Caffeinated Caterpillars in the Classroom

Honors Thesis

*************

PASS WITH DISTINCTION

By

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Advisor: Carol Sheppard, Entomology Department

UH 456

Fall 2002
TO THE UNIVERSITY HONORS COLLEGE:

As thesis advisor for Harmony Borchardt-Wier and Cavina Stillman,

I have read this paper and find it satisfactory.

Carol A. Shugard  
Thesis Advisor  
27 September 2002  
Date
Table of Contents

Introduction ................................................................. 3

Materials and Methods .................................................... 5

  Preliminary Trials in the Laboratory .................................... 5
  Classroom Trial ............................................................ 6
  Alignment of Caterpillar Exercise with EALRs ...................... 7

Results and Discussion ................................................... 8

  Laboratory Results for Caffeine Effects on Caterpillars ............ 8
  Caterpillar Results in the Classroom ................................... 10

Unforeseen Problems ..................................................... 11

Conclusion ....................................................................... 13

Appendix ........................................................................ 15

Works Cited and References Consulted ................................ 23

Figures and Tables

Table 1: EALRs addressed in the Classroom Trial ..................... 8
Table 2: Survival Percentage and Average Caterpillar Weight in the Laboratory Trials .............. 10
Figure 1: Gypsy Moth Diet .................................................. 15
Figure 2: Preliminary Letter to the Teachers ............................. 16
Figure 3: Teaching Calendar ............................................... 17
Figure 4: Daily Lesson Plan ............................................... 18
Figure 5: Classroom Result Graph ....................................... 22
Introduction

The "Introduction to Science" section of the Washington State Essential Academic Learning Requirements (EALRs) manual states: "Learning in science depends on actively doing science. Active engagement in hands-on, minds-on science learning experiences enables students to make personal sense of the physical world and to solve problems" (Washington State Commission on Student Learning, 1998). According to Edwards and Springate (1995) in *Encouraging Creativity in Early Childhood Classrooms*, young children:

1. are developmentally capable of classroom experiences which call for (and practice) higher level thinking skills, including analysis, synthesis, and evaluation;
2. need to express ideas through different expressive avenues and symbolic media;
3. learn through meaningful activities in which different subject areas are integrated; and
4. benefit from in-depth exploration and long-term projects.

Our major goal for this project was to study how insects, specifically *Manduca sexta* caterpillars, could be used to further this method of integrated, hands-on learning. Aided by their teachers, the children were responsible for keeping track of changes in caterpillar weight, as well as recording any notable differences between the control and experimental group (discussed under "Materials and Methods"). At the end of the project, the children were required to analyze and interpret their results. All of the classroom activities for this project were performed by us in cooperation with the children's two teachers. The activities were designed to be appropriate for the grade level, and also to serve as methods the instructors could use in teaching about scientific and life processes.

From a teaching perspective, our purpose was for the fourth graders to see the effects of caffeine on the caterpillars, while learning and utilizing the scientific method, as well as gaining general
information about insect life cycles, over-the-counter drug effects (primarily caffeine), and simple graphing exercises. From a purely scientific perspective, our goal for this project was to observe the effects of caffeine on caterpillar growth, development, and survivorship, first in the laboratory, then in a classroom setting. This, however, was secondary to our main focus, which was introducing the caterpillars into the classroom setting. On a personal level, our goal was to obtain experience working with school-aged children, teaching and observing the learning process.

The experiment and process we developed and provided is meaningful because it encompasses all of the issues deemed important by the National Science Educational Standards (NSESs), the Washington State Essential Academic Learning Requirements (EALRs), and those described in Edwards and Springate (1995) regarding student capabilities. Our students were often required to use higher level thinking skills to answer questions posed by peers or instructors, such as “Why are the caterpillars green?” or “What is the horn of the caterpillar for?” The very essence of an experiment such as this being conducted in the classroom allows for the students to express their ideas through avenues not always offered in public school education. Several subject areas were integrated including, but not limited to, science, math, drug education, writing and problem solving. Finally, the project spanned four weeks, allowing for in-depth exploration by the children.

Insects can be an effective medium for teaching science, as is shown by utilizing the education research database ERIC, which reveals documentation of experiments involving insects, including caterpillars. Most, such as Creepy Crawlies and the Scientific Method: Over 100
Hands-on Science Experiments for Children, spell out how to rear insects—how to find them, maintain them, and observe them (Kneidel 1993). As far as nutritional experiments are concerned, most documents we found reference animal or insect nutrition experiments involving food consumption and composition. Caffeine experiments conducted also involve measuring caffeine level in using different substances using a variety of different methods. However, based on our search of ERIC, no other experiments have been conducted in a classroom setting testing caffeine effects on caterpillars.

Caffeine has several effects on living organisms. In humans it acts as a stimulant in low or moderate doses. An overdose can produce some or all of the following symptoms: restlessness, nervousness, excitement, inability to sleep, flushed face, stomach ache, muscle twitching, rambling flow of thought and speech, and an irregular heartbeat (Avera Health 2002). The overdose quantity is considered to be 250 to 750mg, or the equivalent of about 2-3 cups of coffee (Erowid 2002). The dose we gave the caterpillars was substantially higher than this. They consumed approximately 1/1000 of their body weight in caffeine daily. The human equivalent of this would be drinking 500 cups of coffee or eating 800 Hershey’s™ bars daily. We used this high dose in order to magnify caffeine effects on the caterpillars, so that these effects were easily detectable.

Materials and Methods

Preliminary Trials in the Laboratory

The organism used for our experiment was the tobacco hornworm (Manduca sexta, Sphingidae, Lepidoptera). They were purchased from Carolina Biological Supply Company in the form of
eggs, and put onto feeding media just after hatching (Figure 1 shows the diet recipe). Caterpillars were reared in 150 mL plastic cups approximately one-third full of diet. The control group was fed normal diet from egg to pupa, while the experimental group was fed diet with the addition of caffeine. These experimental caterpillars were reared on normal diet until about the third instar, then transferred to diet containing caffeine for the remainder of the larval stage (i.e. through the fifth instar). For the preliminary trials, three concentrations of caffeine were tested: 1.0g/L, 0.5g/L, and 0.1g/L. A total of 168 caterpillars were used, in three separate trials: 88 on the control diet, 15 on the 0.1g/L caffeine, 15 on the 0.5g/L caffeine, and 50 on the 1.0g/L caffeine. All caterpillars were maintained at about 25 degrees C in a humid chamber with a 16-hour light:dark photoperiod. The caterpillars were weighed every 2-3 days, as well as being visually scored for morphological and behavioral abnormalities. After they had formed pupae, the results were graphed. The pupae were then discarded, as they were no longer needed.

Classroom Trial

For the classroom trial, the diet highest in caffeine was selected, as it caused the most marked difference in the caterpillars versus those in the control group. A population of 48 caterpillars was introduced into two fourth grade classrooms. These classrooms were at Franklin Middle School, Pullman; one taught by Mr. Jim Williamson, the other by Ms. Sue Reault (see Figure 2 for our initial letter to the teachers). Carina worked with Mr. Williamson, and Harmony with Ms. Reault. In terms of our experimental design, each class represented an independent trial, and within each classroom there were six replicates. The students in each room were divided into six groups of four children. Each group was assigned a color to avoid confusion. The colors for the groups in Mr. Williamson's class were blue, green, orange, yellow, purple, and red. The colors
for the groups in Ms. Reault's class were violet, gold, red, teal, orange, and blue. Each group was provided with three experimental caterpillars and one control. At the inception of the classroom trial, the caterpillars were several days old, and therefore mostly in the second instar. The experimental larvae were already on the caffeine-containing media (1g/L caffeine). We came to the classrooms twice a week, for approximately an hour each session over the course of four weeks, to discuss the experiment with the children and weigh the caterpillars. Each day of our visit, there was a short lesson accompanying the observation of the experiment (Figure 3 shows a condensed list of classroom activities we designed and implemented, Figure 4 shows in-depth lesson plans). Our goals for these lessons centered on teaching the children more about the scientific method, insects in general, the life cycle of caterpillars, caffeine effects, and graphing. As depicted in Figure 3 and elaborated upon in Figure 4, our lesson plans moved progressively through these concepts over the course of a month. After each lesson, the children weighed each caterpillar, and recorded the weights in their activity books. In addition, they drew a picture of a caterpillar each day we visited and noted any abnormalities in appearance. After three weeks, the children were asked to make graphs of the caterpillar weights over time. They first made graphs for individual caterpillars, either an experimental or a control. The following period they graphed pooled class data, and compared the experimental caterpillar mean weight with the control caterpillar mean weight. They then wrote a concluding paragraph in their activity book.

Alignment of the Caterpillar Exercise with Washington State EALRs

The classroom experiment addressed several EALRs. Since our project was interdisciplinary, EALRs from several different academic areas were addressed, including Science, Math, Writing, and Communication. The Science EALRs we covered included those involving categorizing
plants and animals, recognizing that living things need air, water, and nutrients to produce energy, and developing and understanding the skills necessary to do scientific inquiry. The Math EALRs we covered involved gathering, organizing and interpreting data. In the areas of Writing and Communication, only a few EALRs were cited. Requirements leading up to other, more advanced skills were not noted (Table 1).

Table 1: EALRs addressed in the Classroom Trial (Note: The notation Science 1.1.1, for example, refers to Science EALR 1.1, Benchmark 1. Benchmark 1 is to be accomplished by grade 4, Benchmark 2 by grade 7.)

<table>
<thead>
<tr>
<th>Essential Academic Learning Requirement</th>
<th>How it was addressed</th>
</tr>
</thead>
</table>
| Science 1.1.2: Categorize plants and animals into groups according to how they accomplish life processes and by similarities and differences in external and internal structures. | On Day 2 we covered General Insect Information:  
  ➢ What is an insect?  
  ➢ vs. other arthropods?  
  ➢ vs. mammals? |
| Science 1.3.1: Recognize that living things need constant energy supplied from food or light and that, in ecosystems, substances such as air, water, nutrients, and the chemicals in food are continually recycled. Describe how an organism’s behavior and ability to survive is influenced by its environment, other life forms, and availability of food and/or other resources. | This topic was covered throughout, especially in discussing why the caffeinated caterpillars are healthy as those consuming a regular diet. In discussing why the lab results were so different from the classroom results, the importance of light and heat were also discovered. |
| Science 2.1.1-5: Develop abilities necessary to do scientific inquiry: questioning, designing and conducting investigations, explanation, modeling, and communication. | The course of our experiment followed this course of scientific inquiry. On Day 1, we discussed the Scientific Method and revisited it in each consecutive lesson. |
| Science 3.1.1-5: Understand the nature of scientific inquiry: intellectual honesty, limitations of science and technology, dealing with inconsistencies, evaluating methods of investigation, evolution of scientific ideas. | While we did not explicitly cover all of these topics, they were integrated into our discussions. We discussed the importance of accuracy, experienced limitations with the scales we used not being sensitive enough, dealt with several inconsistencies, and constantly evaluated our method of investigation, looking for ways to improve upon it. |
| Math 4.1.1-3: Gather information: follow a plan. Read, listen and observe, as well as use technology, to access and extract mathematical information. | Each day the students followed our plan for gathering caterpillar data including weight, length and health. They observed differences from one day to the next and used technology |
Math 4.2: Organize and interpret information.

While many of the students struggled with this skill, they all interpreted the information gathered, graphing the results. They reflected upon these results in class discussions, as well as in their journals.

Math 4.3.1: Express ideas using mathematical language and notation.

The graphs the students developed were as mathematically sound as possible, using the correct notations and tables required.

Writing 1.1.1,3-4: Develop concept or design: represent one main idea or topic, include relevant details, elaborate on details.

In their journals, the students did their best to develop concept and design. On Day 7, we had them write their final analyses of the project, doing their best to represent one main idea, include relevant ideas, etc.

Communication 1.1.1-2: Focus attention: pay attention while others are talking, pay attention to instructions and other information.

For the most part, the students paid attention when instructions were given and when others were speaking.

Communication 1.2.2: Identify visual information.

The essence of experimentation involves identifying visual information.

Communication 1.3.1: Ask questions to clarify content and meaning.

The questions were never-ending!

Results and Discussion

Laboratory Results for Caffeine Effects on Caterpillars

There were two main differences between the experimental and control caterpillars, size and mortality rate (Table 2). Caterpillars fed caffeine at the highest concentration (1g/L) had a much higher mortality rate than the controls. In addition, the average weight of these experimental caterpillars was much less than the controls. Thus, the average maximum weight of the controls was 1.8-fold greater than the average weight of the experimental caterpillars fed 1g/L caffeine. Unexpectedly, the caterpillars fed caffeine at 0.1g/L and 0.5g/L had an average weight of 9.5g and 9.9g, respectively, which values were 1.2 to 1.3-fold greater than the control values. The reason for this is unclear, although it may have been because such a small sample size was used and thus, the differences may not be significant. In addition, slight variations in diet composition (e.g. insufficient blending) may have affected the caterpillars' development.
Table 2: Survival percentage and Average Caterpillar Weight in the Laboratory Trials

<table>
<thead>
<tr>
<th>Diet concentration (g/L)</th>
<th>Starting number</th>
<th>Number survived</th>
<th>Survival percentage</th>
<th>Average mature caterpillar weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 (control group)</td>
<td>88</td>
<td>72</td>
<td>82%</td>
<td>7.7</td>
</tr>
<tr>
<td>0.1</td>
<td>15</td>
<td>15</td>
<td>100%</td>
<td>9.5</td>
</tr>
<tr>
<td>0.5</td>
<td>15</td>
<td>10</td>
<td>67%</td>
<td>9.9</td>
</tr>
<tr>
<td>1.0</td>
<td>50</td>
<td>26</td>
<td>52%</td>
<td>4.2</td>
</tr>
</tbody>
</table>

In addition to the differences listed above, the experimental caterpillars incurred a higher rate of abnormal development than did the controls. For example, several of the experimental caterpillars, primarily those on the highest caffeine dosage, failed to fully molt, which resulted in a band of unshed skin (integument) around their middles (personal observations). This band usually caused a constriction as the caterpillars grew, and was often fatal. Another common abnormality in the experimental caterpillars was the presence of a black line on the head, between the eyes. The most striking difference, though, was in the experimental caterpillars that eventually died. Many of them stayed very small, or even shrunk, and collapsed like deflating balloons full of water.

Caterpillar Results in the Classroom

The children’s caterpillars experienced much higher death rates than the laboratory caterpillars, partially due to the fact that the former were put on caffeine sooner than those in the lab trials (explained below). The high death rates may also have been due to abrupt changes in temperature and humidity, as the larvae went from the controlled environment inside the lab incubator to the uncontrolled environment of the classroom (see below). Over the course of the
experiment, most of the classroom experimental caterpillars remained much smaller than the controls, and eventually died. At the end of the classroom trial, the average weight of the experimental caterpillars was only 0.52g, while that of the controls was also relatively low at 3.26g. Both groups were much smaller than those in the preliminary trials, and were slower to mature. (Figure 5 shows the classroom data graph.)

Some misunderstandings occurred because we were not accustomed to working with such young children. We quickly learned how to relate what we were trying to teach to concepts and ideas that the children would understand, and were often pleasantly surprised by how much they already knew. However, because of time constraints, we were not always able to finish our daily lessons, the weighing and the observing. We were always able to talk about the daily topic (as outlined in the lesson plans that follow), but not always in as much detail as we would have liked.

Unforeseen Problems

There are many things we would do differently if we had a chance to repeat the classroom portion of this project. First, we would allow more time per session. We had less than an hour per day to weigh the caterpillars, teach the daily lesson, and allow the students to observe the caterpillars. Because of this time constraint, on several occasions questions went unanswered, or the lessons were severely truncated. A ninety-minute period would have been more appropriate for the amount of material covered per session. If given the chance to reproduce this experiment, we would request more teaching time for ourselves.
Second, we would have put the classroom caterpillars on caffeine when they were more mature. This problem arose because this particular batch of insects stayed in the egg stage upon arrival much longer than we had anticipated based on the performance of the shipping company in the past. As a result, the classroom caterpillars were only between four and five days old when put on the caffeine diet—much earlier than those in our laboratory test trials. This, along with other variables (such as those mentioned below), left us with a severely depleted caterpillar population by Week 2 of our classroom phase of this project. (Note: We were unable to adjust the calendar to accommodate this unexpected occurrence with the classroom caterpillars because Ms. Reault and Mr. Williamson had their own calendar constraints. Thus, our project had to be done during the four-week block of previously allocated time.)

Third, we would ensure that the caterpillars the children reared were in a warmer environment. The temperature in the classroom was much cooler than in the laboratory incubator that we used in the preliminary trials. These insects grow and develop in a temperature-dependent fashion, that is, they don't thermoregulate (i.e. they are “cold-blooded”). For this reason it is important to give them a stably warm environment. Additionally, one set of caterpillars was inadvertently placed next to an outside door for the first two weeks of the classroom phase of the project, which occurred in February. It was, in fact, one of the children that finally realized that this was the reason the caterpillars in that classroom were smaller than those in the other room! Of the caterpillars that survived, all were slower to develop and smaller than anticipated based on our lab trials. This made for difficulty in weighing the caterpillars for the first two weeks and caused them to pupate at a later date than expected.
Fourth, we would have had more caterpillars per group of students. The students were put into groups of four to five students and had four caterpillars per group. Because of the high mortality rate of the caterpillars, twice that number would have been advisable.

Finally, in weighing the caterpillars, we would have used milligrams instead of grams to avoid using decimals on the graphs. The children had not yet learned how to work with decimals and were very confused during the graphing lessons.

Conclusion

We are satisfied with the outcome of our project. Although we did not meet some of our goals in the way that we expected, we accomplished our primary objective, which was for the fourth graders to see the effects of caffeine on the caterpillars, while learning and utilizing the scientific method, as well as gaining general information about insect life cycles, over-the-counter drug effects (primarily caffeine) and simple graphing exercises. We also accomplished our personal goal of obtaining practical experience working with children.

Our project reflects the current development of specific educational standards for science, outlined by the EALRs and the NSESs. As discussed in the Introduction, the current trend in science education is toward meaningful, hands-on learning experiences, which we certainly provided, and which the students definitely appreciated. For example, the students were always interested and involved in the learning process when they were handling and observing the caterpillars, but were often bored during “lecture” or class discussion. In developing our lesson plans we looked at both sets of standards closely to see what our students were expected to
know—we essentially built our curriculum around them. We feel that these current trends are beneficial. The standards are what should be taught and are easy to incorporate into classroom instruction.

The students were very respectful and excited about our entire project. On the first day of our classroom experience they virtually mobbed us to get at the caterpillars! They immediately became attached to them, each choosing one for their very own. Although we warned them not to get attached because many of the caterpillars would die, they proceeded to name them, and were obviously upset when the caterpillars began to die. Despite our inexperience in the classroom, the students were responsive to our teaching techniques and tried their hardest to do as we asked, even when we were unclear.

Despite our initial reservations about going outside of our comfort zones and teaching small children, we thoroughly enjoyed the entire experience. Harmony, a once-professed Genetics major, has now decided to pursue a career in elementary education. Carina, a secondary English/Language Arts Education major, now knows she is progressing in the right direction. We learned that designing an experiment is complicated, and that learning can occur even when nothing goes as planned. This has been an experience we will carry with us for the rest of our lives.
Appendix

Figure 1: Gypsy Moth Diet (used to rear *Manduca sexta* because of its relative ease of preparation.)

Gypsy Moth Diet

(Modified from Bell et al, 1981)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Wheat Germ</th>
<th>Casein</th>
<th>Wesson’s Salts</th>
<th>Vitamin Premix #28262</th>
<th>Sorbic Acid</th>
<th>Methyl Paraben</th>
<th>Agar, fine</th>
<th>Tap Water</th>
<th>Total Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60g</td>
<td>12g</td>
<td>4g</td>
<td>5g</td>
<td>19g</td>
<td>0.5g</td>
<td>6.5g</td>
<td>400mL</td>
<td>0.50L</td>
</tr>
<tr>
<td></td>
<td>120g</td>
<td>25g</td>
<td>8g</td>
<td>10g</td>
<td>2g</td>
<td>1g</td>
<td>13g</td>
<td>800mL</td>
<td>1.0L</td>
</tr>
<tr>
<td></td>
<td>240g</td>
<td>50g</td>
<td>16g</td>
<td>20g</td>
<td>4g</td>
<td>2g</td>
<td>26g</td>
<td>1600mL</td>
<td>2.0L</td>
</tr>
<tr>
<td></td>
<td>360g</td>
<td>75g</td>
<td>24g</td>
<td>30g</td>
<td>6g</td>
<td>3g</td>
<td>38g</td>
<td>2400mL</td>
<td>3.0L</td>
</tr>
</tbody>
</table>

Preparation:
1. Heat the required amount of water to boiling.
2. Pre-warm the blender with hot tap water.
3. Pour boiling water into the pre-warmed blender container.
4. Using speed control, rotate the stirrer at low speed—just enough to create a vortex.
5. Blend in the agar until the solution is uniform.
6. Slowly blend in remaining dry ingredients and homogenize the mixture at high speed for about a minute.
7. Dispense the diet immediately into rearing containers.
8. After pouring, place paper toweling over containers while they cool, then cap.
December 6, 2001

Sue Reault  
Jim Williamson  
Jefferson Elementary School  
Pullman, WA 99163

Dear Mr. Williamson and Ms. Reault,

The following is an outline of the project Carol Sheppard has talked to you about. Before we get into that, we will tell you a little about ourselves. Harmony Borchardt-Wier is a fourth year honors student majoring in entomology and molecular genetics. Carina Stillman is also a fourth year honors student majoring in 4-12 Education, specializing in English. Our ultimate goal for this project is to gain practical experience helping you educate your students about insects and nutrition in general. We recognize that you will have to fit this into your curriculum and that you, as the experienced teachers, know best how to do this. Therefore, we intend to follow your lead so that we can be a help, not a hindrance.

We have several goals for this project. First, we wish to determine whether there is an effect from feeding caffeine to caterpillars during their development. If this is the case, which preliminary evidence suggests is true, then as our second goal we would like to introduce a simple experiment into your classroom. This experiment will involve rearing caterpillars from hatching to pupation, on either a normal diet or one including caffeine. We will supply all the necessary equipment for this experiment. At the same time, we would also like to present your students with general information about insects and over-the-counter drug concerns, and enable you to have your students be exposed to skills such as data collection, interpretation, and presentation. We would like to meet with you periodically to ensure that our lab exercises help you to meet the Washington State Essential Academic Learning Requirements (EALRs).

We hope that we can meet with you for perhaps half an hour or so some afternoon between December 14 and December 18. After that, we would like to set up a possible time frame convenient for you, that would allow us to carrying the project to completion next semester.

We appreciate your time and interest. Thank you.

Sincerely,

Harmony Borchardt-Wier  
Carina Stillman

P.S. Carol says you can give her a call to coordinate this meeting. Her number is 335-1432 (work) or 332-0212 (home).
Each day the students will be broken into groups of 4 students. There will be a short introduction to the main lesson for the day, and then the groups will do one of three things, rotating after the “weighing group” is done:

- One group will be weighing and writing observations in their Observation Booklets. Each group will have four caterpillars, two control and two caffeinated.
- Two groups will be drawing the caterpillars in their Observation Booklets.
- Three groups will be working on the daily activity.

<table>
<thead>
<tr>
<th>Monday</th>
<th>Wednesday</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4</strong></td>
<td><strong>6</strong></td>
</tr>
<tr>
<td><strong>Scientific Method</strong> including:</td>
<td><strong>General Insect Information</strong></td>
</tr>
<tr>
<td>- Observation</td>
<td>- What is an insect?</td>
</tr>
<tr>
<td>- Formulating a Hypothesis</td>
<td>- vs. other arthropods?</td>
</tr>
<tr>
<td>- Experimentation</td>
<td>- vs. mammals?</td>
</tr>
<tr>
<td>- Conclusions</td>
<td>- Habitats</td>
</tr>
<tr>
<td>Activity: Develop own hypothesis</td>
<td>- Body Parts</td>
</tr>
<tr>
<td><strong>11</strong></td>
<td><strong>13</strong></td>
</tr>
<tr>
<td><strong>Life Cycle of Caterpillar vs. Human</strong></td>
<td><strong>Caffeine Effects</strong></td>
</tr>
<tr>
<td>- Egg=Embryo</td>
<td>- Observed Effects</td>
</tr>
<tr>
<td>- Hatching=Birth</td>
<td>- Effects on Humans</td>
</tr>
<tr>
<td>- Larva=Adolescence</td>
<td>Activity: Worksheet (see attached)</td>
</tr>
<tr>
<td>- Pupa=Teens</td>
<td>Activity: Think and reflect upon their own diets.</td>
</tr>
<tr>
<td>- Adult=Adult</td>
<td>List foods containing caffeine.</td>
</tr>
<tr>
<td>Activity: Writing/Drawing timelines of their own lives</td>
<td><strong>18</strong></td>
</tr>
<tr>
<td><strong>18</strong></td>
<td>President's Day</td>
</tr>
<tr>
<td>No School!!!</td>
<td><strong>19</strong></td>
</tr>
<tr>
<td><strong>25</strong></td>
<td><strong>20</strong></td>
</tr>
<tr>
<td><strong>Graphing Results of Individual Caterpillars</strong></td>
<td><strong>Tobacco Hornworm Specific Info.</strong></td>
</tr>
<tr>
<td>- Line Graphs</td>
<td>- What is the horn for?</td>
</tr>
<tr>
<td>- Interpretations (trends)</td>
<td>- Why do they molt?</td>
</tr>
<tr>
<td></td>
<td>- How might their coloring be useful?</td>
</tr>
<tr>
<td>Activity: Writing and sharing their ideas.</td>
<td><strong>27</strong></td>
</tr>
<tr>
<td><strong>27</strong></td>
<td><strong>Combining/Averaging Group Statistics and Comparison with Other Groups</strong></td>
</tr>
<tr>
<td></td>
<td>- Line Graphs</td>
</tr>
<tr>
<td></td>
<td>- Final conclusions regarding caffeine and caterpillars</td>
</tr>
<tr>
<td><strong>Conclusion:</strong> Overview of experiment in its entirety.</td>
<td></td>
</tr>
</tbody>
</table>
Individual Lesson Plans

Unit Objectives:
At several points throughout the unit, the students will show that they are able to:
- Use a digital scale.
- Show through drawing what they see or observe.
- Make observations and refine hypotheses developed on February 4th.

Each Session:
Each day the students will be broken into groups of 4 students. There will be a short introduction to the main lesson for the day, and then the groups will do one of three things, rotating after the “weighing group” is done:
- One group will be weighing and writing observations in their Observation Booklets. Each group will have four caterpillars, two control and two caffeinated.
- Two groups will be drawing the caterpillars in their Observation Booklets.
- Three groups will be working on the daily activity.

February 4th:

Title: Introduction to Experiment and the Scientific Method

Objectives: Upon completion of this lesson the students will be able to:
1. Apply their knowledge of the scientific method by developing their own hypotheses.

Activities:
1. Introduction to Experiment: A quick run-down of the project will be given.
2. Scientific Method: An overhead/poster of the Scientific Method will shown, each step talked about in a discussion format.
   - Basic Steps:
     - Observation
     - Formulation of Hypotheses
     - Research
     - Conclusions
   - Potential Questions: What sorts of thing might we look at or think about during our observe phase? What is a hypothesis? What kind of research do we need to do (what sort of information should we be looking for?)
3. Activity: The students will develop their own hypotheses, attempting to answer the following: What do you think may happen when insects are given caffeine? (Hint: Think about what happens to people when they eat or drink caffeinated products.)

Materials Needed:
Overhead Projector
Overhead Pens or Chalkboard and Chalk
Scientific Method Overhead or Poster
Student Observation Booklets
Scales
Caterpillars

February 6th:

**Title:** Insects vs. Other Arthropods vs. Humans

**Objectives:** Upon completion of this lesson the students will be able to:
1. Explain what is and what is not an insect.
2. Label various parts of an insect.
3. Generate a simple pie chart given data.

**Activities:**
1. Introduction: An overhead of insect specific information will be shown. Students will take turns reading the given information aloud, and then answer the following question as a group: Is a spider an insect?
2. Activity: Interactive worksheet (see Day 2 worksheet).

**Materials Needed**
Overhead Projector
Insect Information Overhead

February 11th:

**Title:** Life Cycle of Caterpillars vs. Humans

**Objectives:** Upon completion of this lesson the students will be able to:
1. Create timelines of their own lives using past occurrences and possible future events.
2. Compare the life stages of humans with the life stages of caterpillars.

**Activities:**
1. Introduction: An overhead showing human and caterpillar life cycles will be shown and discussed. Students will be asked to think about which stages may be equivalent (approximately).
   - Egg=Embryo
   - Hatching=Birth
   - Larva=Adolescence
   - Pupa=Teens
   - Adult=Adult
2. Activity: Throughout the course of this unit, the students will observe much of a caterpillar’s life cycle. This day’s activity is designed for students to reflect on their past
experiences and postulate future occurrences by giving them an opportunity to develop timelines of their own.

**Material Needed:**
Overhead Projector
Life Cycle Handout
Timeline Handout

**February 13th:**

**Title:** Tobacco Horn Worm Specific Information

**Objectives:** Upon completion of this lesson the students will be able to:
1. Answer correctly (or at least speculate answers) to questions specific to hornworms.
2. Write and share their ideas in their class journals.

**Activities:**
1. Introduction: The lesson will begin with questions posed by the instructor, such as:
   - What is the horn for?
   - Why do they molt?
   - How might their coloring be useful?
   Any student questions will also be answered.
2. Journal Writing: The students will be encouraged to write in their class journals regarding caterpillar characteristics they find interesting.

**Materials Needed:**
Class Journals

**February 20th:**

**Title:** Observed Effects of Caffeine

**Objectives:** Upon completion of this lesson the students will be able to:
1. Identify any observed effects of caffeine on the caterpillars thus far.
2. Reflect upon their own diets and develop a list of foods containing caffeine.

**Activities:**
1. Introduction: We will begin this lesson by talking about any observed differences between the control caterpillars and the caffeinated caterpillars thus far. Some groups may already be seeing huge differences in body weight and health, while others may not. Each group will share what they have seen.
2. Activity: The students will brainstorm a list of foods containing caffeine, and think about their own diets. Caffeine will be portrayed as an over-the-counter drug; one that is not harmful if taken in small doses.
Materials Needed:
Caffeine Worksheet (prompts for identifying specific foods containing caffeine)

February 25th and February 27th (Depending on how much is accomplished):

Title: Graphing

Objectives: Upon completion of this lesson the students will be able to:
1. Graph the data collected throughout the course of the experiment.
2. Write final observations and conclusions.
3. Share any final impressions.

Activities:
1. Graphing: Given a graph, the students will be required to graph the weight progressions of their groups’ caterpillars. They will graph their cafffeinated caterpillar and the averages of the living non-caffeinated caterpillars (in groups where the cafffeinated caterpillar is no longer living, they will graph what they can.
2. Our Graphs: On February 27, we will present the class averages graph, as well as the graphs generated from the lab trials.
3. Conclusion: The class will discuss any final questions they may have regarding the experiment. We will help them prepare the dirt for any of the caterpillars that pupate. The students will work on the final observations and conclusions section in the class journals, to be collected and evaluated as seen fit.

Materials Needed:
Class journals
Graphing worksheets
Overheads of Our Graphs
Title: Class caterpillar averages

Weight (grams)

Date

Feb. 6  Feb. 11  Feb. 13  Feb. 20  Feb. 25

0.00  0.03  0.15  0.24  3.26

Blue = Caffeinated Caterpillars
Black = Control Caterpillars
Works Cited


References Consulted


