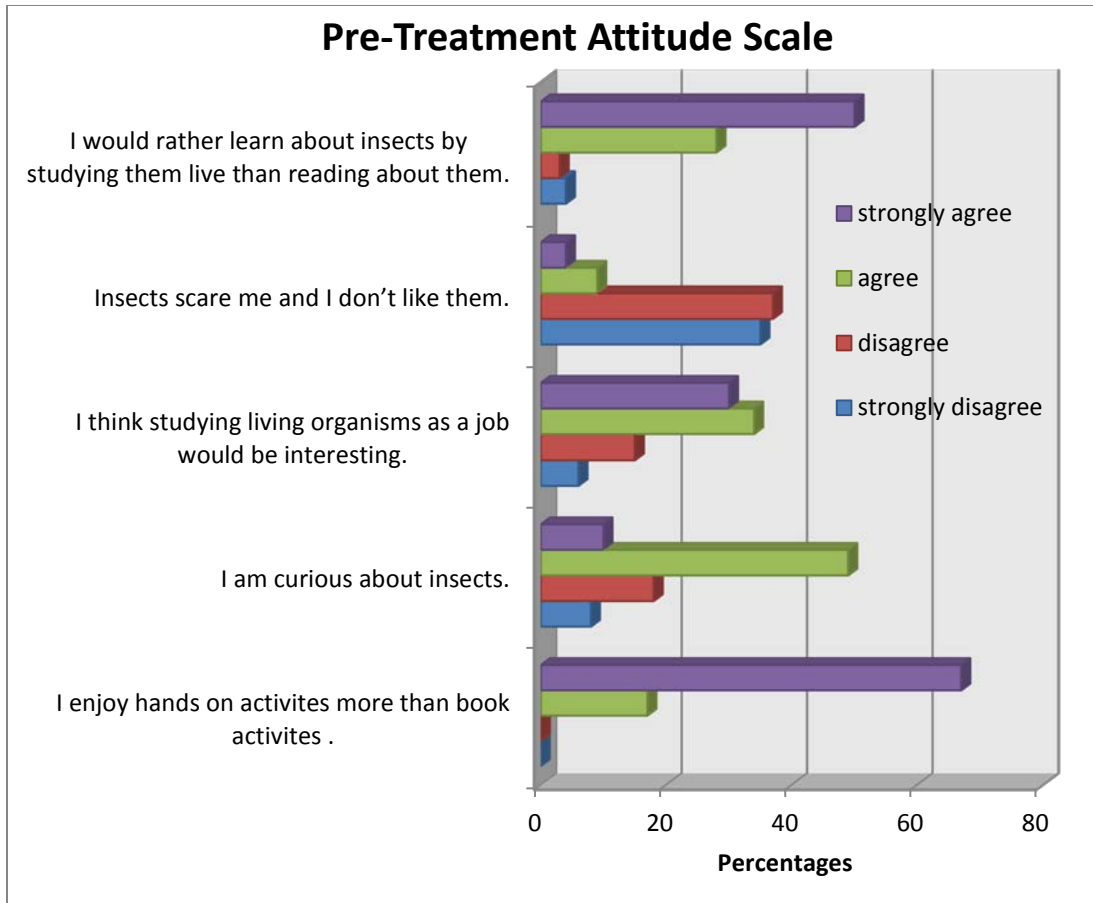


Figure 3. Student's feelings towards hands-on lessons and Insects, ($N=103$).

Post-Treatment Survey

The student attitudes towards insects changed over the course of the study in a few ways (Figure 4). First more students reported that they were curious about insects, only 11% of the students said they were curious about insects before the lessons, while 64% of the students said they were curious about insects after the lessons. Although the number of student who said they wouldn't want to study insects as a job, went up from 26% to 36%. One student's reason for why he did not want to be an entomologist was, "Because it was creepy enough studying the insects live, but every day would drive me crazy." On the other hand, a student wrote that, "I didn't even know there were people who studied insects, they are amazing." One interesting statistic was that the number of

students who would rather study insects using a textbook went up, from 8% to 31%.

When I asked one student why she would rather use the textbook she said, “Insects are gross and our class is always smelly when we do stuff like that.”

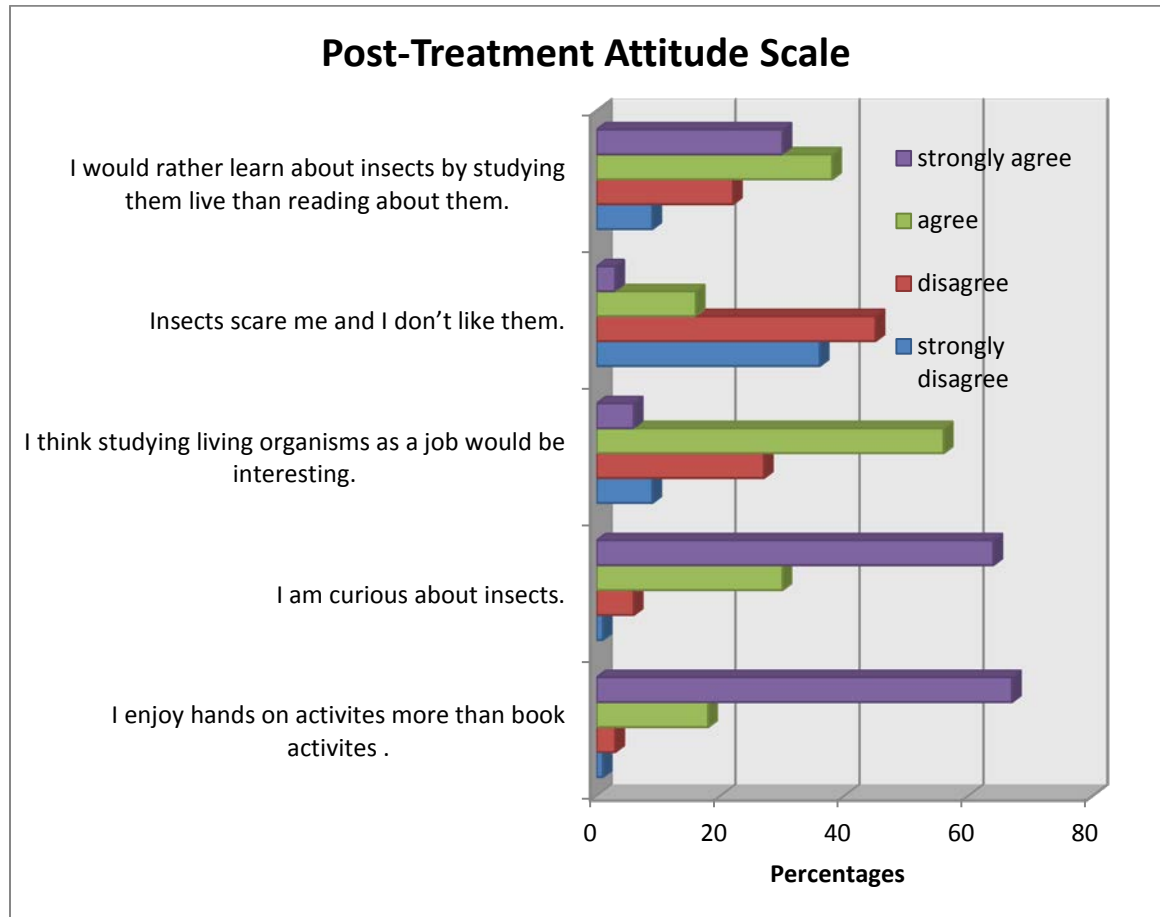


Figure 4. Student's feelings towards hands-on lessons and Insects, (N=103).

Lesson Assessments

Lesson Assessments were done by reviewing the task sheets. I evaluated the task sheet by recording how many students were able to complete the entire assignment.

Level One Lesson, had a similar completion rate of 81%, once again during this lesson students only took notes from a power point and did some research using the internet.

Level Two Lesson had an increased lesson completion rate with 85% of the students

completing the assignment. This assignment was a little more entertaining for the students. However during Level Three Lesson the completion rate fell to 70%, this may be because for the first time the task sheet and assignment had a homework element to it.

Finally, Level Four and Five Lesson, both only had a completion rate of about 2%, meaning that only 2 of 103 students were able to complete the assignment (Figure 5).

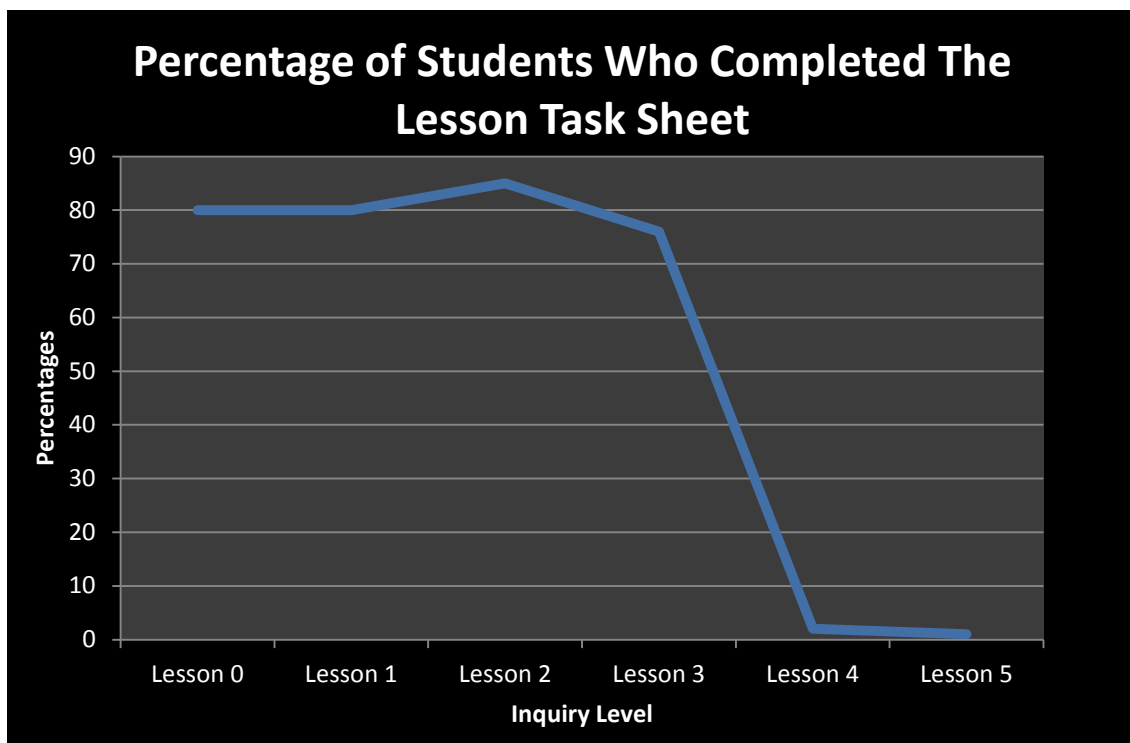


Figure 5. Percentage of student that completed the task sheets, (N=103).

Lesson Evaluation

Level Zero Lesson

Throughout the lesson I walked around the class observing the students behavior. In the first part of the lesson only a few students began to read and then had to be reminded multiple times. As noted in my reflection journal this was the most off task the students were during the whole unit. When asked in the post lesson evaluation how the students felt their behavior was during the class, 65% of the students responded that everyone was well behaved and on task, while 30% of the students said some students were off task and 5% claimed that the class was off task and not following directions. As an observer I noted that the students were not engaged, consequently the average grade on the five question quiz after the documentary was 60%. I asked one of my higher scoring students what she thought about the reading and she said, "I didn't read the textbook to memorize it, I knew it was about insects." When asked in a post lesson evaluation about how much support the teacher gave during the lesson, 47% of the students responded that, "the teacher gave me the question and guided me to the answer." The response was actually at a higher order of thinking than the lesson was.

I asked a student how she found the answer to one of the questions, and she stated, "I had to pay attention to the video." I then asked if they discovered the answer on their own by studying insects, and they laughed and said, "No." After grading the student's task sheets, or movie questions, I found that about 75% of the students finished the questions from the movie. Figure 6 shows the level of inquiry from the Student Post Lesson Evaluation (Appendix C), and their answers for The Level Zero Lesson.

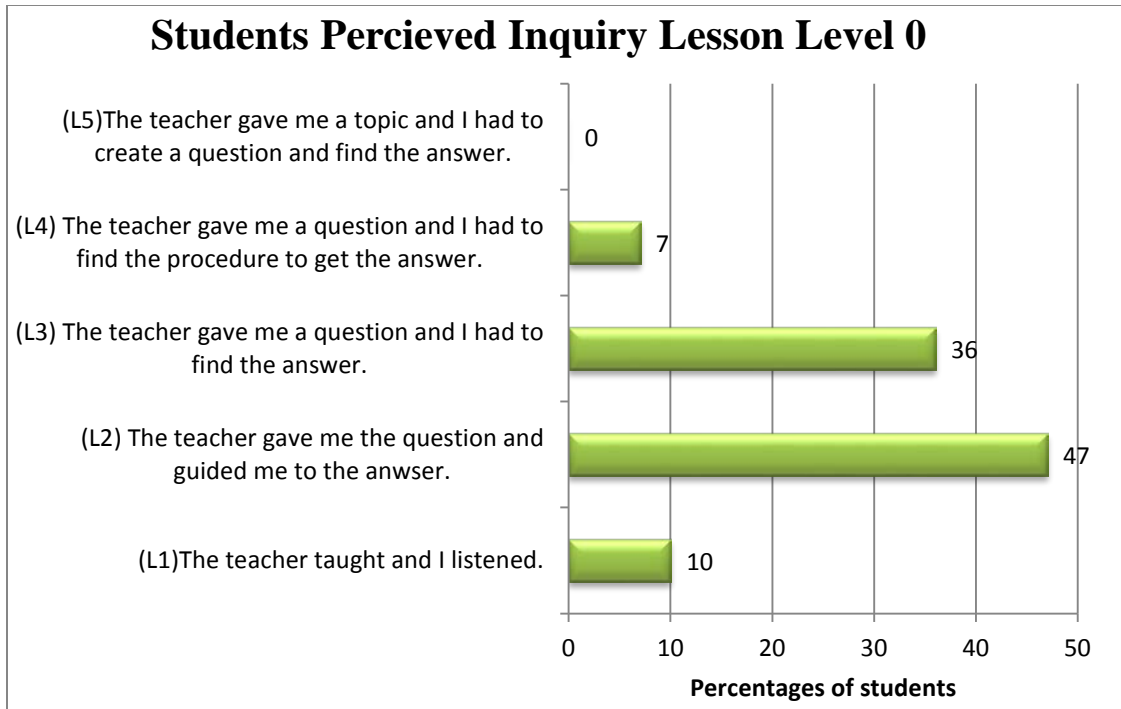


Figure 6. Students perceived level of Inquiry, (L#) stands for teachers intended level of inquiry, (N=103).

The chart questionnaire went from 1-5, following a very similar format to the leveled lessons. The students tended to perceive themselves as doing more inquiry or, just doing more work in general. There wasn't much guiding, the information was fed to them and they had to repeat it back. Although I did stop the video a few times to explain certain topics in more detail and to keep students more engaged.

Level One Lesson

In this lesson over 60% of the students felt that they were investigating at a Level three or higher, while the lesson was only planned as a Level One Lesson. Only part of the lesson was student driven. In addition over 75% of the students reported that the class was well behaved and on task. The students had no problem coming up with research questions, even if some were as simple as one student's question, "Why don't

animals have antennae?” As an assessment each student had to hand in a half sheet of paper with at least five questions about the anatomy of insects.

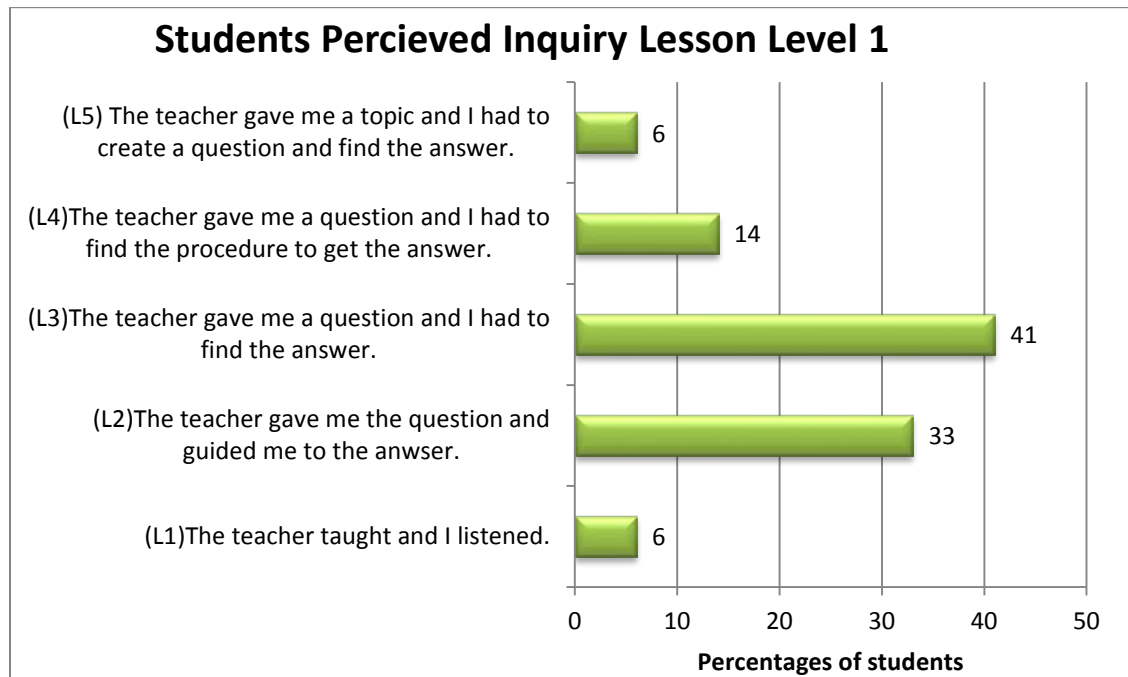


Figure 7. Students perceived level of Inquiry, (L#) stands for teachers intended level of inquiry, (N=103).

Once again students perceived themselves at a higher level of inquiry than the intended lesson. During this lesson 6% of the students stated that they felt that they choose the question to study, not the teacher. In contrast most of the students felt that they were simply answering a question that the teacher proposed; there was no physical experiment that went along with the lesson at that time. It was difficult for the students to create higher order thinking questions, but as the students researched on the computers their searches became more specific.

Level Two Lesson

About 80% of the students completed the task sheet and handed it in. When we discussed it in class almost all of the students agreed that there was more biodiversity in the non-mowed area. I then provided them with a new inquiry, “If we all agree that it is better for the animals and insects to have more plants, why do we all have mowed lawns?” Just as before, the students perceived this lesson to be higher order thinking than it was in reality. Over 85% of the students perceived the lesson to be higher than the planned inquiry level, and 32% even felt that they were at the highest inquiry level.

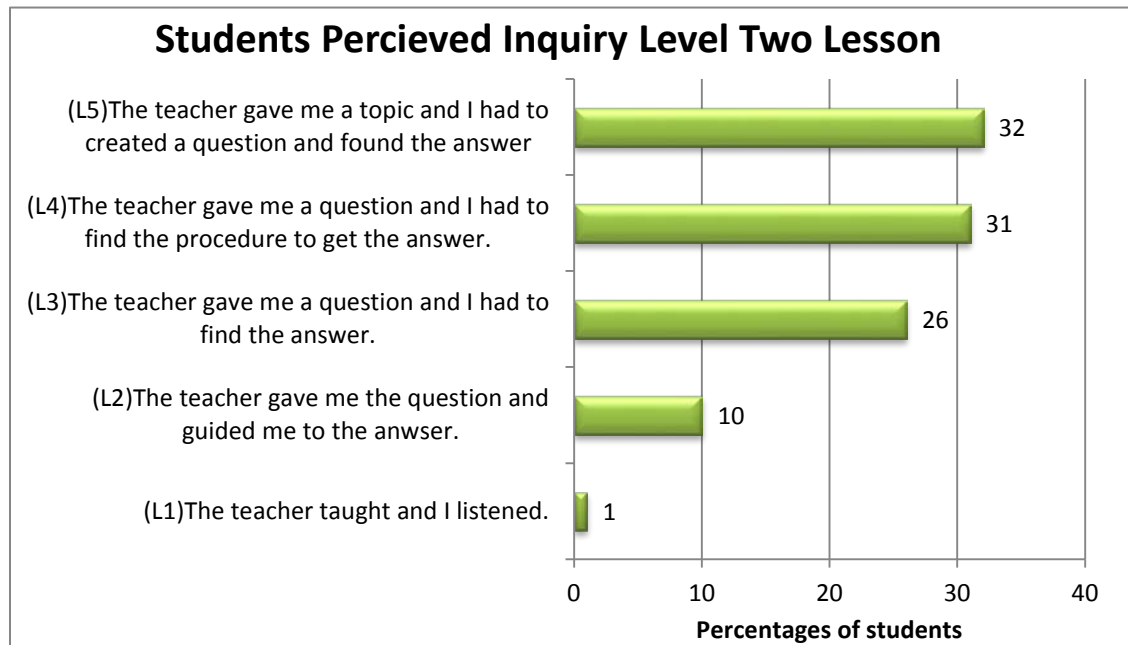


Figure 8. Students perceived level of Inquiry, (L#) stands for teachers intended level of inquiry, (N=103).

When I tallied up the student post lesson evaluations, only 50% of the students felt that the class was on task and well behaved. Throughout all five classes I found that only a handful of students weren't really into the assignment. I asked the inclusion teacher who joined us with the special education class, what she thought of the activity and she replied that, “she couldn't believe the girls that jumped in the bushes looking for

snails!” She also said, “Most of the students were doing the best they could within their own comfort levels.”

Level Three Lesson

Level Three Lesson was back in the classroom the following week. The inquiry question posed was, “What is the anatomy of a cricket?” To do this activity the students were given a cricket, necessary dissecting tools, a microscope and a step-by-step guide to follow the process of a Cricket Dissection Task Sheet (Appendix G). The students then had to carry out the procedure, supply the answers to the questions and describe how future discoveries could be made.

The students got right to work and they were excited to be finally dissecting something. As an observer, I noted in my teacher reflection journal it was evident that the students really enjoyed the activity. The inclusion teacher even remarked that, “I was amazing that only one person got out of their seat without asking.”

Only 70% of the students did the last section that required them to go home and research entomologists on their own and consider other possible inquiries. So in actuality 85% of the students did the activity at Level Two Lesson. This extension assignment dropped the average grade down from an 85% to 70% for the marking period, although only 70% of the class were to complete the entire task sheet.

Finally the students responses on the student post lesson evaluation showed that they overwhelmingly felt that they were doing much of the assignment on their own. Over 85% of the students felt that they were at Level Four and Five Lesson (Figure 9).

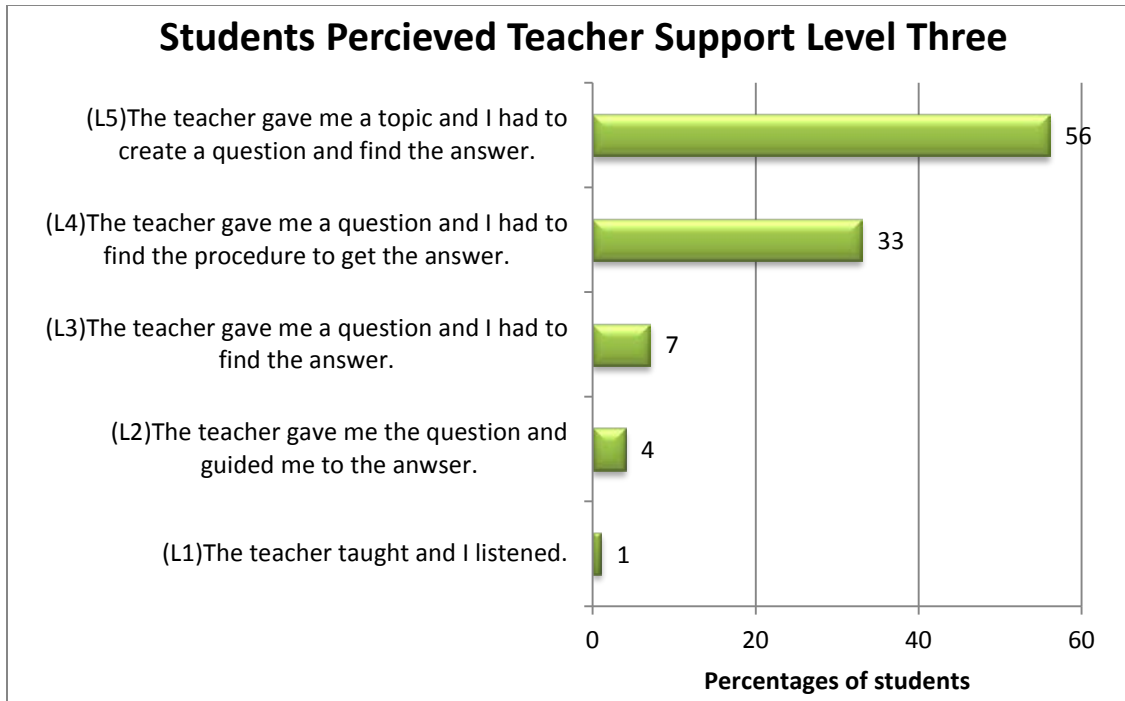


Figure 9. Students perceived level of Inquiry, (L#) stands for teachers intended level of inquiry, (N=103).

Level Four Lesson

When the students received the container and opened it up, there was the usual comments, “cool, ewww, gross, awesome!” I then asked the students the inquiry question, “Are there more than one type of insect present in the container?” The only tools the students had were paint brushes, so as not to hurt the insects and petri dishes.

After observing the insects the students began to put them into groups and I could hear them discussing their opinions. There was definitely some frustration from the students, one student said, “What’s the point, you’re just going to tell us later anyway.” While the explanations varied, some believed the insects to be males and females, some thought they were different species of mealworms, and others said they were water and land insects. Only about 12 of the 103 students hypothesized that all of the insects were the same species.

When asked to put together an experiment to answer the inquiry question most of the students responded that they would dissect the inside of the insects and compare them to other insect's internal body parts. Four students noted that they would observe the insects over time and see what happens, what they eat where they live. Only 2% of the students were able to lay out day to day plans to accomplish their experiments, and only one student asked if they could take one home and observe it over time. Overall only one student got close to a Level Four Lesson on this task, and she only did so with additional teacher support.

Roughly 87% of the students reported that the Level Three Lesson was at a Level Four or higher (Figure 7).

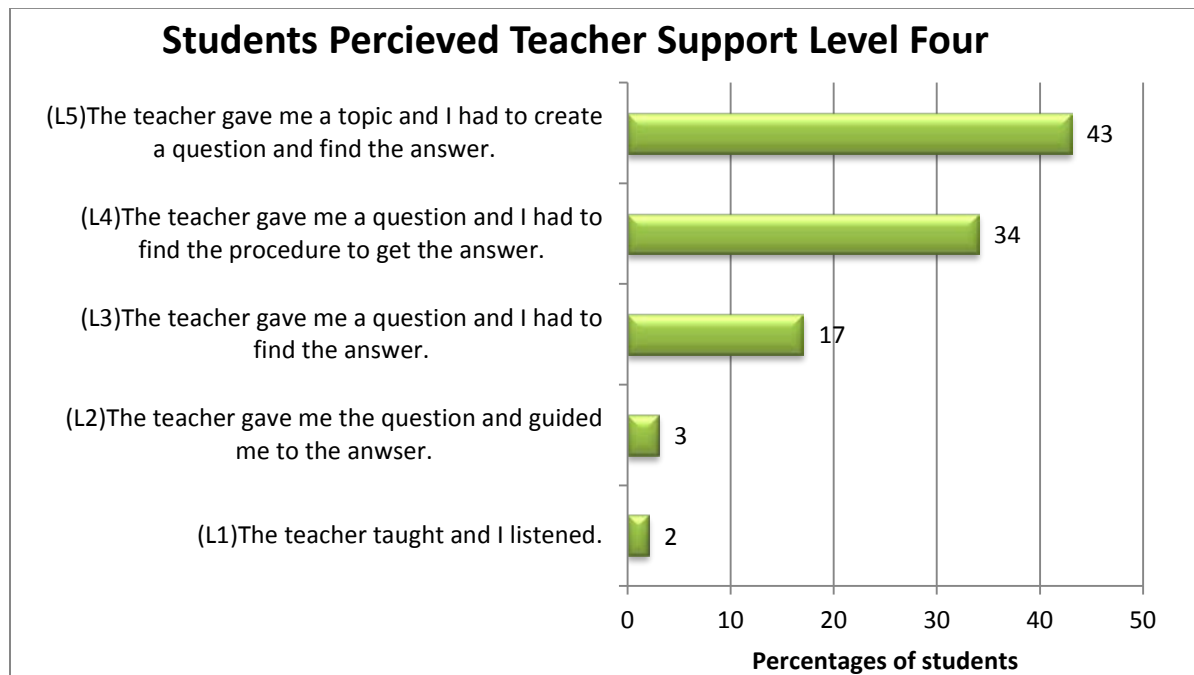


Figure 9. Students perceived level of Inquiry, (L#) stands for teachers intended level of inquiry, (N=103).

Level Five Lesson

The behavior of the students was fine as long as they were comfortable with what they were doing; as soon as they started to run out of ideas unwanted behaviors began to surface. As noted in my reflection journal there were issues with students staying in their seats and focusing on the lesson at hand. Most classes were able to do this exercise for about 15 minutes before I had to remind them of the class rules. Only 32% of the students felt that the class was on task, compared to 65% for The Level Zero Lesson. As in the last lesson, I didn't give the students tools unless they asked for them. Only three of the five classes used magnifying glasses, while no one in the other two classes asked for them, and only two classes used microscopes.

One student asked the question, "is this insect a leech?", and then he tried to see if it would attach to his finger. When the planarian did not attach to his finger, "he said this isn't a leech, a leech would have started to attach to my finger, I've fished with leeches before." In essence he just did an experiment. Only one student finished the assignment completely, she stayed after school and used a microscope; she then took a piece of algae home and looked it up on the internet. Come Monday she brought in a paper written about string algae. She included string algae's life cycle and where it could be found. Only 32% of the student reported that the class was on task and well behaved, this was the lowest score reported for all of the lessons

Most of the student did not design a procedure; they wrote down their questions and listed some resources. The majority of the students overall grades weren't affected by the low score. The Level Five lesson had the lowest completion rate of all the lessons.

The student's ranked The Level Five Lesson as having the most amount of student inquiry. This was the first lesson in which none of the students even ranked the lesson as a 1 in inquiry, in total 94% of the student's perceived Lesson Five to be at level four or greater (Figure 8).

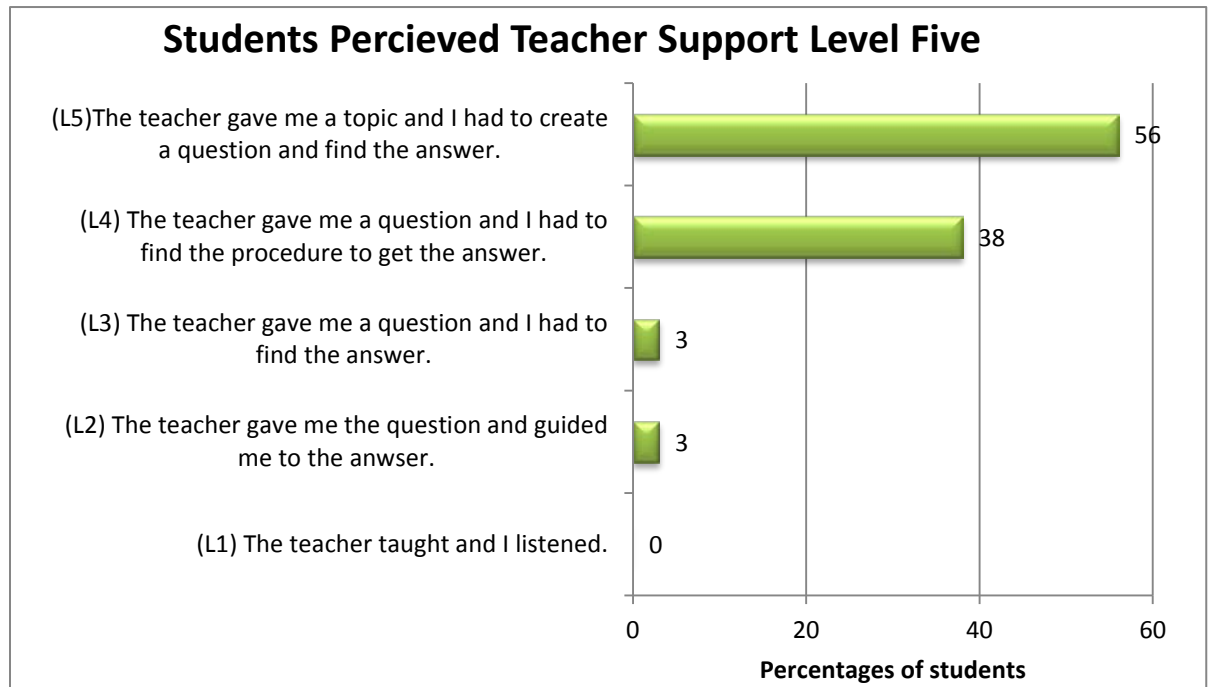


Figure 10. Students perceived level of Inquiry, (L#) stands for teachers intended level of inquiry, (N=103).

When asked what was hard about the lesson, one student's response was, "we can't go home and do experiments, that's what science class is for, and you are our teacher."

INTERPRETATION AND CONCLUSION

The results of my study showed that when 7th grade students were presented with lessons that were at a higher level of inquiry than their skills and background knowledge, their overall quality of work went down as well as their ability to complete assignments.

Furthermore, students were most successful with lessons that were presented at an inquiry level two and three. In addition, inquiry-based lessons increased student's curiosity in science and insects. The student lesson evaluation concluded that the students perceived that they were doing more inquiry, or more personal investigation than the level of the lesson. At the same time, an inquiry matrix and a lesson planning rubric makes teachers more aware of what the students are doing, thus increasing student discovery. Finally, I found through the attitude survey that pushing students comfort levels in the sciences past their knowledge and skill level, may actually make students less eager to pursue science as a possible career choice.

After reviewing my reflection journal and data it was clear that the students felt the most comfortable and accomplished the most when they were responsible for part, but not all of the inquiry. For example during the insect biodiversity study (Level Two Lesson), in which the students had the highest rate of completion, the students carried out the procedure and answered the inquiry question on their own. In this lesson they were responsible for the investigation and made their own conclusions. However they did not have to make any other inquires on their own, or use what they learned in any higher order thinking process. This is where the students had the hardest time, applying what they learned to other situations, or discoveries. This was evident during the Level Three Lesson when the students did a great job with the lesson, which was to dissect a cricket. However, when they had to take what they learned and apply it on their own discoveries, only about 15% of the students were able to complete the assignment.

Consequently once the students moved onto the level four and five lesson, it was very difficult for them to do the inquiry on their own without teacher support. I believe

this part of the study could vary from school to school and can be addressed by providing the students with a stronger background in the scientific method before introducing the studies. The student's completion of work declined when they were working above their knowledge skill or not fully engaged.

After the completion of the project I would feel confident in saying that my students performed best at levels of inquiry two and three. At levels two and three the students still had enough support from the teacher to assist them in the discovery process, yet they were responsible and engaged in a larger part of the investigation. However this may not hold true for students in this same grade that have had more experiences in science, or more disciplined work ethic. I believe this study would have been more effective if done with a larger sample of students at different schools. Students at our school seem to vary from day to day in enthusiasm and work ethic, it is very difficult to keep consist focus and commitment to work.

In addition, this study may not transfer over to topics that tend to be more hands on, like physical science. This is what students were not used to instruction wise, however with repeated guidance at each step many would improve with practice. With practice they will begin to become more efficient in the steps of scientific inquiry. This could lead increased higher order thinking skills since they will be able to focus more on the concepts not the process.

In addition it was interesting to see that the students consistently believed they were doing more steps on the inquiry matrix then they actually where, they perceived themselves as finding the answers. I can use this information to ensure that students have

the feeling of discovery. If you can make students curious and make them feel like they have the ability to make new discoveries, then you have the scaffolding necessary to promote higher order thinking. Furthermore, I feel that 7th grade students may not have to propose the inquiry, plan the procedure, carry out the procedure, answers the inquiry and make new discoveries all in one lesson.

This can be successfully taught by differentiating the experiences in inquiry throughout the year in different lessons in which student can successfully complete the parts of inquiry. As the students become more proficient in the levels of inquiry and the scientific method, they will gain the practice necessary to be successful at putting an advanced investigation together. Lessons should be developed that push students to be critical thinkers, while providing the necessary scaffolding and guidance, so that student can complete the assignments and gain confidence to keep building upon what they learned.

Finally an inquiry rubric and lesson guide assists in the planning, helping teachers to plan lessons and reflect upon what inquiry steps they have covered throughout the year. The inquiry lesson guide assisted in development of the lesson, so that the students were getting varied experiences in the inquiry process. Through-out the year you can take an inventory of what skills the students have done and how you could address a lack of skills in a certain area.

VALUE

This project has given me a wealth of skills which have already begun to change my teaching style and strategies. First, the research on inquiry based lesson planning has

given me the background knowledge to prepare better learning opportunities for my students. This includes the construction and planning of lessons that ensure that students are making their own discoveries. I am now well aware of what is expected from my students and what skills are crucial for them to be able to work at a higher inquiry level in order to problem solve in the sciences and real world. This project has instilled in me the importance of having a student centered classroom in which the students are planning and carrying out their own investigations.

Through my own personal investigation into the scientific investigation matrix, I have learned how to evaluate and critique specific inquiry activities in an investigation. The matrix has helped me to look at my lessons and point out areas in which I am not giving my students enough practice. It also provides me with a tool in which I can manipulate the parts of the inquiry that the students are doing to ensure they get sufficient practice. After the review of my past lessons it became apparent that as a teacher I was putting too much emphasis on what I was doing and not enough emphasis on what the students were doing. It was interesting to find that when students are engaged in some way other than repeating what the teacher has told them, they are more likely to complete assignments and perceive themselves as the ones who made the discoveries.

Although the initial planning of the procedures was more time consuming, the use of an investigation matrix forced me to specifically address sections in the lessons where students were doing the science. Through the use of this planning tool I was able to keep track of the students' experiences and certify that they were gaining the practices needed to be able to make their own investigations from inquiries, planning the procedures, and eventually application of what they learned.

Finally, the project has allowed me to use reflection as a tool to critique my own lesson and attitudes in the classroom. It has taught me to constantly adapt and try to improve my lessons, with the goal that my students will learn more and become better critical thinkers. My hope is that they will view themselves as scientists that are part of the process, and just not watching the process from the sidelines!

REFERENCES CITED

- Baker, W.P., Lang, M., Lawson, A.E. (2002). Management for Successful Student Inquiry. *The Clearing House*, 75(5). 248-252.
- Bianchi, H., Bell, R. (2008) The Many Levels of Inquiry. *Science and Children*, 70(7) 26-29.
- Byers, A., Fitzgerald, M.A. (2002). Networking for Leadership, Inquiry, and Systemic Thinking: A New Approach to Inquiry-Based Learning. *Journal of Science Education and Technology*, 36(1), 81-91.
- Coburn, W.W., Schuster, D., Adams, B., Applegate, B., Skojd, B., Undreiu, A., Loving, C.C., & Gobert, J.D., (2010). Experimental Comparison of Inquiry and Direct Instruction in Science. *Research in Science & Technological Education*, 28(1), 81-96.
- Dewey, J. (1916) *Democracy and education*. New York: Macmillan.
- Dias, M Eick, C.J, & Brantley-Dias, L. (2001). Practicing What We Teach: A Self-Study in Implementing an Inquiry-Based Curriculum in a Middle Grades Classroom. *Journal of Science Teacher Education*, 22(1), 53-78.
- Dolan, E., & Grady, J. (2010). Recognizing Students' Scientific Reasoning: A Tool for Categorizing Complexity of Reasoning During Teaching by Inquiry. *Journal of Science Teacher Education*, 21(1), 31-55.
- Grady, J. (2010) The Inquiry Matrix: A Tool for Assessing and Planning Inquiry in Biology and Beyond. *The Science Teacher*, 77(8), 32-37.
- Llewellyn, D. (2002). *Inquire Within: Implementing Inquiry-Based Science Standards*. Thousand Oaks: Corwin Press, Inc.
- Miller, R. (2006) Unlocking Reading Comprehension with Key Science Inquiry Skills. *Science Scope*, 30(1), 30-33.
- National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.
- National Research Council. (2000). *Inquiry and the National Education Standards: A guide for Teaching and Learning*. Washington, DC: National Academy Press.
- Obama's State of the Union Address. (2011). *The White House Website*. Retrieved February 21, 2011, from <http://www.whitehouse.gov/state-of-the-union-2011>

- Piaget, J. (1970). *The Science of Education and Philosophy of the Child*. New York: Orion
- Priestley, H., Priestley, W.J., Sutman, F.X., Schmuckler, J.S., Hilosky, A., White, M. (1998). *Evaluating the Use of the Inquiry matrix*. Unpublished professional paper, Annual meeting of the Association for Research in Science Teaching. San Diego, CA.
- Smith, William Robert (2000). The Levels of Inquiry Matrix in developing written lesson plans for laboratory-centered science instruction. Ed.D. dissertation, Temple University, United States – Pennsylvania. Retrieved February 26, 2011, from Dissertations & Theses: Full Text.(Publication No. AAT 9990353).
- Sutman, F.X., Schmuckler, J.S., Woodfield, J.D. (2008). *The Science Quest: Using Inquiry/Discovery to Enhance Student Learning, Grades 7-12*. San Francisco: Jossey-Bass.
- Their, H.D. (2000). *Developing Inquiry-Based Science Materials: a Guide for Educators*. New York: Teachers College Press, Columbia University.
- Von Secker, C.E., Lissitz, R. W. (1999). Estimating the Impact of Instructional Practices on Student Achievement in Science. *Journal of Research in Science Teaching*, 36(10), 1110-26.
- Von Secker, C.E. (2002). Effect of Inquiry-Based Practices on Science Excellence and Equity. *The Journal of Education Research*, 95(3), 151-160.

APPENDICES

APPENDIX A

THE SCIENTIFIC INVESTIGATIONS SCORING GUIDE

The Scientific Investigation Matrix Scoring Guide

Lesson Title _____ Level of Inquiry (/5)

Inquiry:

Pre-Laboratory Experience

- Problem or Issue for Inquiry(1pt):

- Plans procedure to be used to address the inquiry(1pt)

Discovery:

Laboratory Experience:

- Carrying out the procedure (1pt).

Post-Laboratory Experience

- Supplies Answers to the inquiry (1pt).

- Considering how discoveries can be applied or can lead to other inquiries (1pt).

APPENDIX B

POST LESSON STUDENT EVALUATION

Post Lesson Evaluation

Lesson Title

1. Describe what you learned in the lesson?

2. What was the question you were trying to find the answer to?

3. How much teacher support was given, circle the number below from 1-5.
 1. The teacher did all the work and I just listened.
 2. The teacher had me read to answer questions and I could easily find the answers.
 3. The teacher gave me the question and guided me to find an answer to the question.
 4. The teacher presented me with a question and I had to find a way to answer the question.
 5. The teacher gave me the topic and I had to find a question and design an investigation to answer the question.

4. Circle the statement that best fits your performance.
 1. I did everything that was asked of me. I understood it completely.
 2. I did everything that was asked of me, however did not completely understand the information.
 3. I did most of what was asked, I completely understood everything.
 4. I did most of what was asked of me, I didn't understand parts of the assignment.
 5. I did not finish the assignment because it was confusing.

5. Rate the class's behavior form 1-3.

1. The class was well behaved; everyone was on task and following directions.
2. The class seemed to be following directions, but some students were off task.
3. The class was off task and students were not following directions.

Is there anything that is still confusing about the lesson, or class instructions?

APPENDIX C

PRE-TREATMENT ATTITUDE SURVEY

Pre-Treatment Attitude Survey

Put an X in the box that describes how you feel.

Question	1=Strongly Disagree	2= Disagree	3=Agree	4=Strongly Agree
I enjoy hands on activities more than learning from the textbook.				
I would rather learn about insects by studying live insects than reading about them.				
I am curious about insects.				
Insects scare me and I don't like them.				
I think studying living organisms as				

Question	1=Strongly Disagree	2= Disagree	3=Agree	4=Strongly Agree
a job would be interesting.				
Total				

Open ended questions:

1. What type of lesson do you enjoy more, a lesson utilizing the text book and key terms, or a hands-on lesson? Please explain why below.

2. Would you want to be an entomologist (scientist who studies insects), why or why not, explain.

APPENDIX D

DOCUMENTARY TASKSHEET

1. T or F? Insects have four body parts?
2. T or F? Scorpions are insects?
3. T or F? Insects have an exoskeleton
4. T or F? Insects make up a large part of the world's Biodiversity?

Video Discussion Questions:

- 1.) How are insects the same as and different from other arthropods?
- 2.) What are the three main parts of an insect?
- 3.) How do honeybees and other social insects work together?
- 4.) How do insects and people work together?

APPENDIX E

BIODIVERSITY STUDY TASKSHEET

Name _____

Biodiversity Study

Insects

Data sheet: First Sample Area

Describe the habitat, lawn, meadow, marsh etc. _____

Insect	Insect 1	Insect 2	Insect 3	Insect 4	Insect 5
#					

Insect 1 description: Size, color, wings,

Insect 2 description:

Insect 3 description:

Insect 4 description:

Insect 5 description:

1. Why do you think these insects live in this habitat?
2. Did you find a lot of insects, why or why not?
3. Is there Biodiversity?

Data sheet: Second Sample Area

Describe the habitat, lawn, meadow, marsh etc. _____

Insect	Insect 1	Insect 2	Insect 3	Insect 4	Insect 5
#					

Insect 1 description: Size, color, wings,

Insect 2 description:

Insect 3 description:

Insect 4 description:

Insect 5 description:

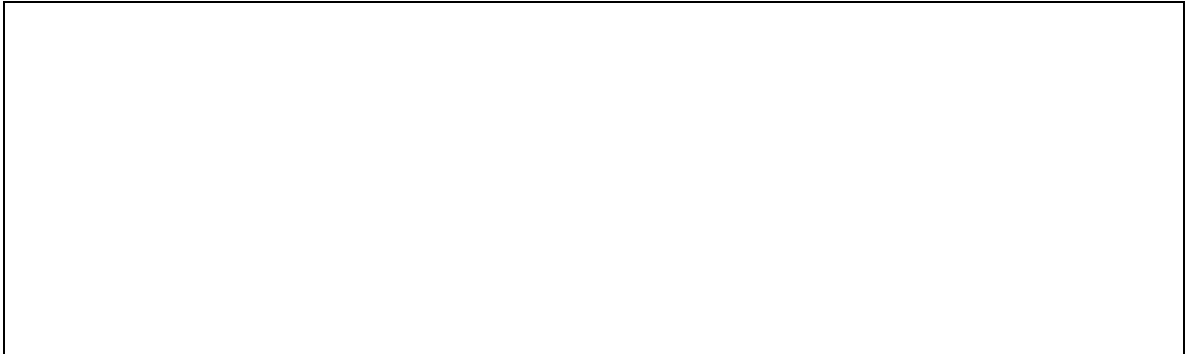
4. Why do you think these insects live in this habitat?
5. Did you find a lot of insects, why or why not?
6. Is there Biodiversity?

Insect Hunt

1. Can you find any flying insects?

Describe the flying insects:

2. Draw an insect you have found below.



3. Draw a local food chain:

4. Did you find any organisms that weren't insects?

5. Can you find any signs of insects, bite marks on leaves or tunneling marks on trees?

6. Can you create a food web, start with the sun!! draw it below.

APPENDIX F

CRICKET DISSECTION LAB AND CRICKET ANATOMY DIAGRAM

B. Do you think the cricket can fly, why or why not?

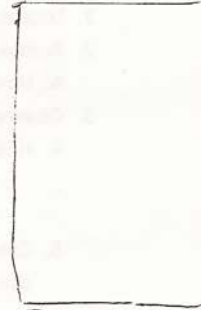


Draw wings here!

5. Observe the head, thorax, and abdomen. Carefully use the knife to slice off the head of the cricket.

A. How many antennae are there?

B. Use the diagram provided, find the mandibles and palps, what do you think those mouth parts are used for?



Draw Mouth parts!

6. Lastly, using the knife cut the abdomen away from the thorax.

A. How are the abdomen and the thorax different?

Follow up:

What questions do you have about crickets or insect anatomy?

Homework: Go online and research entomologists (scientists who study insects), what are some other ways they study insects? In your notebook record your findings.

Cricket Anatomy

