EFFECTS OF USING THE CONCEPT ATTAINMENT MODEL WITH INDUCTIVE REASONING WITH HIGH SCHOOL BIOLOGY STUDENTS

by

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A professional paper submitted in partial fulfillment of the requirements for the degree of Master of Science in Science Education

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Joy Renee Mayer

July 2012
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I would like to thank the members of my graduate committee including Jewel Reuter, PhD. from Montana State University’s (MSU) Masters of Science Education Program as my capstone advisor and Elinor Pulcini Ph.D. from the Center for Biofilm Engineering at MSU as my reader. Two teachers from Notre Dame Academy that helped in the editing of my capstone paper were Stefanie Jochman and Deb Corriveau. I would also like to thank my two daughters and husband for their support while working on my master’s degree and capstone project.
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ABSTRACT

The concept attainment method engages students in forming their own definition of the concept by examining several positive and negative examples of the topic being considered. The model can be used at any grade level and subject area and involves the students using critical thinking and metacognitive skills.

A nontreatment and three treatment units were compared by using pre and postassessments, surveys, interviews with concept mapping, and teacher observations to determine the effectiveness of the concept attainment model on students’ understanding of the biology concepts, thinking skills, and attitudes and motivation. The treatment units included several concept attainment activities per unit on bacteria and viruses, protists, and ecology. Teacher motivation and attitudes were assessed by a survey, teacher journal, and peer observations.

The data indicated that students’ understanding of the concepts and thinking skills did increase with the use of the concept attainment model. Students thought about their thinking process and ways that they learn while doing concept attainment activities. Student attitudes and motivations were slightly increased during the treatment units as many students perceived the concept attainment activities as being a game. Teacher motivations and attitudes increased during the creation and implementation of the concept attainment lessons.

The concept attainment model is an effective teaching method to engage students in creating their own definitions. The lessons helped to increase understanding of the concepts, engaged students to think about their learning, and had a positive effect on their attitudes and motivations in class.
INTRODUCTION AND BACKGROUND

The ability to learn new biology concepts and to think critically is essential for high school biology students. After reflecting on my high school biology classes, I have identified the need for my students to think more independently, apply their knowledge, and develop inductive thinking skills in order to be better prepared for future science courses. I discovered that the concept attainment model helps students to increase these skills. Reid (2011) described the concept attainment model as a way to provide an inductive lesson to help students develop critical thinking skills and a better understanding of the target concept. Critical thinking skills involve analysis, synthesis, and evaluation of evidence in order to make a decision.

This article by Reid (2011) on concept attainment methods inspired me to look into this model and to develop it for my capstone project. I realized that my students learn better when I use analogies and real-world examples during my biology lectures. Concept attainment lessons use examples as a way for the students to build the concept for themselves. Concept attainment is defined as a way to learn a new idea based on comparing and contrasting certain attributes of the concept. An attribute is a major feature or characteristics of the idea being learned. The students learn to think inductively, which is the process of moving from examples to concepts, while developing the biology concepts as they use the concept attainment model.

The significance of using the concept attainment model in my classroom is that it is the natural addition to my biology lessons as a way to increase the students’ thinking skills and content knowledge. The students learned how to develop their own definition...
of a topic and became more aware of their thinking process. The concept attainment model can be used in any subject area; therefore, I can share this technique with interested teachers at my school, Notre Dame Academy.

I have been teaching biology and chemistry for nine years at Notre Dame de la Baie Academy, a private Catholic high school in Green Bay, WI, with 745 students. The ethnicities of the students at the school are 91% Caucasian with the remaining 9% being Hispanic, Black, or Asian. I teach five sections of sophomore general biology classes, which contain a mixture of high and low-level students, with a variety of attitudes and motivations for science. The capstone project included two sections of general biology.

The focus question for my capstone project was: What are the effects of using the concept attainment model with inductive reasoning on students’ understanding of high school biology concepts? The subquestions of the project were as follows: what are the effects of using concept attainment with inductive reasoning on students’ abilities to analyze their own thinking process and learning styles; what are the effects of using concept attainment on the motivation and attitudes of my biology students; and what are the effects of using concept attainment model lessons on my science teaching and my motivation for teaching?

My graduate committee was composed of Jewel Reuter, PhD. from Montana State University’s (MSU) Masters of Science Education Program as my capstone advisor and Elinor Pulcini Ph.D. from the Center for Biofilm Engineering at MSU as my reader. Three people were selected as my support team. Deb Corriveau is a chemistry teacher at my school, and she recently earned her master’s degree in science through Michigan Technological University. She was selected for her science background, knowledge in
science teaching methods, and experience writing a formal paper for a master’s degree. Stefanie Jochman is an English teacher at my school, and she was selected for her editing and writing skill. Pete Mayer is my husband, engineer, and writer. He was selected for his skills in writing and attention to details.

CONCEPTUAL FRAMEWORK

The concept attainment model involves students applying inductive reasoning to determine the idea presented by the teacher through examining several positive and negative examples of the concept. Review of the literature indicates that students’ understanding of biology concepts and inductive thinking skills are increased by using the concept attainment method. The students’ motivations and attitudes towards biology class are improved after lessons applying concept attainment. The teacher’s knowledge of the subject area, critical thinking skills, and motivation for teaching are increased by implementing the model. Many studies have been conducted on how children learn, and research has shown how concept attainment and inductive reasoning can be used in the classroom to increase student knowledge.

The idea of concept attainment was described by Bruner, Goodnow, and Austin (1956) as a natural way to learn. The research showed that we learn by using and making categories, and we continue to use the categories for future learning when presented with new ideas. New concepts are attained by looking at attributes of an object or idea and trying to place them into a category based on prior knowledge and experiences. The process of concept attainment was described as a teaching method by Joyce, Weil, and Calhoun (2004) as a way for students to develop an understanding of a concept by
inductive reasoning. The teacher develops a list of positive and negative exemplars or examples for the desired concept. The students determine the concept by comparing the positive and negative exemplars. Their ideas are tested by creating examples, naming the concept, and thinking about how they came to their conclusions (Joyce, Weil, & Calhoun, 2004). These are the steps involved in structured inquiry. Structured inquiry is a process initiated by the teacher in a form of a question or problem that the students investigate by forming relationships from the data, organizing and interpreting data, and communicating their results (Beacon Learning Center, n.d.).

The concept attainment model is a type of structured inquiry that helps students to determine the differences between relevant and irrelevant information, observe, classify, and draw conclusions (Saskatoon Public Schools, 2009; Stem Resource, n.d.). As students examine the data and look for critical attributes, they are developing critical thinking skills (Reid, 2011). Nickels, Nelson, and Beard (1996) stated that “critical thinking should be the fundamental part of any science course” (p. 334). This process increases their long-term learning and development of inductive reasoning skills (Pritchard, 1994). The development of these critical thinking skills and inductive skills are used with the biology concepts in order for students to gain the skills and learn the concepts.

As a result of students using critical thinking and inductive skills, they will understand biology concepts better with concept attainment activities, because they are using examples. The concept attainment model is based on the idea that observing examples is one of the best ways to learn a concept (Talkmitt, 2008). In a study by
Brown (1992), physics misconceptions were corrected by using understandable, believable, visual examples and analogies to explain physics concepts to the students.

Similarly, in another study by Pugh, Linnenbrink-Garcia, Kosky, Stewart, and Manzey (2010), actively using science concepts in meaningful ways to increase student concept understandings of natural selection and inheritance was researched. Two teachers from two different Midwestern high schools with 166 biology students were involved in the study. The results of the pre and posttests indicated that engaged students had increased concept understanding.

In addition to the study on actively engaging students, a study by Roehrig and Garrow (2007) describes how developing conclusions from data can help to improve students understanding of concepts. The study involved four high school chemistry teachers from two different schools that used a specific guided-inquiry chemistry curriculum. The study found that two of the teachers consistently asked students to use evidence and graphical data from the activities to develop their reasoning skills and make conclusions during class discussions. The students’ average test scores were found to be higher than students not taught using the guided-inquiry curriculum.

The research has shown that using examples, engaging students, and drawing conclusions from data can increase students’ understanding of concepts and that the concept attainment model involves these processes. In the last step of the concept attainment model, the students use metacognition skills to analyze how they determined the concept by answering a series of questions about their thinking process. Example questions include: When did you first think you knew my idea (Reid, 2011); and what thinking processes assisted you in adding and eliminating concepts (Johnson & Carlson,
Lessons that teach students how to think about what they know help students to learn science reasoning and observation skills (Bilica & Flores, 2009). Students’ metacognition questions are used in the concept attainment activities to help the students discover how they are learning the concept and what learning styles work best for them.

Research on student metacognition was conducted by Yuruk, Beeth, and Andersen (2008). The study examined the use of metacognitive activities with 45 high school physics students in Ohio. The activities involved the students becoming aware of their conceptions, monitoring their understandings, and evaluating several concepts to explain physical theories. The students that were using the metacognition activities had increased understandings of the concepts compared to the group of students that did not use the metacognitive activities.

In addition to learning biology concepts and using metacognitive strategies, the students’ motivation and attitudes are altered after using the concept attainment model. The concept attainment model is a change from the normal routine of note taking, lecture, and lab activities. It is exciting for the students to discover the idea on their own, which can help to improve their attitudes towards the lesson if they find it fun and interesting. The students are more engaged and involved, which can increase their motivation for learning the topic (Joyce et al., 2004; Talkmitt, 2008). Research on students’ motivation and attitudes has been conducted on students using the three-phase learning cycle.

Lavoie (1999) studied the effects of a three-phase learning cycle involving exploration, introduction of terms, and concept application on student attitudes and understandings. Five sophomore biology teachers were selected to teach one class of biology using the learning cycle for one semester. The study used questionnaires and
observations to assess the 125 students’ attitudes towards the class using the learning cycle. Students found the class to be more interesting, helped them think more, helped them to better understand the concepts, and that they liked science more after the learning cycle class.

In the same way that students’ motivation and attitudes are changed by using the concept attainment model, teachers’ motivation and attitudes were increased after implementing the model. Preparing the concept attainment lessons increased the teacher’s content knowledge and their own critical thinking skills, because the teacher needed to analyze the topic and create positive and negative exemplars (Pritchard, 1994). Teachers have found great satisfaction in learning to use the model and in helping students to apply the science concepts to real world experiences (Pritchard, 1994). The study by Lavoie (1999) examined teacher attitudes while using the three-phase learning cycle to teach high school sophomore biology students. Journal reflections and questionnaire data showed that teachers were more satisfied with the learning cycle instruction when compared to traditional teaching methods and had a more positive attitude toward their students.

As a result of my research on the positive effects of teacher’s attitudes toward the model, I found useful strategies for creating concept attainment lessons. The concept attainment model can be used as a way to introduce, summarize, or to evaluate the topic (Joyce et al., 2004; Reid, 2011). There are many topics in a high school biology curriculum that involve visual data, observations, and relationships, which work well for an inductive lesson (Reid, 2011). I used concept attainment lessons to teach the concepts of bacteria/virus, protist, and ecology because of the various pictures and examples that
were available for these topics. Additionally, the topics were selected by following the idea presented by Bilica and Flores (2009) that selecting science concepts that are more concrete rather than highly abstract create more useful inductive lessons, because students will be applying their previous knowledge and experiences to discover the concept.

Pursing these strategies further, there is research by Tennyson, Chao, and Youngers (1981) that has shown that learning skills improved when the exemplars increased in difficulty and were paired with negative exemplars. This suggestion was used to create an effective concept attainment lessons for the three topics by varying the difficulty of the exemplars.

In conclusion, the attainment of concepts is a natural way for students to learn biology content, and in the process, the students discover how they learn. The concept attainment model is a way to bring an inductive lesson into the science classroom in order to help students develop critical thinking skills. Both student and teacher attitudes and motivation are improved by using the concept attainment model to increase understanding of biology concepts.

METHODOLOGY

Project Treatment

My capstone project evaluated the effectiveness of the concept attainment model by comparing one nontreatment unit and three treatment units. The nontreatment unit of classification was taught using PowerPoint lectures, a field-guide activity, and a series of worksheets and book questions as homework, and the unit was assessed by a chapter test.
The students took notes on a prepared note sheet during a PowerPoint lecture as shown in Appendix A. The daily lesson plans used for this unit are included in Appendix B. The students learned how to classify by completing the field-guide activity in Appendix C.

The three treatment units on bacteria and viruses, protists, and ecology contained concept attainment activities and used the same unit design as the nontreatment unit. Each treatment unit used PowerPoint lectures, a lab activity, book questions, worksheets, chapter test, and concept attainment activities. The corresponding note sheet for the bacteria and virus unit is included in Appendix D. The lesson plans for this treatment unit are included in Appendix E. The other two treatment units have the same lesson plan design and format.

Each concept attainment activity which I called “What am I Thinking” had the students analyze positive and negative examples in order to determine the concept. The activity involved students looking at a PowerPoint slide that revealed the positive and negative examples one-at-a-time. The slides for the first treatment unit are in Appendix F, the second treatment unit slides are in Appendix G, and the third treatment unit slides are in Appendix H.

For the first step of the activity, I explained to the class that they were to determine what I was thinking about by comparing and contrasting pictures and words that were placed into a positive column or a negative column on the board using a PowerPoint slide, see Appendix F. The students were given a guide sheet called “What am I Thinking” as listed in Appendix I. In the second step, one positive and one negative example were shown to the class. Two more positive and negative examples were shown and then the students answered the first two questions on their guide sheet on the
attributes that made the positive examples fit together. I discussed the meaning of an attribute and how it applied to the questions. The students were instructed to keep their ideas to themselves and to examine several more examples. For the third step, I asked the students to give thumbs-up or thumbs-down if they thought they knew the concept. This technique helped me to determine if most of the class was getting the idea and which students were still forming the concept.

Seven positive and negative examples were shown for each concept attainment activity. After all of the examples were shown, I started the fourth step by asking the students what the positive examples all had in common. As a class, we discussed what the positive and negative examples had in common in order to help all students understand the thinking process involved in making comparisons. For the fifth step of the activity, the students completed the third and fourth questions on their guide sheet. These questions helped the students create their own examples and write a definition of the concept. I asked the group “Does anyone know the name of my idea?” The answers were discussed and a conclusion on the correct answer was determined by the class.

For the final step of the process, the students answered the reflection questions on the guide sheet (Appendix I) about their thinking process and how they determined the concept. I collected and corrected the guide sheets to determine if the students had identified the correct concept and to determine their level of thinking. The students received feedback the next day by having their graded guide sheet returned. As a class, we discussed and shared the different thinking processes that they used during the activity. We also discussed as a class any questions on the concepts learned in the activity.
In addition to the formal concept attainment activity as described, the two biology
classes participated in several smaller concept attainment activities throughout the three
treatment units. During treatment unit 1 on bacteria and viruses, I started a lesson by
having the students state an infectious disease. I had “yes” or “no” on the whiteboard and
placed the disease under the proper heading. After 10-15 diseases, I had the students
determine what the “yes” column had in common. The diseases in the “yes” column
were bacterial diseases and the “no” column diseases were viral disease. During
treatment unit 3, the students were given a homework assignment to select a topic from a
previous chapter and to create their own list of positive and negative examples for that
concept as shown in second part of Appendix I. The student created concept attainment
lessons were used to prepare for their final exam in May by students working in pairs and
figuring out their partner’s activity. The pair then discussed the correct answers and how
they came to their conclusions. For the last concept attainment activity, the students
worked in groups of three and wrote their answers on small white boards, instead of
completing the guide sheet.

The research methodology for this project received an exemption by Montana
State University’s Institutional Review Board and compliance for working with human
subjects was maintained.

Data Collection Instruments

Two classes of high school sophomore biology students during fourth and fifth
periods were included in my action research project from Notre Dame Academy in Green
Bay, WI. I selected this group of students with various levels of achievement in order to
determine whether the concept attainment method would be an effective way for high, middle, and low-level students to learn biology concepts while improving attitudes and providing motivation to do well in biology class. There were 53 students split between two sections. The group was comprised of 41.5% girls and 58.5% boys, with 89% of the students being Caucasian. The fourth period class had two Hispanic students, one exchange student from South Korea and one exchange student from Taiwan. In fifth period, there were two Hispanic students and one student with mild Autism that receives extra time and a reader for his tests. The students enjoyed working in small groups and completing hands-on activities and labs. The students listened well and participated in class discussions and projects. Some of the students preferred to finish things quickly and did not like to think about what they are doing.

Several forms of data were collected to allow for triangulation, ensuring a variety of ways to assess the focus question and subquestions. Interviews with concept mapping, surveys, observations, guide sheets, and pre and postunit assessments were used to assess the students before and after the treatment. A journal, self-evaluation, and survey were used to determine the change in motivation and attitude of the teacher. The data triangulation matrix is shown in Table 1.
Table 1  
*Data Triangulation Matrix*

<table>
<thead>
<tr>
<th>Project Question</th>
<th>Data Source 1</th>
<th>Data Source 2</th>
<th>Data Source 3</th>
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<tbody>
<tr>
<td>Understanding biology concepts</td>
<td>Concept attainment guide sheet with teacher observations - compare treatments 1,2,3</td>
<td>Pre and postunit assessment</td>
<td>Pre and posttreatment interviews with concept mapping</td>
</tr>
<tr>
<td>Analysis of thinking process</td>
<td>Concept attainment guide sheet with teacher observations- compare treatments 1,2,3</td>
<td>Posttreatment interviews</td>
<td>Pre and posttreatment survey</td>
</tr>
<tr>
<td>Student motivation and attitudes</td>
<td>Pre and posttreatment survey</td>
<td>Pre and posttreatment interviews</td>
<td>Observations during non and treatment units</td>
</tr>
<tr>
<td>Teacher motivation and attitudes</td>
<td>Teacher journal</td>
<td>Observation by principal and another science teacher</td>
<td>Pre and postunit teacher survey</td>
</tr>
</tbody>
</table>

The effects of the concept attainment model on students’ understanding of biology concepts were assessed by comparing the guide sheets after each treatment, pre and postunit assessments, and the concept interview questions with concept mapping. Questions 1 through 4 on the guide sheet (Appendix I) were used to determine the student’s understanding of the new concept and were compared after each treatment. A pre and postunit assessment of concepts was given before and after the nontreatment unit (Appendix J) and each treatment unit to allow for a comparison of the understanding of the concepts with and without the treatment. See the pre and postunit assessments in Appendix K for treatment unit 1, Appendix L for treatment unit 2, and Appendix M for treatment unit 3. Two students from each level of low, middle, and high achievement were selected from the two biology classes for an interview with the questions shown in...
Appendix N for pretreatment and Appendix O for posttreatment. The six students were interviewed individually during their study hall before and after completing the concept attainment activity, and I took handwritten notes on the student responses. As a part of the pre and posttreatment interview, the students completed a concept map using a series of words from the unit to show their understanding of the concepts (Appendix P). The concept maps were scored based on the number of connections they made between the list of words.

After measuring students’ understanding of the concepts, the analysis of students’ thinking processes was obtained from comparing questions 5 through 9 on the guide sheet (Appendix I) from each of the three treatment units to determine the growth in students’ thinking process. Interviews of the six students from low, middle, and high-achievement were used to assess their thinking processes (Appendix O). Pre and posttreatment paper surveys (Appendices Q and R), were given to all students to determine how their thinking processes changed and what ways they learn the best.

Next, student motivations and attitudes were assessed by a pretreatment survey in Appendix Q, and the questions asked the students about their attitudes related to how the biology concepts are taught. The posttreatment survey (Appendix R) included several of the same pretreatment questions and also questions on their attitudes towards the concept attainment activity and the class. Posttreatment interview questions in Appendix O were asked of the six students to determine their attitude and motivations during biology class and the effect of the concept attainment activities. The level of engagement and attitudes of all students was observed by the teacher and written in a journal during the activity and
compared between treatments 1, 2, and 3, and to the nontreatment unit. The writing
prompts for the observation journal are listed in Appendix S.

The final data collection instruments assessed my motivations and attitude. A
journal, pre and posttreatment self-evaluation, and peer observations were used to collect
data on my changes in motivation and attitude towards my students and the class. A
weekly journal of my reflections of the nontreatment unit and the three treatment units
(Appendix T) was used to determine my attitude towards my biology students and my
motivations for teaching before and after the concept attainment activities. The school
principal and a science teacher observed my class during a concept attainment lesson and
recorded their observations using the peer observations prompts in Appendix U. I took a
pre and posttreatment attitude survey (Appendix V) to determine my change in attitude
and motivations.

After completing each data collection method, the qualitative and quantitative
data were analyzed. The quantitative data from the pre and postunit assessments were
presented in a graph in order to compare the students’ understanding of concepts before
and after the treatment. The percent change was calculated and shown in a table. The
interviewed students’ concept maps were compared between nontreatment and treatment
units using a graph and table.

A graph was used to show the difference in the thinking processes between
nontreatment and treatment activities. Next, the survey and interview quantitative data
were analyzed in a graph to show changes in student motivations. Qualitative data from
the interviews, observations, and survey questions were reported as a narrative of
students’ comments on the concept attainment activities. A table was used to show a
change in teacher motivations and attitudes by using quantitative data from the peer observation and survey. Teacher comments from the journal and survey were expressed as narratives to show differences in attitude from before and after the treatments.

The project was implemented on January 16, 2012, with the nontreatment unit on classification lasting one and a half weeks. The first treatment unit on bacteria/virus lasted two weeks, the protists treatment unit was one and a half weeks, and the final treatment unit on ecology lasted two weeks. The project concluded on March 9, 2012, as shown in the timeline in Appendix W.

DATA AND ANALYSIS

Understanding Biology Concepts

Students understanding of biology concepts were assessed by using pre and postunit assessments, a guide sheet during the concept attainment activities with teacher observations, and student interviews with concept mapping. A five-question pre and postunit assessment was given during the nontreatment and three treatment units and the average scores are shown in Figure 1. The scores improved in all of the postassessments, but the three treatment postassessment scores were slightly higher than the nontreatment postassessment score.
Figure 1. Comparison of preunit and postunit assessment scores for the nontreatment and treatment units, \((N=53)\).

Note. Assessments out of 5 points.

The average percent change between the pre and postunit assessments are included in Table 2. The percent change value indicates the change between the original preassessment score and the new postassessment score in order to determine the level of student improvement. The nontreatment unit had the greatest percentage change. The higher percent change in the nontreatment unit could have been due to the students not having taken a preassessment before in class and many of the questions were left unanswered. The topics for treatment 1 on bacteria and virus and treatment 2 on ecology were more familiar to the students than the nontreatment unit on classification. Students had a higher initial score on their preassessment, so the change was smaller although a change was still achieved in all of the treatment units.

Table 2

<table>
<thead>
<tr>
<th>Pre and Postassessment Percent Change</th>
<th>Nontreatment</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>335.40%</td>
<td>135.80%</td>
<td>268.40%</td>
<td>99.10%</td>
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A guide sheet was used by each student during the concept attainment activity to record the concept they thought was being explained and their definition of the concept. Figure 2 shows the average score on the guide sheet for the different treatment activities. The graph shows the increased improvement throughout the treatment units. The students learned how the concept attainment lessons were conducted and were improving on understanding the concept that was being taught.

![Figure 2. Average guide sheet scores of concept attainment treatments, (N=53).](image)

*Note.* Guide sheet score was out of 9 points. Treatment 1a- Bacteria, Treatment 1b-Virus, Treatment 2a-Protists, Treatment 2b- Plant-like protists, Treatment 3a-Abiotic and biotic.

I observed the students use of critical thinking skills and learning the concept during the nontreatment and treatment units as shown in Figure 3. The students were using higher level critical thinking skills and showed an increase in learning the concept while completing the treatment activities when compared to the nontreatment activities.
At the end of treatment unit 3, the students created their own concept attainment lesson on topics from three previous chapters. Table 3 includes the average scores of the created lessons based on a grading rubric in Appendix I and the percent of students that finished the activity. The table shows that students used their biology knowledge to create correct and meaningful concept attainment lessons. Students used the created lessons to review for their final exam in May. A student created lesson is in Appendix I.

Table 3

<table>
<thead>
<tr>
<th>Results of Students Creating their own Concept Attainment Lesson (N=53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Student Created Concept Attainment Lesson</td>
</tr>
</tbody>
</table>

Note. Concept attainment lesson was out of 20 points.

Six students were interviewed and completed pre and postunit concept maps in order to assess their understanding of the concepts. Figure 4 shows the increase in the

![Graph showing increase in critical thinking and learning concept scores]

Figure 3. Comparison from teacher observations of the students during treatment and nontreatment activities for critical thinking and learning the concept, (N= 53).

Note. 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree.
average scores of the posttreatment concept maps from the pretreatment concept maps. Posttreatment 2 concept map had the highest score indicating increased knowledge of the biology concepts.

![Bar chart showing average student scores](image)

*Figure 4. Comparison of preunit and postunit concept mapping scores of student interviewed for nontreatment and treatment units, \(N=6\).*

*Note.* Points given for number of connections on concept map.

Table 4 shows the average percent change of the concept map scores and average percent change for pre and posttreatment assessments scores for the students interviewed. Both assessments indicate an increase in understanding the concepts. This is further indicated in the interview results. Percent changes for the nontreatment unit were higher than the treatment units for the interviewed students and this could be due to the unfamiliarity with the topic and taking a preassessment. The same trend was noted with the entire class data from Table 2.
Table 4
Comparison of the Percent Change between Nontreatment and Treatment for Pre and Postassessments and Concept Mapping of Students Interviewed (N=6)

<table>
<thead>
<tr>
<th></th>
<th>Nontreatment</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre and Postinterview Concept Map Percent Change</td>
<td>103.57%</td>
<td>105.56%</td>
<td>87.88%</td>
<td>78.13%</td>
</tr>
<tr>
<td>Pre and Postassessment Percent Change</td>
<td>300.00%</td>
<td>107.69%</td>
<td>250.00%</td>
<td>52.94%</td>
</tr>
</tbody>
</table>

During the interview, the students were asked if the concept attainment activity helped them to understand the concept better than taking notes. Eighty-three percent of the interviewed students thought the treatment did help them understand the concepts better and gave the following responses, “Yes, because it gave me positive and negative things about each topic so it helped to cross out ideas.” “Yes, because it reinforced my knowledge outside of notes.” and “It helped me understand the topic better.” One student interviewed did not find the treatment to be helpful in understanding the concept. “No, I did not like it because I thought it was confusing.”

The guide sheets, pre and postassessments, and the interviews showed that the concept attainment activities did help to increase understanding of the biology concepts. The nontreatment unit’s percent changes for the pre and postassessments and pre and post concept mapping were higher than the treatment unit’s percent changes. This could be due to the lack of prior knowledge of the nontreatment unit topic and their unfamiliarity with taking a preassessment and creating a concept map.
Analysis of the Thinking Process

The analysis of the students thinking about their learning was triangulated by using the metacognitive reflection questions from the guide sheet and my observations during the activity, student interviews, and postsurvey questions. The guide sheet reflection questions asked the students to state when they knew the idea and what examples helped them to clarify their thinking. Figure 5 shows the average example number of when the students knew the answer. There were seven positive and negative examples and on average the students knew the answer by the fourth example for each treatment.

![Figure 5. Average example numbers in which students knew the answer, (N= 53).](image)

*Note.* Concept attainment activities had 7 examples. Treatment 1a- Bacteria, Treatment 1b-Virus, Treatment 2a-Protists, Treatment 2b- Plant-like protists, Treatment 3a-Abiotic and biotic.

A reflection question on the guide sheet asked the students to consider how the negative examples helped them to add or eliminate ideas. Student answers included “The negatives helped to clarify what it was not.” “It helped me to see what is different.” and “I was able to eliminate some choices/ideas.” Often the negatives examples described a different concept from the chapter and the students were able to compare and contrast the two different concepts. For the bacteria and viruses unit, the negative column described a
eukaryote and a student commented “The negatives helped me to eliminate eukaryotes as an option since they described eukaryotes.”

I observed the students thinking about their learning during the treatment and nontreatment activities and the results are shown in Figure 6. The students needed to think about how they figured out the answer to the concept attainment and how they formed the definition of the concept. The questions required them to think about their learning process. The nontreatment unit did not require metacognitive skills.

![Figure 6](image)

**Figure 6.** Average score of students thinking about their learning as observed by the teacher during the treatment and nontreatment activities, (N=53).

*Note.* 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree.

The interviewed students were asked how the questions at the end of the activity helped them think about how they determined the concept. Student responses included, “The questions helped me to go back to the thinking process and see what hint actually made me figure out the idea.” “I liked this type of learning before each chapter because it was a fun way to figure out what we would be learning next.” “The questions showed me how I broke down the problem to find the answer.”
A question on the postsurvey asked the students to rate how strongly they agree that the teacher’s questions or the guide sheet questions helped them to think about how they came to the conclusion of the concept. The students found the teacher questions to be a little more helpful than the guide sheet questions as shown in Figure 7. Student comments from the survey questions include “The activity gets me to think” and “The reflection questions made me think more.” One student said that they didn’t enjoy it because “It’s a lot of thinking.” Others students noted “It helps you think of it in a different way.” “It helps you think more in depth” and “This game helped me to use my brain in a logical way.”

Figure 7. Average score from the student posttreatment survey on using their thinking skills from teacher questions and their guide sheet during the treatment, \(N = 53\).

*Note.* 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree.

Students used critical thinking skills and reflected on their thinking process during the concept attainment activities. The reflection questions on the guide sheet and teacher questions during the treatment guided the students in how to think critically and to decide how they came to their conclusions. The results were shown by the use of reflection questions from the guide sheet and observations during the activity, student interviews, and postsurvey questions.
Student Motivations and Attitudes

Student motivations and attitudes were assessed by using a pre and posttreatment survey, interviews, and teacher observations. Students found the treatment to be a different way to learn the concept and many found it to be like a game. Student response to the postsurvey question that asked them to explain their answer for rating the concept attainment activity included “It changes up the basic class routine.” “It is like a game.” “I liked doing it on the white boards in small groups.” and “It was fun.” Students were asked to evaluate how much they enjoyed biology class in the pre and postsurvey. Figure 8 shows that the students were enjoying biology class more after the treatment units by a percent change of 27.7%.

![Figure 8](image_url)

**Figure 8.** Average score from pre and posttreatment surveys from the question on how much they enjoy biology class based on the scale, \( N=53 \).

*Note.* 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree.

The pre and postsurvey questions asked students to rank the different biology activities in the areas of excitement, relevance, and enjoyablity. The average scores for the concept attainment activity, taking notes, doing hands-on activities, and doing homework are shown in Figure 9. Students enjoyed hands-on activities the most while taking notes and doing the concept attainment activities ranked as second and third.
Students found the hands-on activities done throughout the year to be exciting and enjoyable and taking notes to be very relevant even if they are not enjoyable. The students scored the concept attainment activities to be relevant, but the levels of excitement and enjoyability received lower scores. Most students scored homework very low for excitement and enjoyability, but found it to be somewhat relevant.

![Bar chart showing average student scores](image)

**Figure 9.** Average level of excitement, relevance, and enjoyability on the pre and postsurvey, \(N=53\).

*Note.* Excitement level: -3 = Boring, 0 = Okay, 3 = Exciting
Relevancy level: -3 = Irrelevant, 0 = Somewhat relevant, 3 = Relevant
Enjoyment level: -3 = Unenjoyable, 0 = Okay, 3 = Enjoyable.

Completing the guide sheet each time was not exciting for the students and many students used the same answer each time for the reflection questions. Students expressed in the postsurvey that doing the treatment the same way each time did get boring. Student comments included “The reflection questions were repetitive and I answered them the same each time.” “It gets boring and we shouldn’t have to do a worksheet every time.”

Interviewed students were asked how the concept attainment activity motivated them to find the answer. Common responses included, “It plays like a game, so that
motivates me to find the answer.” and “It motivated me because I wanted to be the first to figure it out. Overall it was really fun.” Students were asked how the treatment affected their attitude in biology class. Common student responses included “If I knew it, I felt good about it and if I didn’t get it, then I try to learn it.” and “It can affect my attitude because I am excited to learn and I really need to take time and think.”

I observed the students during the treatment activities and recorded their participation and attitude and the average scores are shown in Figure 10. The students’ participation and attitude levels were slightly higher during the treatment units in comparison to the nontreatment units. This indicates that the students were motivated to do the activity and participate in class.

![Figure 10](chart.png)

*Figure 10.* Average score of teacher observation during nontreatment and treatment activities on attitude and participation levels, (N=53).

*Note.*  5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree.

The last treatment activity was completed in a small group using whiteboards; the students seemed to really get into the activity and wanted their group to get the answer first. In the postsurvey, a student noted “I liked working in the small groups and with the white boards and would have liked doing this more often.”

Student motivations were increased by using the concept attainment activities since many students found it to be a challenge or a game to get the correct answer as
shown in the interviews and postsurvey results. Student attitudes were positive towards the class and the activities as shown by teacher observations, interviews, and postsurvey results.

Teacher Motivation and Attitudes

My motivation and attitudes towards teaching biology concepts were assessed by a teacher journal, peer observations, and teacher pre and posttreatment survey. During the nontreatment unit, I noted in my journal that I was concerned that students did not want to take the time to think about their learning process and the ways that they learned better. I also noted that students preferred working in small groups than alone on a project, activity, or lesson. I was confident in teaching the unit, but I was not really excited about the unit. One of the activities during the nontreatment unit was using field guides to learn about classification. The students worked in small groups and had an easy time with the worksheet and using the field guide books. They learned about the different ways to classify and compared and contrasted different physical traits. They did not have to think about the process of learning or use critical thinking skills since they could look it up in a book. I visited each group during the activity, but I felt there was little teacher to student interaction.

According to the notes in my journal, teacher and student interactions increased greatly during the treatment units. I conducted an informal concept attainment lesson with the students during treatment unit 1 on bacteria and viruses. At the start of class, I listed “yes” and “no” in two columns on the board. I asked students to give me a name of an infectious disease. After placing about 15 diseases in the two columns and then
through a series of questions and discussions, the class decided that the “yes” column was bacterial diseases and the “no” column was viral diseases. The teacher and student interaction was very positive and the concept attainment activity motivated me to continue the class with a positive attitude. I was motivated because the students were engaged and I wanted that type of environment in the classroom to continue.

I continued to be positive during the treatment units and found that the students thought of the treatment as a game. Towards the end of treatments, I noticed that the students were taking less time with the reflection questions and did not seem to be enjoying it as much as in the beginning. The students stated on their surveys that they did not like answering the same reflection questions after each activity. I felt frustrated, but I tried to come up with a different way to do the concept attainment model in order to keep up the motivation and attitude level of both the students and myself. The final treatment activity used small groups and a white board for the students to record their answers instead of the guide sheet. I did feel encouraged with their increased level of participation and it motivated me to continue to think of new ways to use the concept attainment model in future units.

The second assessment of teacher motivation and attitudes was two peer observations. The freshman physical science teacher and the principal observed my class during two separate treatment activities on two different days and recorded their observations. Figure 11 lists their observations on my attitude, interactions with the students, and the level of student learning. Both observers stated that the level of teacher and student interactions, teacher attitude, and student learning the concepts were a 5. The science teacher commented that "Students were not at all resistant to the process. Joy had
a positive attitude toward the lesson and the students." The principal noted “Good visuals were used and the example list helped retention of the concepts. Students were thinking about the learning process by answering the reflection questions. Positive teacher interactions with the students were observed.”

![Bar chart showing observation criteria](image)

**Figure 11.** Principal and science teacher observations during treatment activities, \((N=2)\).

*Note.* 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree.

The final form of assessment for teacher motivation and attitude was a pre and postsurvey that was used to determine changes in my motivation and attitude in teaching biology and the results are shown in Figure 12. I felt confident about the content that I was teaching during the nontreatment and treatment units, because I have taught them for several years. It was challenging to stay positive, excited, and motivated after teaching
the same class for several years and repeating the same class five times each day. Using
the concept attainment activities during the treatment units was exciting and new, and I
found that it motivated me to be creative and to teach the topics in a different way. I
stayed positive for each class and encouraged the students to learn this new method in
order to increase their critical thinking, understanding of concepts, and metacognition
skills.

Figure 12. Teacher pre and posttreatment survey results, \(N=1\).

\textit{Note.} 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly
Disagree.

Through peer observations, a teacher journal, and a pre and posttreatment survey,
I was able to determine that creating and delivering the concept attainment model to my
biology classes did increase my motivations. I maintained a positive attitude toward my
students and to teaching while implementing my treatment units as indicated by the data.

\section*{INTERPRETATION AND CONCLUSION}

The data were analyzed to answer my project questions on the effects of using the
concept attainment model on the understanding of biology concepts, the effects of
students’ analyzing their thinking process, effects on student and teacher motivations and attitudes. The students showed improvement on the posttreatment assessment questions indicating that the concept attainment model activity helped to increase their understanding of the concepts. A larger percent change was observed during the nontreatment unit when compared to the treatment units. This may have been due to a less familiarity with the nontreatment unit of classification and having more previous knowledge of the treatment units of bacteria and ecology. If this project was conducted again, I would try to use units with similar levels of prior knowledge. The guide sheet scores increased throughout the treatment units which indicated that the students were learning how to complete the concept attainment activities and how to use the examples to form the concept.

Student interviews with concept mapping were also used to determine students’ understanding of the concepts. The students’ pretreatment maps were very incomplete and showed that the students did not have much prior knowledge to the topics. The posttreatment concept maps showed the relationships that students formed about the concepts and indicated an increase in conceptual knowledge. The nontreatment unit also included the students making a concept map before and after the unit. Similar results were seen as the treatment unit concept maps with incomplete maps for the preunit and more details for the postunit concept map. The average percent change between pre and postconcept maps was 103% for the nontreatment and 105% change between pre and postconcept maps for treatment unit 1.

In addition to better understanding the concepts, the treatment also made the students more aware of their thinking processes. The students used metacognitive skills
on the guide sheet and had to really think about the process that they used to determine the answer and write a definition. My observations during the nontreatment and treatment activities showed that students were using more critical thinking skills during the treatment activities. The comments from the interviewed students and the posttreatment survey mentioned several times that the activities made them think.

The interviewed students also commented on how the activities affected their motivations and attitudes towards the class. They found the concept attainment activities to be like a game which made them excited about the class. While observing the students during the activities, I noticed that they were really trying and wanted to get the answer.

Several of the comments from the postsurvey also mentioned that it played like a game, but some of the students mentioned that it got boring answering the same guide sheet questions each time. Changing the guide sheet questions each time for different topics would be one way to keep the activity fresh and new each time. The students liked it when we did the concept attainment activities in teams and used a white board instead of the guide sheet. Based on these types of comments, using the “What am I thinking” activity in a different way each time would help to keep the motivation and excitement level up for this activity and keep the students excited about doing concept attainment activities. Different ways to conduct the concept attainment activities include working in pairs, teams, or individuals, students creating their own activity, and having students list examples with the teacher writing them on the board under a positive or negative column.

My motivations and attitudes towards the classes and teaching were positively affected by creating and implementing the concept attainment model in my biology classes. Comments written in my journal described how creating the lessons engaged
me in the process and allowed me to look deeper into the concept in order to create several meaningful positive and negative examples. The peer observations produced positive feedback on teacher and student interactions and showed that I had a positive outlook towards the lessons and my students. The comparison between the pre and posttreatment survey showed that I enjoyed creating the treatment lessons and that I was motivated to teach the concepts in a different way in order for the students to increase their understanding and thinking skills. I was positive, encouraging to the students, and enthusiastic during the delivery of the treatment units.

In future units, I plan to create additional concept attainment lessons as a way to introduce a new concept or as a way to review a concept. I plan to create different guide sheets with new metacognitive questions in order to keep it fresh and engaging for the students. Implementing the concept attainment model in different formats will be done to ensure students remain interested and excited about learning new concepts by using the concept attainment model.

There are several changes I would make in my data collection and delivery of my nontreatment and treatment units if I repeated the action research project to obtain better results. I would select units that are more similar to each other and units that students have the same prior knowledge. The units on the human body systems would be a good choice since they are related to each other and students have the same prior knowledge. This adjustment would give a more accurate percent change between the nontreatment and treatment units to determine if the treatment did make a difference. I would instruct students several units before the treatment on how to construct detailed concept maps to ensure that the percent change for the interviews with concept mapping between the
nontreatment and treatment units was due to the effect of the treatment and not based on their ability to make a concept map.

In addition to more instruction on concept mapping, I would also focus my research to see the effect of the treatment on different academic achievement levels in my classroom. I would observe and interview low and high-achievement students to determine if the concept attainment model is more beneficial to one of the groups. I could then differentiate my instruction to help those students learn the new concepts.

VALUE

The implications of implementing the concept attainment model are having the students succeed in learning new concepts and thinking more about their learning process. My analysis of the data showed that these two areas did increase while using the concept attainment model. I will continue to use this technique as a way to use examples to help my students understand biology concepts. I hope that the students will learn how to use examples to form new concepts on their own and discover the best ways for them to learn.

My findings showed that the concept attainment model is very useful in the biology classroom as a way to increase understanding of topics, but the method can be applied to any subject area and grade level in which new concepts need to be formed. I would like to share this technique with other teachers at my school. Classroom teachers can customize a lesson by selecting several negative and positive examples that fit the
concept being taught. The teacher has a high level of flexibility in the delivery and presentation of the examples.

The next step in my research would be to develop several new ways to deliver the concept attainment model such as using small groups or have students create their own concept attainment lesson. I would also create new metacognitive questions and additional concept attainment activities for other units. I would be interested in interviewing and observing the students to evaluate the impact of implementing the activities in different ways to determine which format they found to be most helpful for them to understand the topics, keep their interest, and to be the most enjoyable. Since the model is an effective way to teach biology concepts, I will continue to develop new concept attainment activities and work on the best combination of questions to use on the guide sheet.

The project impacted me personally by having me follow through with a two year project. I reflected on my classes and determined what I would like to improve in my teaching and in my students. The project gave me an opportunity to think about changes that I would like to see in my teaching in order for my students to increase their critical thinking skills and understanding of the biology content. I learned that I enjoyed creating new lessons and learning a new teaching method. It was challenging and exciting to offer my students a new way to learn.

Conducting an action research project motivated and challenged me try something new, to learn how to collect and analyze data, and to draw conclusions. I feel that the project had a positive impact on my students and on my teaching. Researching topics for this project made me think about new teaching methods. Implementing a new teaching
method is something that I would like to do more often, but often I do not take the extra
time and effort to fully research a new technique. This project offered me the opportunity
to research, learn, create, deliver, and evaluate a new teaching method to be implemented
my biology classes.

In addition to learning more about myself, I also realized that my students are
willing to try new approaches in the classroom and that they are cooperative and
understanding when it came to taking preassessments and surveys. The students liked a
new approach especially when they perceived the treatment as a game or challenge. The
students started to think about their thinking process and how examples could be used to
help them learn new concepts. The most interesting component of my project was
watching how the students responded to this new teaching method. They are very quick
to adapt to a new approach and were very willing to try something new.

Although the students found the treatment to be like a game, the most challenging
aspect of the project was when the students had completed several concept attainment
activities and started to not answer the metacognitive questions and seemed to be getting
bored or tired with the method. I was concerned about how I could continue with more
concept attainment activities if the students did not want to complete them. I was able to
modify the delivery of the last activity by doing it in a small group and eliminating the
individual guide sheet questions. This change made me realize that delivering the
concept attainment model in several different ways would be beneficial to my students
and would allow me to keep their interest in the treatment.

Being able to adapt to changes and react to my students during the project showed
my professionalism. The project also affected my professionalism by providing me with
an opportunity to do a formal action research project in my class, create new lessons, implement the lessons, collect data, and analyze the results. I was increasing my knowledge of best practices for classroom teachers and fully researching and using one of these methods that have been successfully used in other classrooms.

The impact of my capstone project was that I successfully researched, created, and delivered a new teaching method to my students that helped them to develop critical thinking skills, metacognitive skills, and an increase understanding of the biology concepts. The knowledge and skills that I learned about the concept attainment method can be shared with other teachers, so they too can carry out concept attainment activities in their classroom for any subject or grade level.
REFERENCES CITED


APPENDIX A

NONTREATMENT UNIT STUDENT NOTE SHEET
Chapter 12: Classification

Essential Question: How are living things organized and named?

I. Biodiversity: variety of organisms

A. Classifying organisms

1. **Taxonomy:**

   a) taxon (taxa): particular group within a taxonomic system

2. Common names were confusing and varied from place to place

3. Long descriptions in Latin was used but they were difficult to remember

B. Linnaeus’s system (1700’s)

1. Use organisms’ form and structure to group them into categories
   a) kingdoms was the largest group
   b) plants and animal kingdom

2. Levels of classification

   a) 
   b) 
   c) class
   d) 
   e) family
   f)
g) species: single organism type

3. **Binomial nomenclature:**
   a) **first name:**
   b) **second name:**
   c) example:
   d) written in Latin so all scientists can identify the organism

4. Modern system has **domain** level above kingdom

II. Systematics: organizes living things by similarities in embryos, chromosomes, proteins, DNA, fossils

A. **Phylogenetics:** analysis of evolutionary relationships among taxa

1. **Phylogenetic diagram/tree:**

2. **Fossil record:**

3. **Morphology:** study of the internal and external structures of organisms: the greater the number of homologous morphological features, the more closely related they are

4. Embryological patterns of development: provide evidence of phylogenetic relationships based on similarity among embryos of different species

5. Chromosomes and DNA:

B. **Cladistics:**
1. **Derived character:**

2. Example: birds have a derived character of feathers, most animals do not have feathers other than birds

3. **Shared character:** feature that all members of a group have in common

4. **Cladograms:**

III. Modern classification

A. Three Domains of life: all living things seems to be related by ancestry to one of three major lineages or domains

1. **Domain Bacteria:**

2. **Domain Archaea:**

3. **Domain Eukarya:**

B. Six Kingdom system: first kingdom aligns with domain Bacteria, second kingdom with domain Archaea, and the last four kingdoms with the domain Eukarya

1. Kingdom Eubacteria
   a) unicellular prokaryotes

   b)

   c)

2. Kingdom Archaebacteria
   a)
b) distinctive cell membranes and genetic properties
c) 
d) “archae” means ancient

3. Kingdom Protista

a) 
b) some are multicellular
c) 
d) placed in category if not a fungi, plant, or animal

4. Kingdom Fungi

a) heterotrophic unicellular and multicellular eukaryotes

b) 
c) 

5. Kingdom Plantae

a) multicellular plants

b) 
c) include:

6. Kingdom Animalia

a) multicellular heterotrophs

b) 

IV. Dichotomous Keys

A. Dichotomous key:

B. Used to identify unfamiliar organism
APPENDIX B

NONTREATMENT UNIT LESSON PLANS
Lesson Plan

Date: Day 1
Chapter: 12
Objective: Explain Linnaeus’s system of classification and define taxonomy.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
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<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance</td>
</tr>
<tr>
<td>5 min</td>
<td>Hand back tests</td>
</tr>
<tr>
<td>10 min</td>
<td>Notes I A,B</td>
</tr>
<tr>
<td>20 min</td>
<td>Field guide activity</td>
</tr>
</tbody>
</table>

Homework: p. 339 # 3,4,5

Date: Day 2
Chapter: 12
Objective: Explain the modern phylogenetic taxonomy.

<table>
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<tbody>
<tr>
<td>5 min</td>
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<td>Prayer</td>
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<tr>
<td>5 min</td>
<td>Check homework</td>
</tr>
<tr>
<td>15 min</td>
<td>Notes: II A,B</td>
</tr>
<tr>
<td>15 min</td>
<td>Activity: Make cladogram</td>
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</tbody>
</table>

Homework: p. 345 # 3,4,5

Date: Day 3
Chapter: 12
Objective: Describe the six kingdom system. Describe the three domain system.

<table>
<thead>
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</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>5 min</td>
<td>Check homework</td>
</tr>
</tbody>
</table>
15 min Notes: III A,B

10 min Activity:

Classify the unknown organisms on the worksheet

Homework: p. 350 # 1,2,3,6

Date: Day 4
Chapter: 12
Objective: Use and make a dichotomous key.

<table>
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<tbody>
<tr>
<td>5 min</td>
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</tr>
<tr>
<td>5 min</td>
<td>Check homework</td>
</tr>
<tr>
<td>35 min</td>
<td>Dichotomous key lab</td>
</tr>
</tbody>
</table>

Day 5: Review by filling in a review sheet and playing a review game
Day 6: Chapter test
APPENDIX C

NONTREATMENT UNIT FIELD GUIDE STUDY ACTIVITY
Field Guide Study

Write the type of field guide you received. (Trees, birds, etc)

Find two major categories in your field guide. For each category find two subcategories. For each subcategory name a specific organism.

**Major category**

Sub category

Common name:  Scientific name:

Sub category

Common name:  Scientific name:

**Major category**

Sub category

Common name:  Scientific name:

Sub category

Common name:  Scientific name:

Chose 2 specific organisms in your list from the same major category, list two characteristics that make them belong to their major category.
For the same 2 organisms, list two characteristics that show they are different from the other members of their category.

Exchange field guides. Type of field guide:

List 2 major categories, sub categories, and specific organisms.

<table>
<thead>
<tr>
<th>Major Category</th>
<th>Sub category</th>
<th>Common name:</th>
<th>Scientific name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major category</th>
<th>Sub category</th>
<th>Common name:</th>
<th>Scientific name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

List one characteristic for each specific organism that makes them belong to their major category.
APPENDIX D

TREATMENT UNIT NOTE SHEET FOR BACTERIA AND VIRUS
Chapter 13: Bacteria and Viruses

Essential question: How do bacteria and viruses affect our lives?

I. Prokaryotes: single celled organisms that do not have nucleus
   A. Domains: Archaea and Bacteria
      1. Bacterial fossils found are about 3.5 billion years old
      2. Evolved into many different forms and live in almost every environment and most numerous organism on Earth
   B. Classification
      1. Domain Bacteria: Kingdom Eubacteria:
         a) many different shapes and sizes
         b) shapes:
         c) Gram-negative bacteria: complex cell wall and small amounts of peptidoglycan (protein-carbohydrate compound)
         d) Gram-positive bacteria:
      2. Domain Archaea: Kingdom Archaeabacteria:
         a) unusual lipids in cell membrane and no peptidoglycan in their cell walls
         b) live in extreme environments
         c) methanogens:
         d) extreme halophiles:
         e) thermoacidophiles:

II. Biology of Bacteria
A. Structure
   1. Cell wall:

   2. Cell membrane and cytoplasm:
      a) carries out cellular respiration
      b) photosynthesis if it is a photosynthetic bacteria
      c) cytoplasm: contains ribosomes and DNA

   3. Capsules:

   4. Pili:

   5. Endospores:

   6. Movement structures
      a) flagella
      b) glide through slime layer

   7. DNA: single closed loop of double-stranded DNA attached to the cell membrane
      a) Plasmid: small circular loops of DNA that carry genes that enable the bacteria to cause disease or resist antibiotics

B. Nutrition and growth

   1. Heterotrophs and autotrophs

   2. Phototrophs:

   3. Chemotrophs: get energy from chemicals taken from the environment
4. Four ways

   a) photoheterotroph: uses light but gets its carbon from organisms
   b) chemoheterotroph: obtains energy and carbon from other organisms
   c) photoautotroph: uses light energy and gets carbon from CO₂
   d) chemoautotroph: energy from compounds and gets carbon from CO₂

C. Prokaryotic habitats

1. Obligate anaerobes:

2. Facultative anaerobes:

3. Obligate aerobes:

D. Genetic recombination: three nonreproductive ways that bacteria get new genetic material

1. Transformation:

2. Conjugation:

3. Transduction: virus obtains DNA from a host and as the viruses replicates inside the bacteria the new DNA is added

III. Bacteria and Humans

A. Bacteria and Disease

1. Pathology:
2. **Pathogen**:

3. **Toxins**:

4. Bacteria can cause disease by destroying body tissue

5. **Antibiotics**:

6. **Antibiotic resistance**:

B. Useful bacteria

1. **Decomposers**: break down remains of organic matter in dead plant and animal waste allowing organic compounds to become available to other organisms

2. Used in sewage treatment plants

3. Producing and processing food like

4. Industrial chemical production: mining for minerals and petroleum, insecticides, cleaning up oil spills

IV. Virus Structure

A. **Virus**:

1. **Virology**:

B. Characteristics of viruses

1. Smallest biological particles capable of causing diseases
2. Viruses can only replicate by infecting cells and using the cell’s organelles to make new virus particles

3. Made up of nucleic acid (DNA or RNA) and protein coat called capsid

4. Shapes:

5. Classified by whether they have RNA or DNA and whether it is singled and double stranded

V. Viral Replication

A. Bacteriophage:

1. Structure:

B. Lytic cycle

1. Virus invades a host by injecting its DNA

2. Cell breaks open and releases the new viruses

C. Lysogenic cycle

1. Virus injects DNA into cell

2. DNA of host cell replicates and so does the virus’s DNA

4. At some point the cell will go into the lytic phase and destroy the cell

VI. Viruses and Human Disease
A. **Infectious diseases:**

1. Common cold, chickenpox, measles
2. Mumps, polio, rabies, AIDS, and hepatitis

3. Some viruses can cause cancer by blocking the normal controls on cell reproduction
   
   a) HPV: human papillomarviurs can cause cervical cancer (there is a new vaccine for this virus)

   b) hepatitis B can cause liver cancer

4. **Emerging disease:**

   a) Wild and domestic animals can have viruses that can be transmitted to people

   b) Avian or bird flu is due to close interaction of people and poultry on farms and in markets around the world

B. **Prevention and treatment**

1. **Vaccines:**

2. **Antiviral drugs:** given to infection patients and it interferes with viral nucleic acid synthesis (very few types of drugs)

3. Antibiotics can not destroy viruses, only bacteria

4. **Vector control:** control of animal vectors that carry the virus

   a) Mosquito control to stop yellow fever

   b) Rabies vaccinations to keep pets from of rabies and prevent spread to humans
APPENDIX E

TREATMENT UNIT LESSON PLANS FOR BACTERIA AND VIRUS
### Lesson Plans

**Date:** Day 1  
**Chapter:** 13  
**Objective:** Determine characteristics of bacteria

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance</td>
</tr>
<tr>
<td></td>
<td>Prayer</td>
</tr>
<tr>
<td>5 min</td>
<td>Return tests</td>
</tr>
<tr>
<td>30 min</td>
<td><strong>Bacteria concept attainment lesson</strong></td>
</tr>
</tbody>
</table>

**Date:** Day 2  
**Chapter:** 13  
**Objective:** Explain how bacteria are organized.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>Notes: I A,B II A</td>
</tr>
<tr>
<td>15 min</td>
<td>Activity: Spread of infectious disease</td>
</tr>
<tr>
<td></td>
<td>Homework: p. 466 # 1,2, p. 471 # 1,2</td>
</tr>
</tbody>
</table>

**Date:** Day 3  
**Chapter:** 13  
**Objective:** Explain how bacteria affect humans.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance</td>
</tr>
<tr>
<td></td>
<td>Prayer</td>
</tr>
<tr>
<td>5 min</td>
<td>Check homework</td>
</tr>
<tr>
<td>10 min</td>
<td><strong>Disease Concept Attainment Activity</strong></td>
</tr>
<tr>
<td>15 min</td>
<td>Notes: II B,C III A,B</td>
</tr>
<tr>
<td>10 min</td>
<td>Make a health pamphlet on bacteria</td>
</tr>
<tr>
<td></td>
<td>Prevent disease, treat disease, how bacteria helps humans, types of disease caused by bacteria</td>
</tr>
</tbody>
</table>
Homework: p. 476 # 1,4

Date: Day 4
Chapter: 13
Objective: Study bacteria

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance Prayer</td>
</tr>
<tr>
<td>5 min</td>
<td>Check homework</td>
</tr>
<tr>
<td>30 min</td>
<td>Bacteria stations</td>
</tr>
<tr>
<td>1.</td>
<td>Read about bacteria diseases: write about 3 of them</td>
</tr>
<tr>
<td>2.</td>
<td>Do Bacteria worksheets</td>
</tr>
<tr>
<td>3.</td>
<td>Look at pictures of bacteria and classify their shapes</td>
</tr>
<tr>
<td></td>
<td>Worksheets: Bacterial evolution and classification and Biology of bacteria</td>
</tr>
</tbody>
</table>

Date: Day 5
Chapter: 13
Objective: Study bacteria

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance Prayer</td>
</tr>
<tr>
<td>40 min</td>
<td>Bacteria Video</td>
</tr>
</tbody>
</table>

Date: Day 6
Chapter: 13
Objective: Using real data from Yellowstone National Park, determine the different bacteria present in the various pictures

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance Prayer</td>
</tr>
<tr>
<td>40 min</td>
<td>Yellowstone Bacteria Activity</td>
</tr>
</tbody>
</table>

Date: Day 6
Chapter: 13
Objective: Determine the characteristics of a virus

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance Prayer</td>
</tr>
</tbody>
</table>
**Date:** Day 7  
**Chapter:** 13  
**Objective:** Explain how the structure of viruses. Explain how viruses cause disease.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance</td>
</tr>
<tr>
<td></td>
<td>Prayer</td>
</tr>
<tr>
<td>5 min</td>
<td>Check homework</td>
</tr>
<tr>
<td>20 min</td>
<td>Notes: IV A,B V A,B,C VI A,B</td>
</tr>
<tr>
<td>10 min</td>
<td>Read about a viral disease</td>
</tr>
<tr>
<td></td>
<td>Homework: Virus structure</td>
</tr>
</tbody>
</table>

**Date:** Day 8  
**Chapter:** 13  
**Objective:** Study viruses

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance</td>
</tr>
<tr>
<td></td>
<td>Prayer</td>
</tr>
<tr>
<td>40 min</td>
<td>Virus Video</td>
</tr>
<tr>
<td></td>
<td>Worksheet: Viral replication</td>
</tr>
</tbody>
</table>

**Date:** Day 9  
**Chapter:** 13  
**Objective:** Review

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Question of the Day/Attendance</td>
</tr>
<tr>
<td></td>
<td>Prayer</td>
</tr>
<tr>
<td>20 min</td>
<td>Review overheads</td>
</tr>
<tr>
<td>20 min</td>
<td>Review game</td>
</tr>
</tbody>
</table>
APPENDIX F

TREATMENT UNIT BACTERIA/VIRUS CONCEPT ATTAINMENT SLIDES
### Characteristics of Bacteria Concept Attainment Slide

<table>
<thead>
<tr>
<th>Positive (Yes)</th>
<th>Negative (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Contains DNA</td>
<td>1. Has a nucleus</td>
</tr>
<tr>
<td>2. Heterotroph</td>
<td>2. Multicellular</td>
</tr>
<tr>
<td>3. Lives in many habitats</td>
<td>3. Requires oxygen</td>
</tr>
<tr>
<td>4. Many shapes</td>
<td>4. Larger cell size</td>
</tr>
<tr>
<td>5. Used in some foods</td>
<td>5. Complex cells</td>
</tr>
<tr>
<td>6. Autotroph</td>
<td>6. Many organelles</td>
</tr>
<tr>
<td>7. Can cause disease</td>
<td>7. More time to divide</td>
</tr>
</tbody>
</table>

### Characteristics of Virus Concept Attainment Slide

<table>
<thead>
<tr>
<th>Positive (Yes)</th>
<th>Negative (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Variety of shapes</td>
<td>1. Autotroph</td>
</tr>
<tr>
<td>2. Can cause disease</td>
<td>2. Cell membrane</td>
</tr>
<tr>
<td>3. Has DNA or RNA</td>
<td>3. Has DNA</td>
</tr>
<tr>
<td>4. No nucleus</td>
<td>4. Variety of sizes</td>
</tr>
<tr>
<td>5. Has a capsid</td>
<td>5. Chloroplasts</td>
</tr>
</tbody>
</table>
APPENDIX G

TREATMENT UNIT PROTISTS CONCEPT ATTAINMENT SLIDES
Examples of Protists Concept Attainment Slide

<table>
<thead>
<tr>
<th>Positive (Yes)</th>
<th>Negative (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Red algae</td>
<td>1. Bacteria</td>
</tr>
<tr>
<td>2. Green algae</td>
<td>2. Mushroom</td>
</tr>
<tr>
<td>3. Paramecium</td>
<td>3. Tulip</td>
</tr>
<tr>
<td>4. Amoeba</td>
<td>4. Grass</td>
</tr>
<tr>
<td>5. Slime molds</td>
<td>5. Horse</td>
</tr>
<tr>
<td>7. Diatoms</td>
<td>7. Shark</td>
</tr>
</tbody>
</table>

Pictures of the objects will be used in class.

Plant-like Protists Concept Attainment Slide

<table>
<thead>
<tr>
<th>Positive (Yes)</th>
<th>Negative (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Green algae</td>
<td>1. Amoeba</td>
</tr>
<tr>
<td>2. Brown algae</td>
<td>2. Paramecium</td>
</tr>
<tr>
<td>3. Diatom</td>
<td>3. Slime Mold</td>
</tr>
<tr>
<td>5. Chrysophyta</td>
<td>5. Sarcomastigophora (flagellates)</td>
</tr>
<tr>
<td>6. Dinoflagellates</td>
<td>6. Apicomplexa</td>
</tr>
<tr>
<td>7. Red algae</td>
<td>7. Zoothamnium (ciliate)</td>
</tr>
</tbody>
</table>

Pictures of the objects will be used in class.
APPENDIX H

TREATMENT UNIT ECOLOGY CONCEPT ATTAINMENT SLIDES
### Biotic and Abiotic Concept Attainment Slide

<table>
<thead>
<tr>
<th>Positive (Yes)</th>
<th>Negative (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bacteria</td>
<td>1. Temperature</td>
</tr>
<tr>
<td>2. Paramecium</td>
<td>2. pH of river</td>
</tr>
<tr>
<td>3. Red algae</td>
<td>3. Rain</td>
</tr>
<tr>
<td>4. Frog</td>
<td>4. Mountain</td>
</tr>
<tr>
<td>5. Trout</td>
<td>5. Sunlight</td>
</tr>
<tr>
<td>7. Bear</td>
<td>7. Rock</td>
</tr>
</tbody>
</table>

Pictures of the objects will be used in class.

### Producers and Consumers Concept Attainment Slide

<table>
<thead>
<tr>
<th>Positive (Yes)</th>
<th>Negative (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Euglena</td>
<td>1. Paramecium</td>
</tr>
<tr>
<td>2. Green algae</td>
<td>2. Mushroom</td>
</tr>
<tr>
<td>3. Some bacteria</td>
<td>3. Cow</td>
</tr>
<tr>
<td>4. Oak tree</td>
<td>4. Rabbit</td>
</tr>
<tr>
<td>5. Rose bush</td>
<td>5. Mouse</td>
</tr>
<tr>
<td>6. Grass</td>
<td>6. Hawk</td>
</tr>
<tr>
<td>7. Sunflower</td>
<td>7. Lion</td>
</tr>
</tbody>
</table>

Pictures of the objects will be used in class.
APPENDIX I

CONCEPT ATTAINMENT GUIDE SHEET AND CREATING OWN ACTIVITY RUBRIC WITH STUDENT EXAMPLE
Concept Attainment Guide Sheet

What am I thinking?

1. What characteristics do the items in the positive column share?

2. Create two of your own positive examples of the concept that have not been already given?

3. What name could you give to the items in the positive column? What am I thinking?

4. Write a definition of the concept (idea I am thinking of).

Reflection

5. When did you first think you knew my idea?

6. Which example helped to clarify your thinking? Why?

7. How did the negative examples help you to add or eliminate ideas?

8. What process did you go through as you wrote a definition?

9. How can you use this thinking process in your everyday life? Give one example.
Create your own “What am I thinking?”

1. Use information from either chapters 10, 11, or 12.
2. Find a topic that you would like to use as your answer to “What am I thinking?”
3. Create a list of 6-8 positive examples or characteristics of that concept.
4. Create a 2nd list of 6-8 negative examples or characteristics that do not apply to that concept.
5. Write each example on a separate square/rectangle of paper. You can use the paper I provide or you can type them out on one sheet and cut out the individual words. Paperclip the sets.
6. You will turn in the set of positive examples, set of negative examples, and then one sheet of paper with both sets and the answer. (See my example in class)
7. These will be used to help us review for our final exam at the end of the year.

Graded based on the following rubric.

<table>
<thead>
<tr>
<th></th>
<th>Excellent</th>
<th>Good</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper format</td>
<td>Yes</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Selected from CH: 10-12</td>
<td>Yes</td>
<td></td>
<td>Less than 3 examples</td>
</tr>
<tr>
<td>6-8 Positive examples</td>
<td>6-8 examples</td>
<td>3-5 examples</td>
<td>Less than 3 examples</td>
</tr>
<tr>
<td>6-8 Negative examples</td>
<td>6-8 examples</td>
<td>3-5 examples</td>
<td></td>
</tr>
</tbody>
</table>

Positive Set

<table>
<thead>
<tr>
<th></th>
<th>All related</th>
<th>Most related</th>
<th>Few to none related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related to one concept</td>
<td>All related</td>
<td>Most related</td>
<td>Few to none related</td>
</tr>
<tr>
<td>Not repeated in Negative</td>
<td>Yes</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Relevant to the chapter selected</td>
<td>All relevant</td>
<td>Most relevant</td>
<td>Little to no relevance</td>
</tr>
</tbody>
</table>

Negative Set

<table>
<thead>
<tr>
<th></th>
<th>All not related</th>
<th>Most not related</th>
<th>Few to none related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not related to concept</td>
<td>All not related</td>
<td>Most not related</td>
<td>Few to none not related</td>
</tr>
<tr>
<td>Not repeated in Positive</td>
<td>Yes</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Provides a way to eliminate answers</td>
<td>Many ways to eliminate</td>
<td>Some ways to eliminate</td>
<td>Few to no ways to eliminate</td>
</tr>
</tbody>
</table>

**Total Points**
# Student Example

<table>
<thead>
<tr>
<th>POSITIVE</th>
<th>NEGATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Made up of nucleotides</td>
<td>1. Big factor in protein Synthesis</td>
</tr>
<tr>
<td>2. Carries genetic info</td>
<td>2. carry information of amino acid sequence</td>
</tr>
<tr>
<td>3. (A) Adenine (G) Guanine (C) Cytosine (T) Thymine</td>
<td>3. (A) Adenine (G) Guanine (C) Cytosine (U) Uracil</td>
</tr>
<tr>
<td>4. Made up of Deoxyribose, phosphate, and a nitrogenous base</td>
<td>4. Made up of Ribose, phosphate, and a nitrogenous base</td>
</tr>
<tr>
<td>5. Stands for deoxyribonucleic acid</td>
<td>5. Transcribed from DNA</td>
</tr>
</tbody>
</table>
APPENDIX J

NONTREATMENT UNIT PRE AND POSTASSESSMENT
Nontreatment pre and postassessment questions for classification unit

1. List the six kingdoms.

2. List the three domains.

3. For the following scientific name, *Homo sapiens*, what level of classification is *sapiens*?

4. Explain why a classification system is needed.

5. Explain why the Domain level was added to the levels of classification.
APPENDIX K

TREATMENT UNIT ONE PRE AND POSTASSESSMENT
Treatment pre and postassessment questions for bacteria and virus unit

1. Name two bacterial diseases.
2. Name two viral diseases.
3. How can you treat a bacterial disease?
4. Explain two ways that bacteria can be helpful to humans.
5. Explain why some antibiotics are not working on some bacterial diseases today.
APPENDIX L

TREATMENT UNIT TWO PRE AND POSTASSESSMENT
Treatment pre and postassessment questions for protists unit

1. Name two characteristics of protists.

2. Explain one human use for algae?

3. Explain why one celled algae in the ocean important.

4. Explain a red tide?

5. Discuss two reasons why protists are needed in the environment.
APPENDIX M

TREATMENT UNIT THREE PRE AND POSTASSESSMENT
Treatment pre and post assessment questions for ecology unit

1. Give one example of a predator and its prey and explain their roles.

2. Define a herbivore and give an example of one. Explain why.

3. Name one biotic factor and explain why it is biotic.

4. List two characteristics of the tundra biome.

5. Explain what the niche of a deer would be by giving specific examples.
APPENDIX N

PRETREATMENT INTERVIEW QUESTIONS
Pretreatment Interview Questions

1. What activities that we do in class help you to learn concepts the most? Explain.

2. Tell me how doing those activities can affect your attitude in biology class.

3. What parts of the class do you like the least? Explain.

4. Is there anything else you would like me to know about the way concepts/ideas are taught in class?

Concept Questions for Nontreatment Unit

1. Why do scientists use a classification system?

2. What is the classification system that scientists use? Explain it.

Concept Questions for Treatment Unit One

1. Describe the difference between a bacterial and viral disease.

2. What are the ways to prevent disease? Give at least two examples.

Concept Questions for Treatment Unit Two

1. Describe as many characteristics of protists that you can.

2. Are protists eukaryotes or prokaryotes? Explain your answer. Give at least two examples.

Concept Questions for Treatment Unit Three

1. Define a carnivore and give an example of one. How do you know it is a carnivore?

2. What is an abiotic factor? Give two examples and how do you know it is abiotic?
APPENDIX O

POSTTREATMENT INTERVIEW QUESTIONS
Posttreatment Interview Questions

1. What activities that we do in class help you to learn concepts the most? Explain.

2. Did the concept attainment activity help you understand the biology concept better than taking notes? If yes, explain how it helped. If no, explain why it did not help.

3. What were two main ideas about the biology concept that you learned from doing the concept attainment activity?

4. How did the questions at the end of the activity help you think about how you determined the concept I was thinking about?

5. Did you like this type of learning activity? If yes, explain what you liked about it. If no, explain what you did not like about it.

6. How did the concept attainment activity motivate you to find the answer?

7. Tell me how doing an activity like this can affect your attitude in biology class.

8. Is there anything else you would like me to know about the concept attainment activity that you completed?

9. Please complete the following concept map with me.
Concept Questions for Nontreatment Unit

1. Why do scientists use a classification system?
2. What is the classification system that scientists use? Explain it.

Concept Questions for Treatment Unit One

1. Describe the difference between a bacterial and viral disease.
2. What are the ways to prevent disease? Give at least two examples.

Concept Questions for Treatment Unit Two

1. Describe as many characteristics of protists that you can.
2. Are protists eukaryotes or prokaryotes? Explain your answer. Give at least two examples.

Concept Questions for Treatment Unit Three

1. Define a carnivore and give an example of one. How do you know it is a carnivore?
2. What is an abiotic factor? Give two examples and how do you know it is abiotic?
APPENDIX P

PRE AND POSTINTERVIEW CONCEPT MAPPING WORD LIST
Concept Mapping Word List

Please use the following words for the chapter and create a concept map. Use connection words to tie your ideas together. You may add extra words.

Nontreatment unit: Classification

Word list: domain, kingdom, animal, plant, Eukarya, Eubacteria, Archaeabacteria, protist, fungi, bacteria, Archae, taxonomy

Treatment unit one: Bacteria and virus

Word list: methanogens, extreme halophiles, thermoacidophiles, archaeabacteria, eubacteria, virus, antibiotics, nonliving, disease

Treatment unit two: Protists

Word list: pseudopodia, cilia, flagella, amoeba, euglena, paramecium, animal-like, plant-like, fungus-like, slime mold, red tide

Treatment unit three: Ecology

Word list: herbivore, carnivore, omnivore, decomposer, predator, prey, competition, parasitism, mutualism, food web
APPENDIX Q

PRETREATMENT SURVEY
Pretreatment: Concept Attainment Activity Survey

1. Please circle the number that reflects your level for taking notes using the note sheet and PowerPoint.

   Boring   -3 -2 -1 0 1 2 3   Exciting
   Irrelevant -3 -2 -1 0 1 2 3   Relevant
   Unenjoyable -3 -2 -1 0 1 2 3   Enjoyable

   Explain:

2. Please circle the number that reflects your level for doing hands-on activities at the lab benches.

   Boring   -3 -2 -1 0 1 2 3   Exciting
   Irrelevant -3 -2 -1 0 1 2 3   Relevant
   Unenjoyable -3 -2 -1 0 1 2 3   Enjoyable

   Explain:

3. Please circle the number that reflects your level for worksheets and book assignments for homework.

   Boring   -3 -2 -1 0 1 2 3   Exciting
   Irrelevant -3 -2 -1 0 1 2 3   Relevant
   Unenjoyable -3 -2 -1 0 1 2 3   Enjoyable

   Explain:

4. I have enjoyed the biology class this year

   Strongly agree     Agree      Undecided     Disagree     Strongly Disagree

5. What parts of biology class have you liked this year? Explain.

6. What parts of biology class have helped you learn the concepts the best? Explain.
APPENDIX R

POSTTREATMENT SURVEY
Posttreatment: Concept Attainment Activity Survey

Please circle the answer that best reflects your feeling on the question. Please answer honestly.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The positive examples helped me come to the conclusion of the concept.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. The negative examples helped me come to the conclusion of the concept.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. The picture examples helped me come to the conclusion of the concept.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. The teacher’s questions during the activity helped me to think about how I came to the conclusion of the concept.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. The questions at the end of the activity helped me to think about how I came to the conclusion of the concept.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. The concept attainment activity motivated me to learn the new concept.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. Please circle the number that reflects your level for the concept attainment activity that we just completed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Boring 

| -3 | -2 | -1 | 0 | 1 | 2 | 3 |

Exciting

Irrelevant 

| -3 | -2 | -1 | 0 | 1 | 2 | 3 |

Relevant

Unenjoyable 

| -3 | -2 | -1 | 0 | 1 | 2 | 3 |

Enjoyable

Explain:
8. Please circle the number that reflects your level for doing hands-on activities at the lab benches.

Boring ___ ___ ___ ___ Exciting
-3 -2 -1 0 1 2 3
Irrelevant ___ ___ ___ ___ Relevant
-3 -2 -1 0 1 2 3
Unenjoyable ___ ___ ___ ___ Enjoyable
-3 -2 -1 0 1 2 3

Explain:

9. Please circle the number that reflects your level for worksheets and book assignments for homework.

Boring ___ ___ ___ ___ Exciting
-3 -2 -1 0 1 2 3
Irrelevant ___ ___ ___ ___ Relevant
-3 -2 -1 0 1 2 3
Unenjoyable ___ ___ ___ ___ Enjoyable
-3 -2 -1 0 1 2 3

Explain:

10. What part of the concept attainment activity helped you to determine the concept? Explain.

11. Would you like to use the concept attainment activity again for a different topic? Explain why you answered yes or no.

12. I have enjoyed the biology class this year

Strongly agree  Agree  Undecided  Disagree  Strongly Disagree

13. What parts of biology class have you liked this year? Explain.

14. What parts of biology class have helped you learn the concepts the best? Explain.

Strongly agree  Agree  Undecided  Disagree  Strongly Disagree
APPENDIX S

STUDENT OBSERVATIONS WRITING PROMPTS
Student Observation Prompts

Date:

Day’s lesson/activity:

Student participation in lesson: 1 2 3 4 5
Observations/comments:

Student attitude lesson/activity: 1 2 3 4 5
Observations/comments:

Student desire to learn: 1 2 3 4 5
Observations/comments:

Students were engaged with the material: 1 2 3 4 5
Observations/comments:

Observations on the beginning of class: _______ minutes

Observations on the middle of class: _______ minutes

Observations on the end of class: _______ minutes

Scale: 1 (low or none) to 5 (high or excellent)
APPENDIX T

TEACHER JOURNAL WRITING PROMPTS
Teacher Journal Writing Prompts

Date:
Lesson/ Activity:

General reflections on lesson/activity: 1 2 3 4 5
Comments:

My motivation level towards the lesson/activity: 1 2 3 4 5
Comments:

My attitude toward activity: 1 2 3 4 5
Comments:

My attitude toward students: 1 2 3 4 5
Comments:

Observations on the beginning of class: _______ minutes

Observations on the middle of class: _______ minutes

Observations on the end of class: _______ minutes
APPENDIX U

PEER OBSERVATION PROMPTS
Peer Observation Prompts

Lesson topic and activity:

Today’s lesson/activities were successful in encouraged critical thinking 1 2 3 4 5
Comments:

Today’s lesson/activities helped students to learn the concepts: 1 2 3 4 5
Comments:

Today’s lesson/activities allowed students to think about how they learn: 1 2 3 4 5
Comments:

Student and teacher interaction was positive: 1 2 3 4 5
Comments:

The teacher was positive about today’s lesson: 1 2 3 4 5
Comments:

Observations on the beginning of class: _______ minutes

Observations on the middle of class: _______ minutes

Observations on the end of class: _______ minutes

Any other observations or comments about the lesson and teacher performance during the treatment
APPENDIX V

PRE AND POSTTREATMENT TEACHER ATTITUDE
AND MOTIVATION SURVEY
## Teacher pre and posttreatment survey questions

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel/felt confident in teaching the unit. Explain</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. I have a positive attitude towards my students during classroom lessons/activities. Explain</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. I am motivated to teach the concepts to the best of my ability. Explain</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. The unit I am teaching/taught involves the students to think about how they are learning. Explain</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. The students will or have learned and understand the concepts. Explain</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

What are issues that I am concerned about?

What areas am I confident or feeling good about?
### Action Research Project Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Length</th>
<th>Topic</th>
<th>Activity</th>
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</thead>
<tbody>
<tr>
<td>Jan. 16-24</td>
<td>1.5 weeks</td>
<td>Classification</td>
<td>Non-treatment unit</td>
</tr>
<tr>
<td>Jan. 25-Feb 8</td>
<td>2 weeks</td>
<td>Bacteria and Virus</td>
<td>Concept attainment treatment activity 1</td>
</tr>
<tr>
<td>Feb. 9-17</td>
<td>1.5 weeks</td>
<td>Protista</td>
<td>Concept attainment treatment activity 2</td>
</tr>
<tr>
<td>Feb. 21-March 9</td>
<td>2 weeks</td>
<td>Ecology</td>
<td>Concept attainment treatment activity 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Description and data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Jan. 16</td>
<td><strong>Non-treatment preunit assessment, pretreatment teacher survey,</strong> teacher journal each day: Linnaeus’s system</td>
</tr>
<tr>
<td></td>
<td>Jan. 17</td>
<td><strong>Student observations:</strong> Field guide activity</td>
</tr>
<tr>
<td></td>
<td>Jan. 18</td>
<td>Phylogenetic taxonomy, cladogram</td>
</tr>
<tr>
<td></td>
<td>Jan. 19</td>
<td>Six kingdom system and three domain system</td>
</tr>
<tr>
<td></td>
<td>Jan. 20</td>
<td><strong>Student observations:</strong> Dichotomous key lab</td>
</tr>
<tr>
<td>Week 2</td>
<td>Jan. 23</td>
<td><strong>Student pretreatment survey,</strong> Review and game</td>
</tr>
<tr>
<td></td>
<td>Jan. 24</td>
<td><strong>Postunit assessment</strong> with chapter test, <strong>Teacher postunit survey</strong></td>
</tr>
<tr>
<td></td>
<td>Jan. 25</td>
<td><strong>Treatment 1 preunit assessment, pretreatment interview with concept questions and with concept mapping, student observations, Bacteria concept attainment activity with guide sheet, teacher journal each day</strong></td>
</tr>
<tr>
<td></td>
<td>Jan. 26</td>
<td><strong>Student observations:</strong> Bacteria characteristics and spread of infectious disease simulation</td>
</tr>
<tr>
<td></td>
<td>Jan. 27</td>
<td><strong>Disease concept attainment:</strong> Bacteria and humans, health pamphlet</td>
</tr>
<tr>
<td>Week 3</td>
<td>Jan. 30</td>
<td><strong>Student observations:</strong> Bacteria stations lab</td>
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<tr>
<td></td>
<td>Jan. 31</td>
<td>Bacteria video</td>
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<tr>
<td></td>
<td>Feb. 1</td>
<td><strong>Student observations:</strong> Yellowstone Bacteria Activity</td>
</tr>
<tr>
<td></td>
<td>Feb. 2</td>
<td><strong>Student observations, Virus concept attainment activity with guide sheet, principal/teacher observation</strong></td>
</tr>
<tr>
<td></td>
<td>Feb. 3</td>
<td>Virus characteristics, read about different viral diseases</td>
</tr>
<tr>
<td>Week 4</td>
<td>Feb. 6</td>
<td>Virus video</td>
</tr>
<tr>
<td></td>
<td>Feb. 7</td>
<td>Review and game</td>
</tr>
<tr>
<td></td>
<td>Feb. 8</td>
<td><strong>Postunit assessment</strong> with chapter test, <strong>Posttreatment interviews with concept mapping</strong></td>
</tr>
<tr>
<td></td>
<td>Feb. 9</td>
<td><strong>Treatment 2 preunit assessment, pretreatment interview with concept questions and concept mapping, teacher journal each day:</strong> Animal-like protists</td>
</tr>
<tr>
<td></td>
<td>Feb. 10</td>
<td>Plant-like protists and red tide</td>
</tr>
</tbody>
</table>
Week 5  
Feb 13 **Student observations, Principal/teacher observation, Protist concept attainment activity with guide sheet:** Fungi-like protists
Feb 14 Video
Feb 15 **Student observations:** Protist microscope lab
Feb 16 **Types of protists concept attainment activity with guide sheet:** Review
Feb 17 **Postunit assessment** with chapter test, **Posttreatment interviews with concept mapping**

Week 6  
Feb 20 No School
Feb 21 **Treatment 3 preunit assessment, pretreatment interview with concept questions and concept mapping, teacher journal each day, student observations, Ecology: biotic/abiotic concept attainment activity with guide sheet**
Feb 22 Levels of organization for ecology, abiotic and biotic factors
Feb 23 Predator and prey game and predator video
Feb 24 **Student observations, Ecology: producers and consumers concept attainment activity with guide sheet:** food webs

Week 7  
Feb 27 **Posttreatment survey, posttreatment interviews with concept mapping:** Nutrient cycles
Feb 28 **Teacher posttreatment survey:** No school
Feb 29 Assign zoo biome project, land and aquatic biomes
March 1 **Student observations:** Biome library research
March 2 Planet Earth video

Week 8  
March 5 Review and game
March 6 **Postunit assessment** with chapter test
March 7 **Student observations:** Present zoo biome projects
March 8 Present zoo biome projects
March 9 **Final teacher journal entry**