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thesis entitled

Using Learning Logs, Laboratory Exercises and the Theme of Agricultural Science to Teach Basic Environmental Concepts

presented by

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has been accepted towards fulfillment of the requirements for

Masters of Science degree in Biological Science

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Date July 30, 1997

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USING LEARNING LOGS, LABORATORY EXERCISES AND THE THEME OF AGRICULTURAL SCIENCE TO TEACH BASIC ENVIRONMENTAL CONCEPTS

by

Elizabeth Meyers Schanhals

A THESIS

Submitted to Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTERS OF SCIENCE

Division of Science and Mathematics Education

1997

ABSTRACT

USING LEARNING LOGS, LABORATORY EXERCISES
AND THE THEME OF AGRICULTURAL SCIENCE
TO TEACH BASIC ENVIRONMENTAL CONCEPTS

by

Elizabeth M. Schanhals

This research concerns the revision of the 11-12 grade Environmental Principles course at a class B High School. The goals were to 1.) increase student interest and understanding of the scientific principles behind environmental problems and 2.) move the class from teacher centered to student centered teaching and learning. Learning Logs, laboratory exercises and the theme of Agricultural Science were used in attempt to achieve these goals. Students showed a significant improvement in comprehension of concepts taught in class as indicated by pre and post tests. Learning log entries became a starting point for class discussion, which became more student centered as the class progressed. Most students thought that laboratory exercises and learning logs were worthwhile. Student interest in the science part of the course did improve from the first year the course was taught.

To my parents.....for everything

ACKNOWLEDGMENTS

There are many people to thank. My parents for their strong support and belief in the importance of my education from the very beginning. To my husband, Mike, thank you for your enthusiastic support of all my goals.

Thank you to my Grandparents Edens for running their bed and breakfast during Frontier Workshop weekends, best rates and conversation in town. Thank you also to Grandmother Read for those generous birthday checks the first two years that made it possible to start this program.

I would also like to thank the Division of Science and Mathematics Education at M.S.U. Drs. Merle Heidemann, Ken Nadler, Howard Hagerman and Martin Hetherington for the excellent classes they teach and for their input at the different stages of this project. Thank you also to Drs. Beth Bishop, Cathy Bristow, Maria Davis and Dennis Fulbright for their help in developing labs and gathering materials for this unit. Thank you to the Towsley Foundation for their financial support. Finally, thanks to great roommates Katherine, Cindy and Sue and for the fun and camaraderie supplied by the rest of my classmates.

TABLE OF CONTENTS

ABSTRACT

INTRODUCTION

I. Rationale for Study....................................1

II. Demographics of Study...............................6

III. Review of Scientific Principles.................7

IV. Review of Pedagogical Literature................9

IMPLEMENTATION OF UNIT

I. Basic Outline...13

II. Audio Visual Aides...................................15

III. New Teaching Techniques.........................16

IV. Laboratory Exercises.................................20

V. Laboratory Exercise Write Ups....................31

VI. Concept Maps...33

EVALUATION

I. Pre and Post Tests.....................................35

II. New Teaching Strategies............................37

III.Subjective Evidence...................................44

DISCUSSION

I. What was effective......................................46

II. Changing other units..................................49

III.Aspects that need improvement...................50

IV. Final Conclusions......................................53

BIBLIOGRAPHY...55

APPENDICES

A. Basic Science....................................57

B. Complete Class Outline...........................65

C. Objectives/Tests

1. Unit Objectives.............................76

2. Unit Pre and Post Test......................78

3. Pre and Post Concept Map....................80

4. Entomology Test.............................81

5. Plant Physiology Test........................84

6. Microbiology Test...........................86

7. Biogeochemical Cycle Test...................89

8. Lab Write Up Format.........................91

D. Laboratory Exercises/Demonstrations

1. Demonstration: Pesticide Resistance........93

2. Lab: Food Preference in the Colorado Potato Beetle..95

3. Activity: Desktop Evolution................98

4. Lab: Colorado Beetle Control Simulation...100

5. Lab: Food Search Simulation Lab...........103

6. Lab: Plant Mineral Nutrition..............104

7. Lab: How do Phosphates Affect Algae.......108

8. Lab: Leaf Transpiration in Trees..........110

9. Lab: Chestnut Blight......................112

10. Lab: Investigating Soil Microorganisms for Bilogical Weed Control........................114

11. Lab: Comparison of Plant Roots of Nitrogen Users and Nitrogen Fixers.............118

E. Student Scores

1. Pre and Post Test Scores...................120

2. Lab Scores.................................121

3. Learning Log Scores........................122

4. Concept Map Scores.........................123

5. Survey Scores..............................124

F. Surveys

1. End of Unit Survey.........................125

2. End of Year Survey.........................126

Introduction

A. Rationale for study

To understand and solve environmental problems requires application of knowledge from several scientific disciplines. Therefore, in order to study environmental problems thoroughly in the high school setting, students need to be able to recall, or learn for the first time, concepts from many disciplines. The goals of this project were to: 1.) develop a method of teaching to help students identify and better understand the basic scientific concepts behind environmental problems, 2.) make connections between these concepts and 3.) develop their own line of questioning and suggest solutions to the environmental problems that are based on scientific principles. Moving students from passive observers of problems to active problem solvers with ideas rooted in scientific concepts was important. 4.) Finally, I hoped to increase student interest in the science part of the Environmental Principles course.

I chose "Agriculture: the Science and the Environmental Problems" as the theme to teach Environmental Principles (EP) and provide a local problem that would hopefully motivate students. I chose having students keep learning logs (L.log or L.logs) and engage in laboratory work as the teaching methods used to help students understand and make connections between the concepts underlying environmental problems.

The central questions of this research were: 1.) Will learning logs help students process concepts learned in class and help them make connections between disciplines? 2.) Will learning logs improve classroom discussion and move it from teacher centered to more student centered? 3.) Will laboratory work help students process concepts learned in class? 4.) Will the Agricultural theme increase student interest?

Old vs. New Methods: The first year I taught E.P. it was a semester long course. The class was added to the course offerings because of strong interest from the student body and because, as a department, we wanted to offer an elective science course that might appeal to students who did not want to continue with science after meeting the basic requirements of Biology and Physical Science. The course was divided into three sections. The first marking period (9 weeks) featured the study of environmental problems. We discussed the environmental problems of deforestation, feeding the world, exotic species and species extinction and global warming. It was assumed that the students remembered basic scientific principles behind the problems from freshman Biology. I expected students to be able to discuss concepts such as eutrophication, biogeochemical cycles and predator/prey realtionships in appropriate context. I ended up reteaching, on an as needed basis, many concepts in lecture format on the spur of the moment as I had anticipated that students had learned and remembered the concepts as most were taught in freshman biology. The next six weeks we covered the history of the environmental movement in the U.S., important environmental legislation, important people in the movement and environmental organizations. The last three weeks covered wilderness skills and preparation for a class backpacking trip.

The environmental problems and underlying concepts covered in the first nine weeks, during the first year the course was taught, were taught through note taking during lecture, reading current articles and classroom discussion of articles. After memorizing the concepts along with a lot of alarming statistics about the environment, students took a test. Students also completed library research projects.

Discussion of articles was weak. Students could not explain the scientifc basis of the environmental problem featured in the article. They were not making the connection between the science concept taught and the problem. As Bicak (1997) has noted, students were more likely to bring up economic, political, religious and cultural information during the discussions rather than scientific processes when discussing environmental problems. My students were great philosophers and could easily complain about what was wrong with the world, and pass judgment, but they did not suggest scientifically based solutions to the problems, nor did they have solid questions. Bicak (1997) states that a sound environmental ethic should be established on accurately interpreted ecological principles. Unfortunately, he notes, this is a rare occurrence. Understanding of how the system works has not kept pace with awareness(Bicak, 1997).

My approach to teaching E.P. during the first year, was similar to my approach to teaching freshman Biology; very compartmentalized. I taught cell biology, photosynthesis, respiration, genetics and everything else as a separate chapter. When students were done with the chapter they were not required to apply the information to problems or future chapters. In the old approach to teaching E.P. I would introduce an environmental problem through a current article. We would discuss the article. I would teach concepts as needed without asking students to make connections between concepts or to environmental problems discussed earlier. Students also would not come up with these connections on their own during discussion. Rosenthal (1990) notes that there is a pattern in biology education that tends to persist and to resist change. I had been taught in this manner and simply applied it to E.P. Rosenthal (1990) calls for science education to move beyond knowledge to include methods for acquiring knowledge and the personal and social uses of that knowledge. While the necessity of applying many disciplines to understand and solve environmental problems was obvious to me, it was not to my students with the compartmentalized approach I was using. Revising environmental curricula poses a great challenge as well as untapped potential, especially with respect to opportunities for interdisciplinary configuration (Ramsey, John 1992).

The end of the year survey indicated that the least favorite part of the class was the first nine weeks. While it is hard to compete with a backpacking trip, I was disappointed that students were not interested in the scientific basis for the environmental problems. In fact, a full two-thirds of the class suggested cutting that portion of the class.

For the 1996-97 school year the E.P. course was extended to a full year. This addition of a full 18 weeks would allow for significant changes in the curriculum, giving me more flexibility in how I chose to address the problems encountered during the first year of the course. I decided that the entire first semester would be devoted to the science behind environmental problems and solutions. This was a little bit frightening considering so many students wanted to cut that part of the curriculum. Topics for second semester would be divided between environmental policy, resource management, important people, environmental organizations, a community service project, wilderness skills, and finally the class backpacking trip.

The new approach to teaching E.P. involved three major changes: 1.) Choosing local environmental problems centered around one theme, Agriculture, as a coherent context for teaching scientific concepts behind problems, as opposed to the old method of reading articles about problems, taking notes and discussion of articles lead by teacher questions. The school is in an agricultural community. This theme would be more relevant to students' immediate lives than global warming and deforestation in South America, thereby providing motivation to learn. 2.) Using L. logs for students to process their understanding of scientific concepts as opposed to simply taking notes, reading and discussing articles. Learning logs would also provide a means for students to record their thoughts, ideas, questions and suggestions for scientific solutions to environmental problem. 3.) Using laboratory exercise and lab exercise write ups to show students scientific concepts behind environmental problems or solutions and help them process concepts once again.

B. Demographics of Study

Environmental Principles is an elective science course offered to Juniors and Seniors. The course has been offered only two years. The first year it was offered for a semester. The second year the course was offered as a full two semester class. The only prerequisite for the course is that students have completed the Biology and Physical Science requirements set by the school. While the class was intended to attract students who would normally not take a science class above the required courses, students who have taken Chemistry I and/or II and Physics also signed up for the course. Student plans after high school include the

Armed Forces, two year culinary programs or two year tech. programs, community college, four year college non science majors and four year college science majors. In the two years the class has been offered there were top ten seniors as well as students with learning disabilities. The class was evenly divided between males and females.

When designing the curriculum and lessons a wide variety of student interests and learning abilities had to be taken into account. Activities needed to be designed so that students could perform to the best of their individual abilities. For the purposes of this study achievement levels based on student grade point averages (g.p.a.) were assigned before students entered the class. Students were divided into high (3.6-4.0 g.p.a./ 90-100%), medium (2.9-3.5 / 72%-89%) and low groups (0-2.8 / 0-71%). The school is located in Ottawa County, Michigan. While the school is primarily a suburban middle class community, the county as a whole is both urban and rural.

C. Review of Scientific Principles

The scientific disciplines used as basic background in E.P. for the second year were: 1.) Entomology, 2.) Ecology, 3.) Plant Physiology, 4.) Microbiology and 5.) Biogeochemical Cycles (Geology). The concepts taught under each discipline were:

1.) Entomology and Pest management: morphology, taxonomy, and life cycles of insects

2.) Ecology: survival of the fittest, carrying capacity, density dependent and predator-prey relationships and symbiotic relationships

3.) Plant Physiology: nutrient needs and transpiration.

4.) Microbiolgoy: conjugation

5.) Geology or Biogeochemical Cycles: the nitrogen and water cycles.

The outline of the basic science and its application to E.P.is below. A complete description of the basic science can be found in Appendix A.

Entomology (Campbell, N. 1996)

In order to understand and solve the problem of insect pest management, one must understand insects. Entomology is the study of insects.

Pest Management (Nebel, Bernard 1990)

Pests are any species that cause disease, transmit pathogens or compete with humans for food. They include insects, animals, weeds, bacteria and fungi. This section of the unit discusses primarily insect pests, synthetic pesticides, biological control and Integrated Pest Management (IPM).

Plant Physiology (Raven, P. 1986)

Plant physiology is the study of how plant structures function. Agricultural scientists study plant physiology so that they can better understand how plants grow, what makes them not grow, and what makes them grow better for use by humans.

Microbiolgy (Raven P. 1986)

Microbiolgy is the study of small microscopic living things, like bacteria and fungi. Microorganisms can both help and harm plants in an agriculture setting.

Biogeochemical Cycles (Raven, P. 1986)

Biogeochemical cycles are a complex series of chemical and biological reactions that occur as elements and small compounds circulate amoung plants, animals, soil, water and the atmosphere. Molecules and compounds that cycle through biogeochemical cycles are used by plants and thus concern farmers. The nitrogen cycle was taught thoroughly in this unit and the water cylce reviewed quickly.

D. Review of Pedagogical Literature

Theme: Agricultural science and the environmental problems associated with Agriculture was chosen as the theme for teaching basicenvironmental concepts. Agriculture is a billion dollar business in Ottawa County (Citizens Guide to Natural Resources and the Environment, 1996). Issues such as eutrophication, use of pesticides, and problems resulting from urbanization are affecting the community in which I teach. The local paper occasionally runs articles on these issues covered in class. One way to increase student interest is to use current issues and problems and local resources, both material and human (Yager, 1991). An entomologist and a horticulturist, from a local nursery, were excited about helping develop this unit and plan a field trip. Ira Krup from the Ottawa County M.S.U. farm extension also was willing to act as a resource and help with materials. With agriculture as the theme I would be able to highlight several careers and bring in guest speakers.

Learning Logs: L.logs are journals that students use to record their thinking, ideas, plans, accomplishments, procedures and products during a unit (Thompson, A. 1990). Students respond to teacher written prompts. These prompts direct student writing before, during and after a topic is introduced. They help students with the job of remembering, organizing, predicting, integrating and evaluating information (Rudell, M. 1993). By assigning well designed prompts, I could ask students to build on knowledge learned previously, make connections between concepts as well as move students beyond basic scientific knowledge of a problem towards asking questions, develop hypothesis, and suggest solutions (Rudell, M. 1993).

Writing assignments in the old E.P. included essays on tests and the occasional paper on an assigned issue. Both assignments asked students to demonstrate knowledge, and rarely asked for the application of ideas. In classrooms surveyed, most writing assignments asked students to demonstrate knowledge, rather than encourage them to speculate, question, or explore ideas (Applebee 1991.) While L. logs would provide a place for students to record their growing knowledge of the scientific concepts behind environmental problems, they would also provide a place for the questioning and speculation of someone who might be solving the problems of the future. After writing in their L.logs, students would then have concrete ideas, questions a solutions to bring to a class discussion. Too many merely accept the notion that teaching is the transmission of information from teacher to student (Yager, 1991). Discussions driven by student L.log entries would move the class away from teacher centered to student centered. Student questions, and fellow student answers would be at the core of the discussion, not teacher question and answers.

It was important to have a set time each day in class for writing in L. logs.

> When students know they will be writing at a certain time and place, their minds begin to rehearse (during class, out of school, in the middle of lectures and reading) gathering information, ideas and ways of saying things to fill writing time. This is an important event, for it means students are thinking, analyzing, and processing content information, it means also they are internalizing information and ideas that are part of the class (Calkins 1986).

I chose to give students a prompt the first five minutes of class. They could respond with their prior knowledge to the topic of the day while I took care of paper work that normally occupies the beginning of class. Students could use the last five to ten minutes of class to respond to the same prompt, hopefully with insight provided by the lesson. Besides recording the knowledge gained during the period, students would be required to record the following: a.) questions they still had about the subject b.) connections of the material to environmental problems or other concepts taught and c.) ideas they have in regard to the concept or issue. During L.log writing time, the teacher does not simply assign, abandon and grade. It is the teacher's role to consult with writers, answer questions, give mini-lessons and act as a sounding board (Rudell, 1993.)

It was hoped that using L.logs, along with the change to the Agricultural theme, would help increase student interest in the science portion of the class. Fulwiler (1997) has noted that students pay attention more when they are learning to answer their own questions compared to teacher questions. There should also be the added benefit of building a rapport between the students (Fulwiler 1987).

Implementation of Unit

I. Basic Outline

The science foundation of my Environmental Principles class covered five major disciplines, taught in the following order: Entomology, Plant Physiology, Microbiology, Biogeochemical Cycles. Ecology was taught with the Entomology and Microbiology sections. As concepts from each discipline were taught, corresponding Environmental Problems and their solutions were discussed. The unit took a total of 13 weeks to complete. The basic plan follows below. A complete class outline can be found in Appendix B. A list of unit objectives and a copy of all tests can be found in Appendix C. Laboratory exercises, activities and concept maps can be found in appendix D.

Week One

-Setting the stage: List objectives of unit on overhead, Pretest, Pre-Concept Map, L.log format (a complete list of L.log questions can be found in Appendix B)

-Subject: Entomology

-Concepts: taxonomy, morphology, life cycle

-Activities and Lab Exercises: Movie, "Agriculture in Ottawa County" (Ottawa County Extension Office), Observation of Madagascar Hissing Cockroaches and Colorado Potato Beetle

Week Two

-Subject: Entomology continued

-Concepts: Natural selection, evolution, synthetic pesticides, biological control

-Lab Exercises and Demonstrations: Colorado Potato Beetle Food Choice (Biship 1996), Pesticide Resistance (Bishop 1996), Desktop Evolution

Week Three

-Subject: Entomology and Pest Management

-Concepts: Integrated Pest Management, heterogeniety, density dependent relationships, carrying capacity

-Movie: Celery I.P.M. (M.S.U. Agriculture Extentsion, 1992)

Week Four

-Subject: Pest Management

-Concepts: same as week three

-Lab Exercises: Colorado Potato Beetle Pest Management Simulation (Lovegreen 1992), Profitability of Search (Bristow 1996)

-Entomology Test

Week Five

-Subject: Plant Physiology

-Concepts: Nutrient needs of plants

-Lab Exercises: Nutrient Deficiencies in Radishes

Week Six

-Subject: Plant Physiology

-Concepts: Crop rotation, cascading effect, eutrophication

-Lab Exercises: Algae and Phosphates (Donnely 1995)

-Field Trip: Zelinka Nursery

Week Seven

-Subject: Plant Physiology

-Concepts: Transpiration

-Laboratory Exercises: Transpiration Lab (Campbell 1991)

Week Eight

Subject: Plant Physiology, Pest Management

Concepts: crop rotation, heterogeniety, biological control of pests, nutrient needs

Plant Physiology Test

Week Nine

Subject: Microbiology

Concepts: genetic engineering, fusion, symbiotic relationships, sterile technique, biological control of pests

Lab Exercises: Chestnut Blight (Fulbright 1995), Microbes and Weed Control (Kennedy 1995)

Week Ten and Eleven

Subject: Microbiology

Lab Exercises: Continued from Week Nine

Microbiology Test

Week Twelve

Subject: Biogeochemical Cycles

Concept: Nitrogen and Water Cycles

Lab Exercises: Observing Roots of Nitrogen fixers and non-Nitrogen fixers (Schipper 1996)

Week Thirteen

Nitrogen Cycle Test

Wrap up: Post Test, Post Concept Map

II. Audio-Visual Aides

I only used two audio-visual aids during the 13 week unit; Agriculture in Ottawa County(Ottawa County Extension Office, 1996) and Celery I.P.M.(M.S.U. Productions, 1996)

III. New Teaching Techniques

The new teaching strategy used in this unit was the use of learning logs. While the labs used in this unit were developed and used for the first time in this unit, I had previously used labs and lab write ups as teaching tools for other classes.

Learning Logs (L.log or L.logs)

Rationale: The purpose of L.logs was to provide a place for students to: 1.) process content information through the writing process, 2.) record their understanding of the connections between content areas and the connections between content and environmental problems and their solutions and 3.) record questions and ideas they have as extensions of content taught. As a by-product of the entries, students would also use L.logs to evaluate their own progress and as a starting point for classroom discussion.

Summary: Learning log focus questions were assigned at the beginning of each hour. L.log questions were also written in the weekly syllabus. Students were given five minutes to answer the question with their current knowledge. After the lecture, lab or activity, the L.log question was usually reasigned for students to add information they'd learned in class. Students were also expected to list questions they had about the subject and make connections with what they'd learned to past lessons or environmental problems.

Protocol for Evaluation: Learning logs were collected every Friday at the end of the hour. Twenty five L.logs took 30 minutes to one hour to grade, depending on the quality of the assignments and student answers. Assignments had for parts labeled "Before, After, Questions and Connections." The "Before" section was the student's response to the focus question before the lesson was taught. The "After" section was the student's response to the focus question after the lesson was taught. The "Question" section was for students to ask questions they still had about the subject. Finally, the "Connections" section was a place for students to record connections they made between the concepts learned that day and concepts learned in the past, or connections with the concept learned and their everyday life. Each assignment was graded on a scale of 0 to 4: 0 = not done, 1 pts. = 3 parts incomplete, 2 pts. = 2 parts incomplete, 3 pts. = 1 part incomplete, 4 pts. = complete. One point was added to the score for original or insightful answers above and beyond what was considered a good answer. It took students about two weeks to get used to the nature of the L.log assignment. Most students tried to get by with incomplete answers the first week and skipped the "questions" and "connection" part of the entry completely. They were also very concerned about having the "right" answer.

I started the unit by writing L.log assignments on the overhead. When students were absent, L.log assignments were a difficult to make up. I tried to solve this problem by typing out all of the assignments for the week and handing them out on Monday. While this solved the absentee problem, three students began to use their writing time to socialize or do homework for the next hour. I then had to take points away for not using time in class. I would find these students on Friday morning in the hallway trying to answer all of the weeks L. log assignments at once. The assignments also lost their relevancy if not completed on the day of the assignment. One student in the class decided he was above the assignments completely. They were "obvious" and "dumb." I was surprised at this student's attitude as he loves creative writing and I thought this assignment would appeal to him.

It soon became appearant that setting aside five minutes at the beginning of the hour and ten minutes at the end of the hour each day would be unrealistic. There just isn't enough time in a 50 minute period to do L. logs and a lab. I eventually moved writing time to the final 10 minutes of class, or whatever time was left at the end of the hour. With this problem, as well as problem with doing the "before" section of L.log assignments, I decided it was necessary to change the format mid way into the Plant Physiology section of the unit. I continued to have the question of the day placed on the overhead and read by a student to provide focus for the day. However, instead of discussing each question at the end of the hour, I tried to set aside the last 15 to 20 minutes of each Friday to dicuss all the L.L. assignments for the week. This met with some success, but discussion days were added or moved as needed to fit in with labs or other school events.

The best thing about L.logs was their effect on class discussion. I assigned one student as the discussion leader, typically on Fridays. It was their job to call on people and record who had contributed. Students earned participation points for contributing to the discussion. Everyone had something to contribute, instead of just a handfull of students, because everyone had written something down. The quality of the discussions improved compared to the previous year or to any of my other classes. Students had good questions and good observations based on science. They responded to each other, added ideas and clarified concepts. Students would pass around their L.logs to share sketches. When conversation lagged, it was the student leader's job to ask a question to get it rolling again. I added prompts only once in awhile to cover a point that was missed or help if the student leader, or others, could not come up with a prompt.

IV. Laboratory Exercises

The purpose of lab exercises were to provide hands on learning of concepts taught. Eleven labs, activities and demonstrations were used in this unit. A description of each lab, activity and demonstration, along with a short discussion of its effectiveness follows. All labs and activities were new to this year's E.P. course. Complete laboratory exercises can be found in Appendix D.

Demonstration: Pesticide resistance in the Colorado Potato Beetle (adapted from Bishop, B. 1995)

Rationale: The purpose of this demonstration was to show pesticide resistance in a common pest insect.

Summary: The Potato Beetle was one of the first insects to show insecticide resistance to DDT in 1952 (Pest Profile). This two day demonstration involved a technique potato farmers in Michigan use to see to what insecticides their particular population of beetles is resistant. The teacher placed 5 beetles in each of 3 petri dishes. One dish was a control, while the others contained a piece of filter paper soaked in the pesticide Sevin and Furadan, respectively. The next day some of the beetles in each experimental dish, were alive, and some were dead. The beetles that are alive were resistant to the pesticide. There were more beetles alive in the control than the experimental dishes.

Evaluation: This was a very dramatic demonstration of pesticide resistance.

Activity: Jellybean Desktop Evolution

Rationale: The purpose of this activity was to show students how populations evolve over generations.

Summary: Students chose a population of jellybean bugs (10 bugs = 10 jellybeans). Over time "insecticides selected" for different colored beans. For example the teacher might say that the insecticide Sevin kills all the red jelly beans. Only the individuals that survive reproduce and students add one jelly bean of the same color for every jelly bean left on the desk. Over the course of several generations, students could see the frequency of colors in their population change and the population "evolve."

Evaluation: This activity took ten minutes and a was quick review of evolution via natural selection. Because students picked their own jelly beans, or population colors, students got different results and could see the fitness differences between populations.

Lab: Food Preferences in the Colorado Potato Beetle (Bishop, B. 1995)

Rationale: The purpose of this laboratory activity was to demonstrate a method of biological pest control, food traps.

Students were to explain the pros and cons of synthetic and biological pest control and also, the relationship between entomology and pest control as it applies to this situation.

Summary: The Colorado Potato Beetle is a pest that affects both potato and tomato farmers. The beetle prefers potato plants to tomato plants so tomato farmers can place potato plant traps in their field to attract the beetle away from their money making crop. This method of biological control saves farmers money normally spent on insecticides to which the beetles are often resistant.

Evaluation: In all cases the beetles prefered the potato to the tomato plant. In the control boxes, the beetles did eat tomato plants. The beetles can be a challenge to keep in the class room, as they require constant care. My first batch of beetles was obtained from Beth Bishop, department of Entomology, M.S.U. in July 1996, these beetles did very well, reproducing for two more generations before they escaped or died. I tried to refridgerate my second batch to keep them in the larvae stage longer. They died. I got my last batch of beetles from a local potato farmer. I was able to keep the beetles in the classroom through November, at which time they all died.

Lab: Colorado Potato Beetle Pest Control Simulation Lab (adapted from Lovegreen, K. 1992)

Rationale: The purpose of this lab was for students to simulate the effectiveness of two different methods of pest control: application of *Bacillus thuringiensis(B.t.)* and crop rotation vs. no method of control.

Summary: This lab consisted of three simulations. In each simulation students acted as beetles. In Simulation One students simulated population growth and crashes as the "beetles" "ate" their way through various instars to adults. The beetles invade a field of paper leaves. Beetles ate five leaves within arms reach in order to reach the next stage in the life cycle. Three students acted as natural predators and can eat one beetle at any stage each round. This continues for three"years." Students graphed the number of caterpillars versus the number of leaves eaten for each year. In Simulation Two all of the leaves were treated with the bio pesticide *B.t.* Two of the beetles were "mutants" and are resistant to *B.t.* The simulation ran through three generations and the data was graphed. For Simulation Three, the potato field was replaced with legumes. All graphs were compared and students evaluated which method of control was most effective.

Evaluation: Simulations One and Two were done outside with students picking up paper leaves. It happened to be a breezy day and the "leaves" blew around. It also got hectic for me to give each student their next instar. I should have had shoe boxes for instars and eaten leaves to be placed in after use. For simulation three the next day, I scaled the lab down and moved it inside to the desktop. This was much more effective. Students could write their numbers on the board and we could discuss the results more easily. It was much less stressful for the teacher and the students. In our simulation crop rotation was the most effective for beetle control, then *B.t.*

Lab: Profitablity of Search and Density Simulation (Bristow, C. 1995)

Rationale: The purpose of this lab was for students to simulate a density dependent relationship: The relationship between the density of the food source and the amount of food eaten in a given amount of time.

Summary: One person acted as a beetle and hunted for food, while blindfolded, by tapping the desk with their finger. Each time their finger landed on a leaf that leaf was "eaten" and removed from the desk. This was repeated with a different number of leaves on the desk each trial. Each trial lasted one minute and was repeated three times. Data was averaged and graphed.

Evaluation: Students expected the relationship to be direct and tried to manipulate results. When a certain high density is reached, the beetles, theoretically, can't hunt any faster. About half the students were able to see this in their results, the other half had results that showed the more food available the more food eaten, even at high densities. This lab took a day and a half, more time than I wanted to spend on this concept. The lab was too similar to the pest control simulation lab. Next year I will do one or the other.

Lab: Nutrient Deficiency Lab

Rationale: The purpose of this lab exercise was for students to observe the effects of the absence of several nutrients on plant growth, thus understanding the need for fertilizers.

Summary: Each group of students grew six radishes in separate plastic cups. One radish recieved a complete nutrient solution; the others lacked Nitrogen, Calcium, Sulfur, Magnesium and Phosphorus respectively. The plants were fed with 10 ml of their assigned solution every other day. Plants were measured when fed. At the end of five weeks the negative Nitrogen and negative Phophorus plants were dead in each group.

Evaluation: Students loved this lab even though there was "a ton of data to graph." Some groups got little radishes that they wanted to eat. Three students commented that they had never grown anything before and it was "cool." Some days it became a little hectic to squeeze in feeding and measuring. I had to be reminded by students to allow time at end of hour to take care of their measurements. While this was a long term lab, students never lost track of the purpose of the lab as they did with some of the other long running labs.

Lab: Algae and Phosphates (Donnely, S. 1995)

Rationale: The purpose of this lab exercise was for students to observe the effects of leaching of fertilizers into groundwater and lakes. Students were to explain the connection between fertilizers and eutrophication.

Summary: Students filled five petri dishes with pond water. One dish was the control. Ten ml of one of the following solutions was added to the other dishes: Commercial plant fertilizer, ammonium phosphate, potassium phosphate and ammonium sulfate. After seven days the relative amount of algae in each dish was measured.

Evaluation: The results were very pronounced. Algae grew the most in both petri dishes containing the phosphates and

Rapid Grow. Students easily made the connection between the lab and the concept of eutrophication. The simplicity of this lab also allowed for a good discussion of scientific method and an extension activity in their L.logs. Students designed an experiment using this one as a model.

<u>Lab:</u> Transpiration (Campbell, N. 1991)

Rationale: The purpose of this lab exercise was for students to observe transpiration and explain the relationship between transpiration and the water cycle.

Summary: Students took plastic baggies, weighed them, and tied them around the stem of three leaves in the shade and three leaves in the sun on the same tree. After two days students removed the baggies and reweighed them. Leaves in the sun transpired more water than those in the shade.

Evaluation: The simplicity of this lab allowed for another L.log extension activity where students designed their own lab. This experiment was great preperation for the Michigan High School Proficiency Test. Students were able to explain the relationship between the water in the baggies, transpiration and the water cycle.

<u>Lab:</u> Chestnut Blight (Fulbright, D. 1995)

Rationale: The purpose of this lab exercise was for students to: 1.) use aseptic technique, 2.) observe which strains of the fungus will transfer its genes through conjugation to which strains of Chestnut blight and 3.) Explain the role of microbiology, fusion and genetics in solving pest problems.

Summary: The chestnut tree used to be the largest hardwood crop in the U.S. and is codominant with oak and hickory. It prefers sandy, well drained soils. The chestnut blight, which is caused by a fungus, has wiped out the chestnut population. Those trees left standing are unsuitable for lumber due to scaring. The blight has two forms: one is a virulent form and kills the tree; the other form is a hypovirulent form, carrying a virus. It does not kill. The hypovirulent form can pass its genes to the virulent form through a conjugation bridge.

Dennis Fulbright of M.S.U. provided all the fungi, petri dishes and medium for this experiment. We used four strains of blight for the lab. Sch(Euro 7) is a hypovirulent form with a virus from Italy. It is white and grows fast. Sch(Mi) is hypovirulent, slow growing and has a virus from Michigan. Sch V is a virulent form, orange in color and kills trees. Wis 25 is a virulent form of a different genetic group from the Sch strains. A control plate for each strain was innoculated by cutting a 10 mm plug of agar with a scalpel from culture plates with the different forms of the Chestnut blight sent by Dr. Fulbright. For the experimental plates two plugs of different strains were placed on the edge of the plate right next to each other in the following manner: plate 1.) Sch Mi and Sch, plate 2.) Sch Euro and Sch, plate 3.) Wis and Sch Euro, plate 4.) Sch Euro and Sch Mi. Students record the growth of the fungus every other day by using colored pencils to draw a diagram of what they see with measurements in mm.

Results were as follows: 1.) Sch Euro had a faster growth rate than Sch Mi in the controls. Sch grew at a comparible rate to Sch Euro and Wis. 2.) Sch turned white, indicating that Sch Euro fused with Sch, 3.) Sch Mi fused wtih Sch in all but one of the groups. 4.) Sch Euro did not fuse with Wis.

Evaluation: Because of the long term nature of the lab and the new techniques used, most students forgot the purpose and the concepts associated with the lab by the time it was completed. Students also had a difficult time interpreting results. I helped students a great deal with this task. Students found the lab interesting, but frustrating. While students had a difficult time with their lab write ups, and lab grades were lower than normal, they did do very well on the test question that corresponded to this lab.

Lab: **Investigating Soil Microorganisms for Biological Weed Control (Kennedy, A. 1995).**

Rationale: The purpose of this lab was for students to: 1.) use aseptic technique, 2.) grow and isolate microorganisms from soil and roots, 3.) observe whether microorganisms encourage or inhibit radish growth and 4.) explain the relationship between pest management and microbiolgy.

Summary: This lab took three lab days to prepare. One day was required to collect data, and two to six days for incubation of plates. Two methods were used to collect soil microbes. One used a slurry of the collected soil; the other used impressions of a weed root. After students plated and imcubated soil samples, a bioassay was then prepared. Thirty drops of the bioassay was then transfered to a separate petri dish. Ten radish seeds were pressed into the plate.A control dish with sterilized water was also prepared. After 3-4 days, students measured the root length of the radish seeds.

Evaluation: At the end of the lab many students had forgotten the purpose and key concepts of the lab, probably due to the length of the lab and all of the new techniques learned. Next time I will have a two or three question L.log entry at the end of the hour concerning technique and methods. This was the first time students had used sterile technique. As a result contamination of samples was rampant. Student interest in the lab was high. "I feel like a real scientist," was my favorite comment.

<u>Lab:</u> Observing the roots of Nitrogen Fixers and Non-Nitrogen Fixers (Schipper A. 1996)

Rationale: The purpose of this lab was for students to observe nodules on legumes and the bacteria in the nodules. Also, students were to explain the relationship between the nitrogen cycle, symbiotic relationships and microbiology.

Summary: Legume and corn plants with roots were provided. Students observed and sketched nodules on legume roots. Students prepared a slide of squashed nodule stained with methylene blue. They observed the bacteria *Rhyzobium* using the microscope.

Evaluation: Most students had trouble making the stain and using the microscope. Only two groups got good stains of the bacteria. These slides were used as class samples for everyone to view. Students were able to explain connections between the nodules, the nitrogen cycle and microbiolgy as related to the lab.

V. Laboratory Exercise Write Ups

Rationale: The purpose of the lab exercise write ups (see Appendix C for lab write up format and point sheet) was for students to identify concepts learned in class that apply to the labs, process the concepts through writing and analyze the scientific design of each laboratory activity.

Summary: Students were given a lab rubric, or "point sheet," (appendix C) to follow for all lab write ups. Lab write ups were divided into five sections: 1.) Title, 2.) Background; to include concepts that relate to lab, problem and hypothesis, 3.) Materials and Methods; to include statement of whether hypothesis is correct, references to data, suggestions for further research and application to the real world.

Protocol for evaluation: Students used their L.log entries to help write the background section of laboratory exercise write ups. Having students write background concepts as part of their lab activity reports was one more time students processed key concepts. Because of the wide range of abilities of students in the class, I found it necessary to give students time in class to work on write ups. I could teach mini-lessons with small groups to review concepts, answer questions or refer students to specific L.log assignments. These work days became very productive.

The point sheet format (Appendix C) of grading enabled students to grade themselves before they turned in the assignments. After students had written a couple reports they got better at assessing themselves. The quality of the lab write ups improved as the unit progressed.

VI. Concept Maps (Appendix C)

Rationale: The purpose of the maps was two fold. One, it would provide an evaluation tool for me to see if students understood concepts and the relationship between concepts. Two it would provide a visual piece for students to see their own progress and change in understanding of concepts.

Summary: Concept maps are picture representations or diagrams students make that show their concept of how key words relate. Students put words in categories and then draw lines to show how categories are related. It is often considered a visual represenation of an outline. Students were to develop five concept maps; one at the beginning of the unit, one at the end of the unit and one at the end of each section of the unit.

Evaluation: Concept maps provided an excellent conferencing tool. I would use class work time to talk with students about their partially completed map. Concept maps were also used as items for discussion in student Learning Logs. Students would comment on differences between maps and use the maps to analyze what they had learned. However, concept maps did take more class time than expected. Next time I would just use maps at the beginning and the end of the unit.

EVALUATION

I. Pre and Post Tests

Pre and Post test questions were designed to determine whether students could identify and explain science concepts behind agriculural environmental problems and solutions. Pre and Post test results show that this class of 24 students did make significant gains (t=4.4, d.f.=22, p>0.001; individual student pre and post test scores can be found in Appendix E) when comparing their pre and post test knowledge of the scientific basis of environmental problems. This class was broken down into three ability groups for purposes of this study: high, mid and low. Students were placed in the high group if they had a G.P.A., before entering the class, of a 3.6 to 4.0 (90-100% range), the mid group 2.9-3.5 (72-89%) and the low group 2.8 or lower (72% or below). The six students in the high group showed an average improvement of 51%, the 13 students in the mid group showed an average improvement of 37% and the six students in the low group only 15.8%. Since this class is supposed to be geared towards the mid and low groups to keep them "in" to science, I was primarily concerned with their improvement. However, the teaching strategies used in this unit seemed to be most effective in teaching the high group, as they showed the greatest improvement, which is typical of students in a high achievement group. Two students in the mid group and three students in the low group did not take the final post test as they skipped that day. I did not drop their scores from this evaluation as they did attend other classes on days they skipped class and they were given every opportunity to take the post test. This lack of desire to take the test indicates a lack of confidence about their ability to succeed on the test. The average l.l score for these five students was a 29%. Three of the five students did not turn in L.logs at all. Learning logs were especially ineffective with these five students. Also, these five students did not participate fully in class discussions, as conversations tended to stem from L.log entries. The average lab score for these five students was a 56%. While two of the students who did not take the final unit test did score in the 80th percentile range on labs and one in journals, for unknown reasons they did not feel the final unit test was important enough to take. Perhaps they did not have the confidence that they would find success on the test. The results show that if these five students are excluded from the study, the mid group shows an improvement of 34% and the low group shows an improvement of 31%.

Post test results show that in the high group, three students scored in the high range (90-100%), one in the mid range(72-89&) and one in the low (0-71%). In the mid group, no students scored in the high range, two students scored in the mid range and eight students scored in the low range and two students did not take the test. In the low group three students scored in the low range and three students did not take the post test. The teaching strategies did not help bring the low group into the 72 percent passing or "C" range.

II. New Teaching Strategies

A. Effectiveness of Labs: The average lab write up score for all labs was 72% (Individual student lab scores can be found in Appendix E). Students in the high group scored on average 90%, mid group 75% and low group 61%. In the high group four students scored in the high range and one in the low range. The student who scored in the low range did not believe he needed to do any of the assigned work to learn the material. Any work he turned in was a result of a great deal of pressure from his parents and myself. In the mid group four students moved up to the high range, six students stayed in the mid range and three students moved down to low range. In the low group one student moved up to the high range, two to the mid range and the rest scored in the low range.

In the mid and low groups 37% of the students moved to a higher ability group, based on past academic performance, 47% stayed at their achievement level and only 15% moved down a level. Overall, 29% moved up, 79% stayed in their achievement group, and 17% moved down. As judged by the number of students that moved up an achievement level, the labs were effective at teaching concepts and scientific method.

Labs were grouped together by discipline: Entomology, Plant Physiology and Microbiology. The Nitrogen Cycle lab was not graded using the standard lab write up format so it can not be compared to other labs here.

Overall, students averaged the highest scores on the Plant Physiology labs (77%), followed by the Microbiology labs (71%) and lastly the Entomology labs (70%). The Entomology Labs were taught first, so the score might not reflect true student understanding of concepts, but rather getting used to the new lab write up format.

When broken down by ability level, the trends in lab scores does not follow the average scores cited above. The low group scored highest (66%) on the Entomology Labs, the Microbiology Labs (61%) and the Plant Physiology Labs (56%). The mid group scored highest (84%) on the Plant Physiology Labs, 74% on the Microbiology Labs and 66% on the Entomology Labs. The high group scored highest on the Entomology and Plant Physiology Labs (83% and 84% respectively) and 76% on the Microbiology Labs.

Only four students chose not to turn in one lab each. They turned in all other labs. Results do not show a correlation between % improvement and lab scores.

B. Learning Logs (Individual L.log scores can be found in appendix E): The average L.log score for all students, all entries was 51%. In the high group the average score was 76% and two students moved down an achievement level. In the mid group the average score was 52% and four students moved up, eight down. In the low group the average score was 28%. One student moved up. Overall, 21% of the students moved up, 42% moved down and 34% stayed in their achievement bracket. I am concerned by the number of students who moved down in achievement level as L.logs were not graded based on content but rather on completeness. Low scores indicate incomplete assignments and therefore, a lack of importance of assignment as perceived by the student.

Eight students, 33% of the class, across all ability level, chose not to turn in any learning log entries. There is no relationship between L.log and percent improvement or L.log and test scores. I cannot determine underlying reasons. Some ideas include: students don't enjoy writing, students were concerned about having the correct answer, students don't see importance of assignment and/or daily L.log entries were too much.

C. Student Interviews: Three students were interviewed, one from each ability group. The pre-unit interviews were administered one week before the unit was taught, at the end of the summer. The post-unit interviews were administered one week after the unit was taught and grading was completed, after school. All interviews were conducted in the school library. Students were chosen for interviewing by drawing their name out of a beaker.

Rather than include the lengthy interview transcript, I will try to convey the jist of each interview. All students were visibly nervous at the pre-interview. They all relaxed however as the interview progressed. It was the first time I had met all three students and classes had not yet started. In the post interview the student in the high ability group showed the most confidence through body language and voice projection. This student also did not mumble. The student representing the low group was restless during the post interview, would not look me in the eye, mumbled and clearly wanted to get the post interview over as soon as possible. This student grew more uncomfortable as the post interview progressed. The mid student, while not as confident in voice projection, was not restless and did not appear uncomfortable.

In the post interview the student representing the high group was able to list five fields of basic science related to agricultural science as opposed to only two at the pre-interview. He was also able to define the fields of science involved in agriculture science more thoroughly during the post interview. Examples given of application of these fields to problems were from labs studied and articles discussed. All examples involved science. Rather than suggesting "human hair, snakes and shooting them," to get rid of pests, as mentioned in the pre-interview, during the post-interview this student came up with "crop rotation, predator-prey relationships like aphids and ladybugs, potato traps in potato fields, and genetic engineering."

The student representing the mid group was able to list four fields of science that we had covered in the post interview vs. only three in the first, none of which we would study. The student's concept of the nitrogen cycle remained the same, but concepts involving application of ecology, pest management and microbiolgy improved somewhat. The student did make a big mistake and refered to Nitrogen, Potassium and Phosphorus as microorganisms. The student was able to give the most correct examples from material covered in class from the Ecology and Entomology section of the unit.

The student representing the low group was only able to list two fields of science used in agricultural science, both not studied in our unit, at the post interview. This student mentioned two fields that we were going to study in the pre-interview. Definitions of the fields of science used to solve agricultural problems did not improve, in fact they became more brief. Nor were any examples from labs, articles or learning log entries given.

D. Opinion Surveys (for results: Appendix E, for actual survey questions: Appendix F)

End of Agriculture Unit: Fifty eight percent of the class thought L.logs helped them to better understand the science behind environmental problems. Ninety six percent of the students thought that keeping L.logs did not help them write better. Sixty two% of the class thought that L.logs were worthwhile.

Positive comments about L.logs included: "I liked your comments," "I felt like you cared about me," "I liked

hearing what my classmates wrote in their l.logs," and "I liked L.log discussions...I felt like a real scientist sharing my ideas." Negative comments about L.logs included: "dumb," "a waste of time," "busy work," and "redundant." The total number of positive comments was 24 while the total number of negative comments was just the four above. Positive comments tended to be more thoughtful than negative comments, more than just one word answers. I also received unsolicited positive comments from parents regarding L.logs. Because of the number and types of comments, I feel that positive comments outweigh negative comments.

Ninety six percent of the students thought labs helped them understand the science behind agricultural problems better. Ninety two percent of the students thought lab write ups were worthwhile. A full 100% liked the Colorado Potato Beetle food choice lab the best. Student opinions as to the least favorite lab varied from none of them to all with the food choice lab being mentioned once.

Positive comments about labs and write ups included: "I thought they were impossible at first, but then I got the hang of it," "I liked doing the write ups in class. I needed your help. I also got help from my lab group. I hope that was o.k.," and "Lab days and work days rule." Negative comments included: "too redundant...background information was the same as L.logs," "too many labs at once, I couldn't keep them straight," and "too many lab write ups, we could have covered more stuff if we hadn't been writing all the

time." Twenty one students had positive comments. One student had a positive and negative comment and two students had only negative comments.

End of Year: Fifty seven percent of the students would recommend the class to a friend, 16% would not and 26% were not sure if they would recommend it or not. Only 11% thought the class was too hard. No one in the class thought the class was boring. Five students dropped the class at the end of the semester, indicating they were dissatified with the class. Again, as in the previous year, 100% of the students thought the Wilderness Skills part of the class was the best. However, this year, no one suggested that the science part of the class be dropped for the coming year, and no one mentioned it as their least favorite unit.

E. Concept Maps: Comparison of pre- and post-unit concept map scores (see Appendix E for individual student performance) shows that students made gains in their understanding of concepts behind environmental problems associated with agriculture. Students made an average of 3.6 more correct connections between concepts of different disciplines on their post-map as compared to the pre-map. Students earned, on average, 11 more points total on their concept map. Scores were not turned into percentages as there was not a set number of points students could earn. Students received grades based on completeness. Students could earn more points for adding more correct information and adding correct connections. Students in the high achievement level made the most gains in total improvement and connections made, followed by the mid group and the low group.

III. Subjective Evidence: While statistical analysis does not show that L.logs were not effective in improving test scores, I still feel they have value. Class discussion improved dramatically. Instead of just two or three high achieving students volunteering, all students in all achievement groups who wrote in their L.logs participated in class discussion. Also, L.logs provided a method of moving the class from teacher centered to student centered instruction and learning. Another benefit of the L.logs was improved teacher-student relationships. I really got to know the kids. This year I was invited to every senior's graduation party as opposed to none last year. Students looked forward to getting their L.logs back. We had great dialogues going. I was able to encourage normally shy students to speak out during class discussion. Two students, one low and one mid, showed greatly improved self esteem during the unit. I even received one letter from a parent in this regard. Four parents at conferences mentioned that journal topics became dinner conversation.

I am, however, concerned that four of the eight students who did not turn in L.log assignments dropped the class at semester. Did frustration with the learning logs cause them to drop the class? Two of the four students who dropped transfered to a different school. I asked the other students to write me a letter explaining why they dropped the class, or to talk to me during lunch. Neither student wrote me a letter and both avoided me after the request.

DISCUSSION

I. **What was Effective**

Labs: Labs were an effective method of teaching concepts and scientific method as indicated by 70% performance level. I was encouraged by the number of students who moved to a higher achievement level, low to mid or mid to high or low to high, on lab write ups. However, there is no relationship between lab scores and % improvement.

The Plant Physiology Labs, which include the Plant Nutrient Lab, Transpiration Lab and Algae Lab, as a whole were the most effective labs at teaching their particular subject concepts at a 77% performance level. The Entomology Labs and Microbiology Labs can also be considered effective at an average 70% and 71% performance level respectively. On the post test, of those students who took the test, all but one mentioned potato traps in tomato fields as an alternative to synthetic pesticide use. This indicates that the Potato Beetle Food Choice Lab made quite an impression on students.

Three Seniors from this class who had to retake the science part of the Michigan Proficiency Test, which took place mid way through the unit, passed the second time. They said, voluntarily, that the labs and the write ups done in this class helped them on the test. Five Juniors from the class who took the Proficiency test for the first time also said, voluntarily, that the labs and the lab write ups helped them.

Giving students class time to work on lab write ups was necessary for the success of labs. It allowed me to reteach and reinforce critical concepts and it allowed students to teach each other. If I hadn't allowed the class time, the mid and low level students would have been really frustrated with the laboratory write ups. I am sure the number of students who did not turn in labs would have increased significantly. During the Entomology section, the first, of the unit students expressed a lot of frustration with the laboratory write ups. "What do you want," and "I don't get it," were common statements. As the unit progressed there was less frustration and students worked more independently on their write ups.

Interest level in the labs was high as indicated by the end of the unit survey. Students saw the value in labs and lab write ups in helping them learn concepts.

Learning Logs: There was no relationship between student learning log scores and percent improvement. While there is no quantitative evidence that the L.logs were an effective teaching strategy for improving student comprehension of concepts, I do believe that they were valuable tools for moving the classroom from teacher centered to student centered and for improving student inquiry and application of concepts. It is L.log entries such as the following which have convinced me to keep experimenting with L.Logs:

1.) "When I go to the grocery store, I appreciate all the food available more."

2.) "I ate a carrot today and realized it was like our radishes and had soaked up NPK from the ground. Then I figured out that the NPK in the ground dissolved in the rainwater just like the chemical NPK out of the bottle dissolved in the water we fed our radishes."

3.) "We had baked potatoes for dinner and it suddenly dawned on me what the potato went through to get to our table. So I told my family the adventures of Mr. Potato Head...surviving the potato beetle and fungus to nourish us. My family thinks I'm weird."

4.) "The possibilities that genetic engineering offers us, like the fusing of different strains of chestnut blight, is really endless. It reminds me of the old Super Friends cartoon - "Wonder Twins activate, form of a bucket of water, form of an elephant" - and then the twins would work together to save the world.'

Comments like these are hard to quantify, but I think the value of giving students the time and space to think like this is invaluable. The entries show students are thinking about how the concepts learned in class relate to their world.

For those students turning in learning logs, interest level was high. All of the students that turned in logs thought that learning logs were worthwhile, even though they might not have thought that they helped them understand content.

II. Changing the teaching of other units

Judi Devlin, a fellow science teacher, began to use L.logs based on conversations with me. She needed a way to move the class from teacher centered to student centered. The L. logs helped her keep track of all the different projects students were working on, questions they had and what they were taking away from the experience. She also used the learning log as a starting point for classroom discussions. Every Friday students shared what they accomplished and learned during the week. She felt class morale improved after a month of using L.Logs, just as I felt enthusiasm for the class built as the use of L.logs progressed.

Next year the other Biology teacher and I have decided to try L.Logs with the freshman Biology students. We will assign an entry on each test day. Assigned entries will focus on how concepts learned in that unit relate to other units, how the concepts are applied to the everyday world and how information in the unit relates to problems. Students who turn in their tests early can write. Test are designed so that students have approximately 10 minutes left at the end of the hour. We will discuss entries as a class the following day. We will also require one open-ended entry of their choice for each unit. Entries will be picked up at the end of the discussion. While grading 24 learning logs was manageable, the thought of grading 120 is a little daunting. We will have a student from Grand Valley as an aide in both our classrooms next year, so we thought that would be a good time to try the L.logs.

III. Aspects of Unit that Need Improvement

Learning Logs: Daily L.log assignments were too tedious and not practical for a 50 minute class period. There were not enough minutes in the period for the original format of L.logs: "Before writing, After lesson writing, Questions, Connections." This required 15 minutes a day, five for the beginning of the hour before the lesson and 10 for end of hour. The lesson became rushed and the pressure of making writing time or missing writing time altogether became to distracting. I also did not feel that 10 minutes was enough for some students to get warmed up for writing. By the middle of the plant physiology section it became apparent that I was losing the interest of several students. I made adjustments by cutting down on the number of assignments to two to three per week and made them more open ended. Students did not have to follow the original format.

Because it was the first time I taught much of the material, I did not have an accurate idea of how long different lessons would last. That, along with normal interruptions such as Homecoming, assemblies and field trips for other classes, caused writing time to become inconsistent. It obviously frustrated some students while others were able to accommodate the inconsistancies.

I still think that consistent writing time is important. For next year's E.P. course I will have one assigned entry per week. The entry will serve as the theme for the week and will be given every Monday. Students will have the week to think about the question as they go through labs, articles and notes and writing time will be the first 20 minutes of class on Friday with discussion time the last 30 minutes. I will also require one entry per week that is of the students choice. L.Logs will be collected at the end of the hour on Friday.

I am concerned about the number of students who did not perform at their achievement level, as measured by g.p.a. before they entered the class, for the L.logs and also about the number of students who dropped the course at semester. Many of those students who did not do the L.logs at all. Did those students drop the course as a direct result or indirect result of the L.logs?

It was intended that L.logs be an "easy A." Students earned all five points for merely completing the assignment.

L.log assignments were divided into four parts. I'm not sure what makes students good learning log writers: finding this out will be a logical extension of this study. One high achieving student, who loves to write and I thought would really excell in this medium, didn't turn in any L.logs. On the other hand, one low level student loved learning logs and earned 100% marks for all entries. While I do recognize that all teaching strategies will not appeal to all students, and I did not expect all students to love L.logs, I did not anticipate the number of students that would not turn in entries.

Labs: While students found the lab Comparing Roots of Nitrogen Fixers and Non Nitrogen Fixers interesting, I did not feel in was worthy of a lab write up nor did it help students understand the concept of cycling Nitrogen and the different forms of Nitrogen. I am searching for another lab to add to this section.

At one time during the unit we had three labs going: the Nutrient Lab, Chestnut Lab and Microbes and Radish Growth Lab. Because of the long term nature of these labs, it was difficult to plan them so they wouldn't overlap. Many students found this frustrating and had a difficult time keeping procedures and concepts straight. Next time I will try to fix this question by having "lab quizzes" during which students can use their L.logs.

IV. Final Conclusion

Students did make gains in their understanding of concepts and connections between concepts related to agricultural science,as indicated by pre- and post-test scores and pre- and post-concept map scores. While students did show significant gains in understanding the concepts, it is not clear what caused the gains: 1.) merely teaching the unit, 2) Labs, 3) Learning Logs or 4) Any combination of the above. Labs were the most effective at reinforcing concepts taught in class and stimulated the most student interest, but there is no relationship between percent improvement and lab scores. While results show that there is no relationship between L.logs and percent improvement and that average achievement level on the L.logs was low, they did act as a reference for lab write ups and might have provided a key building block for the success of the labs. It would be interesting to teach the class without the L.logs to see if labs and write ups were as successful. Also, L.logs provided an invaluable method of moving class discussion from teacher to student centered and for moving students from mere regurgitators of information to processors, applyers and questioners of knowledge.

Interest in the science section of the class did improve, probably due to a variety of factors, including the change to a local theme of Agriculture, Labs and yes, even L.logs. No one in the class suggested dropping the unit at the end of the year and 30 students have signed up for the class next year as opposed to the 24 students in last year's class. Also, 57% of this year's class said they would recommend the class to a friend, 26% were "not sure," because it would depend on the friend, not because the class wasn't good. This indicates growing interest in the course.

The theme of agricultural science allowed me to address environmental problems facing our community, while teaching basic science concepts underlying environmental problems world wide. I also like that the field of agriculture, as well as the problems associated with it, is multidisciplinary. This theme naturally lends itself to a more multidisciplinary approach to teaching. Students could easily make connections between disciplines of science and their application in an agriculture setting. Another advantage of the theme was that there were many resources available from the community. Next year I look forward to two guest speakers, both farmers, who I was unable to schedule this year.

I will continue to experiment with L.logs and I expect that asking students to do fewer entries will increase student performance. I also think that a consistant, unpressured writing time will help. I felt that the benefits of L.logs outweighed the negative aspects and I am encouraged by the positive experience my fellow science teacher had with L.logs in her classroom.

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APPENDICES

APPENDIX A

APPENDIX A

Basic Science

1. **Entomology:** The basic morphology of the insect includes an exoskeleton of chitin, three body parts (head, thorax and abodomen), one pair of antennae, three pairs of legs on the thorax, two pairs of wings (with exception) and mouthparts composed of a pair of mandibles, pair of maxillae, a hypopharxynx and a labium.

The taxonomy of the insects is: Kingdom Animalia, Phylum Arthropoda, Subphylum Uniramia and Class Insecta.

Features contributing to the success of insects are: 1.) an exoskeleton to protect against the environment and predation, mobility, a small body size with physiological functions that maximize utilization of energy, reproductive fecundity and short life cycle permits rapid adaptative changes, high genetic variability within the same species, complex metamorphosis under hormonal control, protective coloration, mimicry and defensive chemicals.

There are two distinct life cycles of insects, incomplete and complete metamorphosis. During incomplete metamorphosis insects go through a gradual transition from egg to adult. The insect emerges from an egg into a nymph. The nymph is a smaller version of the adult, without wings or mature reproductive organs. Examples of insects that undergo incomplete metamorphasis are the grasshopper, cockroach and lice. During complete metamorphosis insects go through four stages: egg, larva, pupa and adult. The larvae looks nothing like the adult, is wormlike and has a segmented body. The pupa is an inactive stage and forms a protective covering called a cocoon. Examples of insects that undergo complete metamorphosis are butterflies, beetles and bees.

2. Pest Management: The goal of pest control is to reduce the pest population to a level at which no further reductions are profitable. This is called the economic injury level. If the population of a pest is below the economic inujury level, then the costs of control outweigh the benefits of further population declines. If the pest population is above the economic injury level the economic benefits outweigh the cost.

One way of managing insect pests is with synthetic pesticides. These are chemicals made by people to kill pests. Chemical control of pests began 2,500 years ago. During World War II, insecticides were developed to kill mosquitos that spread malaria to soldiers. After WWII widespread, heavy use of synthetic pesticides began. Agricultural use accounts for 75% of pesticide use, houshold use, 12%. Household users apply four to eight times more synthetic pesticides per hectare than farmers.

Positive aspects of synthetic pesticide use include: losing 1/3 less food to pests, a 35% increas in yield, a $9 billion dollar return on investment, decreased loss of soil and more land available for other uses because not as much land needs to be farmed.

Negative aspects of synthetic pesticides includes killing nontarget species. There are 67,000 cases of human pesticide poisoning per year. Honeybees are beneficial insects that are vulnerable to insectides. There is also the problem of water contamination. Pesticides degrade slowly and persist in the environment and some adhere to the soil. The U.S. spends $1.3 billion/ year to monitor groundwater for pesticides. Pesticides are incorporated into food webs and accumulate in fish, bird, and shellfish to levels that make them unfit for humans.

The development of pesticide resistance by target species is the final drawback to synthetic pesticides. Pesticide resistance involves the principles of evolution and natural selection. There is a lot of genetic variation within insect species. Some insects are naturally resistant to insecticides. They survive application of insecticides and pass on their insectitide resistant genes to their young. The young do not have to compete with adults for food because most were killed by the insecticide. Therefore, there is a high rate of survival for the pesticide resistant young. Over time, the resistant young reproduce and eventually the whole population is resistant.

Alternatives to synthetic pesticides include biological control, natural pesticides, disease resistant crops,control by cultivation, control by insect sex attractants and growth regulators and control by sterilization.

Biological control of insects involves the use of natural predators and parasites to control pests. Advantages of biological control are that it is nontoxic, usually targets a specific pest and is self-perpetuating. It is unlikely that the pest will develop resistance. Drawbacks are that the control population requires time to reduce the pest population and farmers need immediate results. The best control agents usually require 15 to 20 years of research before they are ready for widespread use.

Natural pesticides are chemicals produced by plants, fungi or bacteria that are harmful to pests. Antifeedants are chemicals that prevent certain insects from feeding by destroying their sense of taste. An example of this are *cirus* plants. Nerve poisons induce rapid paralysis. Rotenone, produced by the roots of legumes, inhibits cellular respiration. This chemical is effective against aphids, red spider mites and the Colorado Potato Beetle. Finally, *Bacillus thuringiensis (B.t.)* is a bacterium that occurs naturally in the soil and produces crystals composed of toxins that are released during digestion in insects. These crystals damage the digestive tract of insects and cause death.

Breeding resistant strains of a crop with nonresistant strains to produce a cross that is resistant is another method of biological control. Gene transfer is the process of introducing a beneficial gene from one species into the cells of another species. The gene that codes for the production of *B.t.* toxins has been introduced into the genome of cotton, potato and tomato.

Insect hormones can be used to control pests. For example, female insects use hormones to attract males. Traps can be set with the sex attractant to capture all the males, thus preventing them from mating with the female. Also, juvenile horomones that regulate growth and development of insects can be used to keep the insect in the juvenile stage. If the larvae cannot develop into the adult stage they cannot reproduce.

Sterilization of males is another method of biological control. When the males are released, they mate with females, which lay infertile eggs. This lowers the birth rate and reduces the population. Problems with this method of control are several. The female must mate infrequently and preferably only once and it is often difficult to raise insects in a lab. The target area must be well isolated, so the program is not undermined by immigration of fertile males.

Control by cultivation involves crop rotation and heterogeniety. Crop rotation is planting each field to a different crop every one to three years. This helps prevent the pest populations from building up by eliminating its food source. Heterogeniety is planting more than one crop in the same field. Typically, farmers plant one crop over a vast area in a monoculture for ease of planting and harvesting with big, efficient machines. Underlying both methods of control by cultivation is the ecological principle of population density, predator-prey relationships and carrying capacity.

Integrated Pest Management (IPM) is the coordination of all suitable procedures that can be used in an envionmentally compatible a manner to maintain a pest population below the economic injury level. It does not exclude synthetic pesticides but endeavors to minimize their use.

3. Plant Physiology: There is evidence that early Egyptians cultivated their soil and Greeks added organic matter to soil. Romans used crop rotation, added lime and grew legumes to improve soils for plant growth. Europeans in the 17th century observed that minerals containing nitrogen would enhance plant growth. Macronutrients are nutrients plants need in larger concentrations, while micronutrients are nutrients plants need in trace amounts. There are 16 essential elements for plant growth. Each element has a specific function in the plant and when the plant does not get enought of that element, the plant shows a specific deficiency symptom.

Most land can only be farmed for a few years before the nutrients in the soil are lost and need to be added in the form of fertilizer (Campbell,1996). The nitrogen cycle is greatly affected by farming. Removing plants from the soil causes soils to lose nitrogen as plant decomposition returns nitrogen to the soil. Also, when plants are removed there is nothing to take the nitrates up and nitrates leach from the soil. To solve this problem, farmers add nitrogen to the soil in the form of fertilizer. This upsets the balance between denitrification and nitrogen fixation also leading to an excess of nitrogen in the air. Nitrogen is also lost through runoff into rivers and groundwater, causing eutrophication.

Eutrophication is the process by which excess nutrients in lakes cause an increase in the density of photosynthetic organisms (Campbell,1996). This results in increased oxygen production during the day, but decreased oxygen production at night. When algae die, they sink to the bottom. Decomposers use all the oxygen in the deeper water and all of these conditions together cause many organisms to die.

Transpiration is the process by which water evaporates from the surface of leaves. Water in the leaves must be replaced or the leaves will wilt and the plant will die. Water is replaced by the flow of xylem sap upward from the roots. This process also brings nutrients to the plant from the roots.

4. Microbiology: Symbiotic relationships, when two organisms live in association with one another, are of three types: commensalism, parasitism, mutualism. In commensalism, one organism benefits and the other neither benefits or is harmed. In parasitism one organism benefits and the other is harmed. In a mutualistic relationship, both organisms benefit. *Rhizobium* are bacteria that live in association with legumes in symbiotic relationships, an example of commensalism (Nebel, B. 1981). The bacteria obtain sugar from the plant, and the plant gets nitrogen that the bacteria fixes from the soil.

Microorganisms can also be used to help farmers grow plants by using the chemicals produced by fungi and bacteria to kill weeds and insects as a natural pesticide. This would be a form of biological control (see Entomology).

Microorganisms also harm plants. Some produce chemicals that kill plants we want to grow. Some bacteria (see Biogeochemical cycles) are involved in denitrification, which takes nitrogen away from plants.

When working with microorganisms in the lab it is important to use sterile technique so you don't contaminate your sample with microbes from your desk, hands, air or tools. Sterile technique involves: 1.) wiping the area you're using with bleach solution, 2.) sterilizing all glassware and equipment with an autoclave at 20 p.s.i. for 20 minutes and 3.) dipping all tools in alchohol and then passing the tool through a bunsen burner before and after use.

5. Biogeochemical Cycles: Nitrogen Cycle - Nitrogen is important to plants as a nutrient used in making proteins. We get proteins from eating plants, hence this is important

APPENDIX B

APPENDIX B

Complete Outline

Week One

Day 1

1. List objectives of the Agricultural Science unit on the overhead.

2. Agricultural Science pretest (Appendix C)

Day 2

1. Concept Map #1 (Appendix C)

2. Five minute learning log entry. List all of the environmental problems associated with agriculture you can think of.

3. Class discussion.

4. Learning log entry to follow up on discussion: What problems did you add to your list? Which problem do you thing is most pressing? Why? What questions do you have?

Day 3

1. L.log.: List all the disciplines of science that a farmer uses to get crops in and out of the field.

2. Movie: Agriculture in Ottawa County

3. L.log: What disciplines of science will you add to your original list after watching the video? Questions? Connections?

Day 4

1. L.log: Observe the Madagascar hissing cockroaches. List observations. Record questions you have.

2. Notes: Entomology: taxonomy, morphology, life cycle

3. L.log: What observations could you add to your original list? What questions do you still have?

Day 5

1. L.log: Why are insects so successful?

2. Activity: Observe egg, larvae, pupa and adult stages of the Colorado Potato Beetle. Record observations in L.L. What questions do you have?

3. Notes: Entomology continued and Colorado Potato Beetle

4. L.L.: Why are insects so successful? Questions? Connections?

Week Two

Day 1

1. L.log: The pesticide Sevin is sprayed on a crop of potatoes to eradicate a beetle pest. The first year the pesticide is successful in killing all but 10% of the beetle pest. The second year it is successful in killing only 50% of the pest. Why is the pesticide less successful the second year?

2. Demonstration: Pesticide Resistance (see Appendix D)

3. Notes: evolution and genetics

4. Activity: jellybean desktop evolution (see Appendix D)

5. L.log: Redo question of the day. Add questions and connections.

Day 2

1. L.log: List the pros and cons of synthetic pesticide use.

2. Notes: Synthetic pesticides

3. Lab: Set up Potato Beetle Food Choice Lab (Bishop, B. 1996).

4. L.log: List the pros and cons of synthetic pesticides. Questions, connections.

Day 3

1. L.log: A farmer decides not to use synthetic pesticides. What other options does the farmer have? What environmental considerations should be taken into account?

2. Notes: Alternatives to synthetic pesticides.

3. L.log: Add to L.log of the day. What have you learned? Questions? Connections?

Day 4.

1. Lab: Collect data for Potato Beetle Food Choice Lab

2. Notes: How to write a correct lab write up. (Appendix C)

Day 5

1. Work day: Work on potato beetle lab write ups.

Week Three

Day 1

1. Work day: Work on lab write ups.

Day 2

1. L.log: What is Integrated Pest Management?

2. Notes: Integrated Pest Management.

3. Movie: Celery I.P.M. (Michigan State University Agriculture Extension, 1992).

4. L.log: Redo question of the day. Questions? Connections? Ideas?

Day 3

1. Read: That Feminine Touch (Raloff, J. 1994).

2. L.log: Respond to article. What did you learn? Questions? Connections?

3. Discussion: add to learning logs.

Day 4

1. Read: Pesticides May Challenge Human Immunity (Raloff, J. 1996).

2. L.log: Respond to article. What did you learn? Questions? Connections?

3. Discussion: add to learning logs.

Day 5

1. L.log: What do the ecological principlal of density and carrying capacity have to do with pest management?

2. Notes: Carrying capacity, Density dependent and independent relationships.

3. L.log: Redo L.L. entry. Questions, connections.

Week Four

Day 1

1. PreLab: Colorado Potato Beetle Simulation Lab (Appendix D) (Lovegreen, K. 1992)

2. Lab: Treatment 1 and 2

Day 2

1. Lab: Continue simulation lab: Treatment 3

Day 3

1. Work day: Lab write up.

Day 4

1. Read: Agricultural Lands Upset Predatory Insects (Cowen, R. 1994).

2. Discussion

Day 5

1. Lab: Profitability of Search (see appendix D)(Bistow, Kathy 1996).

2. Discussion

Week Five

Day 1

1. Work day: Lab write up

Day 2

1. L.log: How can the environmental problem of crop loss...world hunger by solved by science? List the fields of science used to solve problem. Describe how each is applied.

2. Discussion

Day 3

1. Entomology Test (Appendix C)

Day 4

1. L.log: Purple streaks on corn. What is wrong? What should be done? What environmental problems are associated with this issue?

2. Notes: Plant physiology

3. L.log: Add to todays L.log What have you learned? Add questions, connections.

Day 5

1. Lab set up: Nutrient deficiency lab (Appendix D)

Week Six

Day 1

1. Lab set up: Nutrient deficiency lab continued
2. Homework: Read article: Bringing Ancient Ways to Farmer's Fields (Wokomir, R. 1995).

Day 2

1. L.log: Respond to article, What questions do you have? Connections?
2. Discussion
3. L.log: Respond to discussion. What did you learn...

Day 3

1. How does crop rotation relate to plant physiology, entomology? What environmental problems does it solve.
2. Discussion
3. L.log: Redo

Day 4

1. L.log: A Farmer applies phosphorus fertilizer to the corn. What environmental problems could result?
2. Notes: cascading effect, eutrophication
3. Lab: Algae (Appendix D)(Donnely, S. 1995)
4. L.log: Redo

Day 5

1. Field Trip to Zelinka Nursery

2. L.log: What did you learn? Careers? Questions? Connections to what we've discussed in class?

3. Homework: Thank you note.

Week Seven

Day 1

1. Collect data: Algae Lab

2. Work day: Lab write up

Day 2

1. L.log: What is transpiration?

2. Notes Transpiration

3. Lab: set up Transpiration Lab (Appendix D)(Campbell, Neil 1996)

4. L.log: redo, connections, environmental problems?

Day 3.

1. Concept Map #2

2. L.log: compare and contrast your first and second map.

Day 4

1. L.log: What is cellular respiration? What is its purpose? What are connections between respiration and environmental problems?

2. Collect data: Transpiration Lab

Day 5

1. Work day: Transpiration Lab Write Up

Week Eight

Day 1

1. L.log: What are characteristics of a good experiment?

2. Discussion

3. L.log: Design an experiment that is a "further study" of the aglae lab or the transpiration lab.

Day 2

1. L.log: a. How are the fields of Plant Physiology and Pest Management Related? b. Describe the relationship between genetics, microbiolgoy and plant physiology. Give a specif example of a natural system where all three interact. Questions? Connections?

2. Discussion

3. L.log: add to

Day 3

1. Plant Physiology Test (see Appendix B)

Day 4

1. L.log: Write a three page essay titled: The Science Behind Agricultural Environmental Problems and Solutions to the Problem...or...What I've learned so far in Environmental Principles.

Day 5

1. Notes: Microbiology

2. Read: The Green Gene Revolution (Dyson, J. 1992).

3. L.log: What environmental problems can be solved through genetic engineering?

4. Discussion

Week Nine

Day 1

1. Notes: Microbiology

2. L.log: How can plant physiology and microbiology be used to solve environmental problems?

Day 2

1. Notes: Chestnut Blight (See Appendix D)(Fulbright, D. 1995)

2. Lab: Chestnut Blight

Day 3

1. Lab: Chestnut Blight

Day 4

1. Lab: Microbes and Weed Control (Appendix D)(Kennedy, A. 1995).

Day 5

1. Lab: Microbes and Weed Control

2. L.log: What are connections between microbiolgy and plant physiology?

Week Ten

Day 1

1. Lab: Microbes and Weed Control

Day 2

1. Work day: Labs

Days 3

1. Lab Microbes and weed control

Day 4

1. Work day: Collect data and Chestnut Blight lab write up

Day 5

1. Work day: Finish lab write ups

Week 11

Day 1

1. Work day: Collect data and Microbes and Weed Control lab write up.

Day 2

1. Discussion: Summarize labs

Day 3

1. Microbiology Test (Appendix C)

Day 4

1. Concept May #3

2. L.log: Describe how your map has changed.

Day 5

1. Work day: Plant Nutrient Lab write up

Week 12

Day 1

1. Notes: Biogeochemical cycles - Nitrogen Cycle

2. L.log: What is the relationship between microbiolgoy, plant physiology and the nitrogen cycle?

Day 2

1. Notes: Nitrogen cycle continued

2. L.log: Why is it helpful to understand the nitrogen cycle if you're going to try to solve the problem of world hunger?

Questions? Connections?

Day 3

1. Lab: Observing Roots of Nitrogen fixers and non-Nitrogen fixers (Appendix D)(Schipper, A. 1996).

2. L.log: A farmer has successfully planted corn for three years. This year corn shows a nitrogen deficiency. What are the symptoms? What fields of study does the farmer need to be familiar with to deal with this problem? Where did the Nitrogen go? What are sources of nitrogen for plants?

Day 4

1. L.log: A farmer has had great success growing squash for three years. This year the plants are dwarfed, light green with yellow lower leaves. Identify the problem. What crop should the farmer grow next year? What three disciplines

helped the farmer solve this problem.

Day 5

1. Read: The Coming Food Crisis (Stover, D. 1996)
2. L.log: Respond to the article (before and after discussion)

Week 13

Day 1

1. Nitrogen Cycle Test (Appendix C)

Day 2

1. Concept Map #4

Day 3

1. L.log: Essay titled: "What I've learned about agriculture science and environmental problems."

Day 4

1. Unit Post Test (Appendix B)

APPENDIX C

APPENDIX C

OBJECTIVES AND TESTS

1. Unit Objectives

Students will be able to:

A. Explain the relationship between different biological disciplines.

B. Explain how disciplines are applied to improve agricultural practices and solve agricultural problems:

1. a. Explain the relationship between entomology, genetics and evolution in an agricultural setting.

   b. Give specific examples of how the above relationship is applied to agriculture practices.

2. a. Explain the relationship between plant physiology, microbiology and the nitrogen cycle in an agriculture setting.

   b. Give specific examples of how the above relationship is applied to agricultural practices.

3. a. Explain the relationship between the ecological concept of population dynamics and entomology in an agricultural setting.

b. Give specific examples of how the above relationship is applied to agricultural practices.

4. a. Explain the relationship between the ecological concept of heterogeneity and biodiversity and entomology in an agricultural setting.

b. Give specific examples of how the above relationship is applied to agricultural practices.

C. List three environmental problems associated with agriculture.

D. Explain all sides of the issue of pesticide use and support their point of view.

E. Identify questions about agricultural science.

2. Agriculture Science Pre and Post Test

1. List all of the fields of biology farmers need to be faimliar with to get crops in and out of the field.

2. List all the environmental problems associated with agriculture.

3. Do you think farmers should use synthetic pesticides? Describe the pros and cons of using synthetic pesticides. Explain you answer.

4. List three macronutrients necessary to grow healthy plants. Describe what each nutrient does for the plant.

5. Explain why insects are so successful.

6. List or describe 5 ways a farmer can get rid of pests without using synthetic pesticides. List the scientific concept behind each method.

7. Define plant physiology. Describe the relationship between palnt physiology and the nitrogen cycle. Be specific.

8. Define microbiology. Give two examples that show the relationship between microbiology and plant physiology. How might this information be used by farmers?

3. Pre and Post Concept Map

Use all of the words in a concept map. Use lines to connect words that are related. Describe how words are related. Add extra words, concepts...anything you'vbe learned that you feel belongs on the map. Explain how they belong. Points will be awarde based on effort and thoughfulness of your map.

Entomology	Plant Physiology	Germination
Fungi	Biological Control	Agriculture Science
Microbiology	Nitogen Cycle	Nutrient Needs
Transpiration	Nutrien Cycles	Density Dependent
Bacteria	Water Cycle	Carrying Capacity
Ecology	Eutrophication	Synthetic Pesticides

4. Entomology Test

(1-7) List seven reasons why insects are so successful.

1.______________________

2.______________________

3.______________________

4.______________________

5.______________________

6.______________________

7.______________________

(8-11) List four morphological characteristics of insects.

8.______________________

9.______________________

10.______________________

11.______________________

(12-15) List four major environmental problems associated with agriculture.

12.______________________

13.______________________

14.______________________

15.______________________

(16-19)List four positive aspects of synthetic pesticides

16.______________________

17.______________________

18.______________________

19.______________________

(20-22) List three negative aspects of synthetic pesticides.

20.______________________

21.____________________

22.____________________

(23-26) Describe/Name four alternatives to synthetic pesticides. For each alternative name the scientific concept behind each method.

Alternative | Science Concept

23.____
_

24.____
_

25.____
_

26.____
_

(27-30) Read the following experimental design. Identify four things that are wrong with the design.

Problem: Which plant is the preferred food of the potato beetle?

Hypothesis: The potato beetle will eat more potato leaves.

Materials and Methods:

DAY 1

1. Cut two leaves with stems from each plant: tomato and potato.
2. Weigh each stem.
3. Place the stem of each leaf in a labeled vial filled with 5 mL of water.

4. Plug the vial with cotton.

5. Place the vials in boxes with beetles according to the directions below.

box a: two potato leaves and one tomato leaf

box b: potato leaf

6. Cover the box with plastic wrap.

DAY 2

1. Weigh the potato leaves. Record data.

27.____________________

28.____________________

29.____________________

30.____________________

31. The pesticide Sevin was sprayed on potato plants to kill potato beetles. The pesticide was 90% effective. The second year Sevin was only 50% effective. Why weren't all the beetles killed the first year? Why was Sevin not as affective the second year? In your answer use the words: genes, evolved and resistant.

32. A potato farmer has noticed the dreaded potato beetle on his crops. What should he do? Write a letter to the farmer. Be sure to describe ALL the farmer's options, rationale for using each option, and possible consequences of each option.

5. Plant Physiology Test

1-3. List the three major macronutrients and describe threir function in the plant.

macronutrient function

1.______________________ ______________________

2.______________________ ______________________

4-6. Identify the Native American "three sisters" and explain how they help each other physiologically.

4.__________________________-

5.__________________________-

6.__________________________-

7. Describe how the Egyptians, Greeks or Romans applied plant physiology through their farming methods to improve their crop yields. Identify the culture and then explain what they did.

____

8-10. Identify the controls for the following labs:

8.___________________________________-nutrient deficiency lab

9.___________________________________-algae lab

10.__________________________________-transpiration lab

11. Design an experiment to test the hypothesis: The amount of water transpired will be more in a maple tree and less in an oak tree. In your experiment make sure to include a control group, a large sample size and only one variable.

12. Essay. Describe The relationship between plant physiology and eutrophication. IN your essay cover the following points:

   a. define plant physiology
   b. define eutrophication
   c. identify situations where eutrophication occurs
   d. define cascading effect
   e. describe the steps of eutrophication

13. Give one example of how plant physiology is connected to the field of Entomology/ insect pest management. Name the ecological concept that ties the two fields together and describe how the concept is applied in both fields.

14. a. Graph the following data using a line graph. On your graph include correct titles, legends and scale. b. Describe the trends you see in the data. c. Predict the pattern of growth for the next 5 days.

Day	Plant Height (complete)	Plant Height (-N)
1	0cm	0cm
2	1	1
3	5	3
4	10	7
5	15	9
6	17	10
7	18	10.2

6. Microbiology Test

1. Define micro_______________

2. Define biology_____________

3. Define microbiology______________

4-6 Describe three things you do when using aseptic technique in a microbiology lab.

4.________________________

5.________________________

6.________________________

7. Design an experiment to test the following hypothesis: Plants will grow taller if lacking the nutrient Nitrogen than if lacking the nutrient Calcium. In your design include a large sample size, identify the control and experimental groups. Also, make sure you only have one variable that changes.

8-18. Answer the questions based on the following experiment.

Design: In petri plate #1: 10 dandelion seeds are "planted" using sterile technique in P.D.A. In petri plate #2 a soil fungus and 10 more seeds are "planted," also using sterile technique.

Data:

Plate #1		Plate #2	
seed number	length	seed number	length
1	5mm	1	2mm

2	5
3	6
4	6
5	7
6	7
7	7
8	7
9	5

8. Write one hypothesis for the lab.

____

9. T or F According to the data, soil fungus helps dandelion seed germinate.

10. T or F According to the data, soil fungus will also inhibit germination in corn seedlings.

11. T or F The results of this experiment are scientifically valid.

12. What MAJOR element is missing from the design of the above experiment?___________________________

13-18. Construct a bar graph showing the number of seeds germinated vs. plate 1 and 2. Include a main title and labels for the x and y axis.

19. Write an essay that describes how environmental problems can be solved using the fields of Microbiology, Plant Physiology and Genetics.

Title: Environmental Problems can be solved using the fields of Microbiology, Genetics and Plant Physiology.

7. Biogeochemical Cycle Test

1. List four sources of Nitrogen for plants.

_______________ _______________ _______________ _______________

2. Why do plants need Nitrogen?____________________________

3. By what process is Nitrogen lost from the soil?__________

4. Bio=________________

5. Geo=________________

6. Biogeochemical cycles=_______________________________

7. Two examples of biogeochemical cycles are:

_________________________ and ___________________________

8.-16. Matching

Mineralization	Denitrification	*Rhizobium*
Nitrobacter	Nitrification	*Nitrococcus*
nodules	competition	mutualism

a.______A growth on the roots of legumes made of bacteria that fix nitrogen for the plant.

b._____The name of the bacteria that fix nitrogen for plants.

c._____An Ecological relationship in which organisms compete for limited resources.

d._____The process by which bacteria and fungi decompose the complex compounds in dead bodies and release ammonia gas.

e._____An Ecological relationship in which both organisms benefit.

f._____A bacteria that converts ammonium into nitrite, a form of nitrogen that is not usable by plants.

g._____A bacteria that converts Nitrite to Nitrate, a form of Nitrogen that is usable for plants.

h._____A process that occurs when there isn't any oxygen in the soil. Bacteria uses the Nitrates instead of oxygen to make energy, leaving plants without any nitrogen.

i._____A process by which nitrifying bacteria use ammonium as an energy source. Ammonium is converted to Nitrite and then Nitrate. Oxygen is required for this to occur.

17. Describe the relationship between Plant Physiology, Microbiology and the Nitrogen Cycle. How can the three sciences be used to help farmers? Use the following words in your answer: nitrogen, microorganisms, protein, *Rhizobium*, nitrification and denitrification.

18. Rotating crops is good for plant nutrition. Why? Why else is rotating crops good, according to what we've studied this year?

19. What two Ecological Relationships can be observed during the process of Nitrogen fixing? Give examples.

8. Lab Write Up Format

1. Title 0 1 2

-Needs to describe the experiment in detail without being wordy!!

2. Background 0 1 2 3 4 5 6

-Describe concepts learned in class that relate to the lab

-State the problem

-State you hypothesis

3. Materials and Methods 0 1 2 3 4 5 6 7 8

-List any materials you used including reference manuals

-Also called "directions." List in steps everything you did to conduct this research.

-If methods are included in handout, just include that with any changes you made.

-Diagram lab set up

-Add directions for any calculations you made.

4. Data/Results 0 1 2 3 4 5 6 7 8 9 10

-Any information collected should be presented in this section.

-Raw data as well as calculated data

-Charts and graphs

5. Conclusions 0 1 2 3 4 5 6

-In this section explain whether your hypothesis was correct or incorrect.

-Refer to data that supports your conclusion.

-Explain what you might do differently next time.

-Make suggestions for further research.

-How does this apply to the real world?

APPENDIX D

APPENDIX D

LABORATORY EXERCISES AND DEMONSTRATIONS

1. Demonstration: Pesticide Resistance

Purpose: To show students the resistance of the Colorado Potato beetle to different pesticides used by Michigan Potato Farmers.

Materials:

1. 24 Colorado Potato Beetles-call you local farm extension for the nearest potato farmer.
2. Three large petri dishes or other shallow dish with lid. Dish should be shallow enough so that beetles cannot escape the pesticide by crawling on the sides.
3. Three large pieces of filter paper or paper towel cut to fit containers.
4. Three different pesticides. Again, talk to your local farm extension or pick up something at Franks. I used Sevin and Furadan.
5. Rubber gloves for handling pesticides.

Methods:

Day 1

1. Label three petri dishes: Furadan, Sevin and Control.
2. Mix pesticides according to directions. Wear Gloves. D not allow students to handle.
3. Soak one piece of the precut filter paper in the Sevin, on in the Furadan and one in the Distilled water.

4. Place the filter paper in the bottom of the corresponding petri dishes.

5. Place six beetles in each dish. Seal dish with parafilm. Leave overnight.

**Your local farm extension might have petri dishes that are already prepared, just ask!

Day 2

1. Count the number of beetles surviving in each dish.

2. Dispose of petri dishes in plastic bag, then in trash can.

Results:

Results will vary depending on you population of beetles. Some populations are more resistant to Furadan, others to Sevin.

Questions to discuss with students:

1. Why did some beetles live and some dies in the Sevin and Furadan dishes?(natural resistance, genetic variability)

2. Which pesticide should the farmer of this field use to get the most for his money? (the pesticide that results in the most deaths.)

3. Next year, when the farmer does the same test, predict the results. (More beetles will survive in each dish as the beetles that are resistant to the pesticide will survive and reproduce more beetles that are resistant to the treatment.)

2. Lab: Food Preferences in the Colorado Potato Beetle

Background: Discuss information and concepts discussed in class that relate to the lab.

Question: What is the preferred food of the Colorado Potato Beetle.

Hypothesis: State in "If/Then" form.

Materials:

- 6-8 vials per group depending on assigned treatment
- tomato and potato leaves
- plastic wrap
- shoe boxes

Treatments:

#1 -- potato

#2 -- tomato

#3 -- potato vs. tomato

Methods:

Day 1

1. Cut stem and leaf from assigned plant. Make sure stem is long enough to fit in vial. Weigh plant and record on chart.
2. Fill vial with a small amount of water, put stem in vial, plug with cotton. Check for leaking when plant is laid on its side.
3. Place plants equidistant apart in shoe box with leaves facing in. Place two beetles in the middle. Leave overnight.

4. Cover box with plastic wrap. Poke holes in plastic wrap and place box under light.

Day 2

1. Place beetles back in beetle house.
2. Weigh leaves. Record.

Data:

1. Record in chart form.
2. Record for class data.
3. Graph

Conclusions:

In paragraph form include the following:

1. Was your hypothesis correct? Refer to specific data.
2. Describe what this means in terms of pest management.
3. Describe practical applications of your discoveries for the tomato and potato farmer.
4. Make suggestions for further research.

Teacher Notes:

Beetle Care: Adult and larvae beetles will feed on tomato and potato leaves. To grow potato plants cut potatoes into quarters, keep in bag until "eye roots" form, plant in potting soil. You will need to plant two pots per week to keep up. Keep beetles on plants that are in pots under plant lights. Cover plant with fine mesh screening supported by an unbent hanger. Adults will lay yellow eggs on the underside of leaves. Remove leaves with eggs and place in a petri dish with a moist towel until larvae hatch, about four to eight days. At this time place larvae on a new tomato plant. You may encounter problems with aphids. I was able to control them with soapy water. For further information consult the Pest Profile of the Colorado Potato Beetle (Grafius).

3. Desktop Evolution: Demonstrating Pesticide Resistance with Jellybeans

Purpose: To model evolution by the forces of natural selection as a result of genetic variability.

Materials:

1. Jellybeans- about 30 per student. You could also use colored pieces of construction paper to cut down on cost.
2. Desk-covered with paper towel if students want to eat jellybeans at end of activity.

Methods:

This is a teacher led activity. The teacher will read instructions and ask students to stop periodically to discuss what is happening to their population and others in the class.

Teacher says:

1. Direction: Do not eat jellybeans until end of activity. Place paper towel on desks.
2. Direction: Pick out 10 jelly beans. Each jellybean represents one Colorado Potato Beetle.
3. Question: a.) What do you notice about your population compared to the others. (different colors) b.) What do the different colors represent? (genetic variability within the population, NOT different insects)
4. Direction: The pesticide Sevin is sprayed on you field.

All beetles with red, yellow and green genes are immune to the pesticide. You may kill these insects by eating them or removing them from the field.

5. Questions: Compare you populations. Who will be the most successful farmer this year? Why?

6. Direction: Your beetles reproduce. For each color left, add on jellybean of the same color. This is the second generation.

7. Question: What happens to the population in the second generation? How is it different from the first generation? (There are no red, yellow or green beetles.) Will the farmer be successful at killing beetles with a second application of Sevin? (No, because all the remaining beetles have genes that are resistant to the pesticide.)

8. Direction: The farmer sprays Furidan on the field. All black and white beetles die.

9. Question: Which beetles are resistant to both Furidan and Sevin? (The colors surviving.) What will happen to the color of the population over time? What should the results of this activity suggest to a real farmer? (switch pesticides every year.)

Follow up assignment: Explain how populations evolve over time. Use the words natural selection, genetic variation, reproduction.

4. Lab: Colorado Beetle Control Simulation

Background: Discuss information and concepts learned in class that relate to the lab.

Question: What is the best method of pest management for the Colorado Potato Beetle? natural predators, B.T. or crop rotation?

Hypothesis: State in "If/Then" form.

Materials: -200 potato paper leaves
- copies of potato beetle life cycle

Methods:

SIMULATION ONE: Are predator-prey relationships enough?

1. Scatter potato leaves around the designated field. Put out plenty of leaves, at least 200.
2. Copies of potato beetle life cycle instars, pupa and beetle are in the box. Start with the first instar.
3. The object of the game is to make it through to adult moth in order to lay eggs for the next years' population.
4. Each student is to "forage for leaves." "Eat" only 5 leaves within an arms reach for each instar. After eating 5 leaves go to the appropriate box and pick up the next growth stage and return to the same field. Repeat until you reach the adult moth stage.
5. Three students will be appointed natural predators. They can eat 1 beetle at any stage in each round.
6. Proceed until all have reached adulthood or were eaten by predators.

7. Graph the number of beetles vs. the number of leaves eaten for the first year.

8. Only females can lay eggs, so calculate the number of eggs laid for the next year's starting population (= # females X 100 eggs)

9. Put 200 leaves back out in the field for year two. (Farmer replants field)

10. Let all students repeat the foraging and life cycles. Each student needs 10 leaves to get to the next stage since there are so many more of them this year. (Each person will represent 2 beetles) Predators hunt.

11. Graph results for year 2.

12. Continue for year 3. Each student needs 20 leaves to get to the next stage.

SIMULATION: *B.t.* to the Rescue?

1. Start simulation 2 as you did with simulation one. Before you start to forage observe your first install. If it is marked with an "M" you are the Mutant and are immune to the biopesticide *B.t.* All other beetles need to turn over the leaves when you pick them up. If you have a leaf marked with *B.t.* you have eaten the bacteria that will kill you. Leave the field.

2. Continue foraging. Graph the number of leaves eaten and the number of beetles left at the end of years one, two and three. All beetles produces from the mutant beetle in years two and three are also immune to the biopesticide.

SIMULATION 3: Crop Rotation?

1. Set up simulation three like simulation one. For year two plant corn and year three replant the potatoes.

2. Graph the number of leaves eaten and the number of beetles for years one, two and three.

5. Lab: Food Search Simulation Lab

Background: Discuss information and concepts learned in class that relate to the lab.

Problem: How does the density of the food affect the profitability of the "beetle's" search for food?

Hypothesis: State in "If/Then" form.

Materials: blindfold, clock with second hand, two people

Methods:

1. Read all directions and construct a table based on the data you will collect.
2. Place 200 "plant" squares on a desk. Blindfold one person. This person is the "beetle."
3. The person hunts by tapping their finger on the desk. Each time the person taps a square the square is "eaten" and removed form the desk. Record the number of squares captured in one minute.
4. Replace squares. Repeat for a total of five trials.
5. Repeat steps 204 with 150, 100, 75, 59 and 25 squares.

Results:

1. Record data on table.
2. Calculate appropriate averages and record on data table.
3. Graph averages.

6. Lab: Plant Mineral Nutrition

Background: Discuss information and concepts learned in class that relate to the lab.

Questions:

1. Which nutrient, when absent, will have the greatest affect on plant height?
2. What will be the effect of the absence of each nutrient?

Hypothesis: State in "If/Then" form.

Materials and Methods:

1. Prepare four sets of six label. Label each set as follows: complete, -N,-Ca, -S,-Mg, -P
2. Obtain six flasks or 2-L bottles and label them with one of the four sets of labels.
3. From the large bottles of prepared solutions, use a graduated cylinder to deliver 200 mL of each of the solutions to your labeled flasks. Cover them with a piece of aluminum foil or cap.
4. Obtain six cups and label them with the second set of labels. Punch three small holes in the bottom of each cup.
5. Fill each cup 2/3 full of Perlite.
6. Obtain six drain dishes and label them with the third set of labels.
7. Place your six cups into the matching labeled drain dishes.
8. Wet the Perlite in the cups with some distilled water.

9. Obtain 24 radish seeds. Plant four seeds in each of the six cups, then cover with about 1 cm of Perlite.

10. Obtain six test tubes. Label them with the fourth set of labels. Measure out ten mL of water and add it to a test tube. Using a permanent marker, mark the ten mL level on the test tube. Do the same with the other five tubes.

11. Into the test tube labeled "complete", pour out ten mL of the "complete" solution from your flask. Add this ten mL to the Styrofoam cup labeled "complete." Do the same for the other five solutions. Be very careful to add the correct solutions to the correct cups.

12. Add enough distilled water to each cup until some of the water drains out of the bottom of the cup and into the drain dish.

13. Place your six cups in their drain dishes onto a tray, and put the tray under the light source.

14. On Mondays, Wednesdays, and Fridays, add 10 mL of the correct solution to the correct plant. Add enough distilled water until some drains out the bottom of the cup. On Fridays, add some additional distilled water for the weekend.

15. After one week of plant growth, select the "best looking" plant from among the four plants in each cup. Using scissors, cut the other three plants off at the base of their stems. Do not pull the plants up.

16. When you "water" you plants, make careful observations. Note color changes, and any changes in leaves or stems. Measure the height of the plants. Record on a chart.

17. Keep your six flasks of solutions covered with aluminum foil when not in use, and store them in a drawer. This will help prevent algae growth and bacteria contamination.

Results:

Record in chart form. Graph plant height for each nutrient solution over time.

Conclusions:

In paragraph form:

1. Summarize the effects of each nutrient solution on the growth of the plants. Refer to specific data.

2. Which nutrient deficient solutions had the greatest negative affects on the plants? The greatest positive affect?

3. Suggest practical applications of this research.

4. Suggestions for further research?

Teacher Notes:

<u>Preparation of Solutions (Stock)</u>

For each group of four students, make 100 mL of each solution. To make 1 Liter, dissolve the indicated amount of each chemical into 500 mL of distilled water and add additional distilled water to make one liter.

	per liter	per 100 mL

.1M $Ca(NO_3)_2$	16.0 g	1.6 g
.1M KCl	7.5 g	0.75 g
.1M $MgSO_4$	12.0 g	1.2 g
.1M NaH_2PO_4	12.0 g	1.2 g
.1M $CaCl_2$	11.1 g	1.1 g
.1M Na_2SO_4	14.2 g	1.4 g
.1M $MgCl_2$	9.5 g	0.95 g
.1M NaCl	5.9 g	0.59 g
.2M $NaNO_3$	17.0 g	1.7 g

Trace element solution:

Dissolve the indicated amounts of the chemicals given bellow in 500 mL of distilled water and then add additional distilled water to make 1 liter

Boric Acid	2.86 g	Cupric chloride 0.05 g
Manganese chloride	1.81 g	Sodium molybdate 0.025 g
Zinc chloride	0.11 g	

Iron Solution:

1. Dissolve 3.3 grams of iron citrate in 500 mL of distilled water. The solution will have to be heated

to 2. Add enough distilled water to make on liter.

3. If possible, autoclave for 15 minutes.

Preparation of the mineral deficient solutions (2 L each)

stocks	complete	-N	-Ca	-S	-Mg	-P
water	1720mL	1720	1720	1720	1720	1720

7. Lab: How do Phosphates affect algae growth?

Background: Discuss information and concepts learned in class that relate to the lab.

Hypothesis: State in "If/Then" form.

Materials:

5 petri dishes	any household fertilizer
ammonium phosphate	potassium phosphate
ammonium sulfate	1000 mL pond water
6-50 mL graduated cylinders	6-250 mL beakers
sunny area or light	

Methods:

1. Label the petri dishes with the following names: control, plant fertilizer, potassium phosphate, ammonium sulfate, and ammonium phosphate
2. Get a 250 mL beaker and fill it with pond water. Pour 25 mL of pond water into each of the labeled petri dishes.
3. Pour 10 mL of each chemical into their respective dishes.
4. Put the dishes under the light. You should see substantial growth in 5 to 7 days.

Results:

Record, in chart form whether algae grew in each dish. Record the relative amount of algae in each dish. Can you figure out a way to quantify the data?

Teacher Notes:

Stock Solutions

Beaker	Chemical (g)	Distilled Water (mL)
1	5 g fertilizer	10 mL
2	1 g ammonium phosphate	10 mL
3	1 g potassium phosphate	10 mL
4	1 g ammonium phosphate	10 mL

8. Lab: Leaf Transpiration in Trees

Background: Discuss information and concepts learned in class that relate to the lab.

Question: How does the rate of transpiration differ between shade and sun leaves.

Hypothesis: State in "If/Then" form

Materials:

-plastic baggies -masking tape -pencil

-scale

Directions:

__**Day 1**__

1. Label two plastic baggies with the date, your name, species of tree and shade or sun.

2. Weigh each baggie with the label on. Record the weight on your chart.

3. Place the baggies over a leaf in the shade or sun as indicated by the label. Make sure the baggie is sealed.

__**Day 2**__

1. Collect baggies. Be careful not to let any water drip out.

2. Weigh baggie with label but not with the twisty tie used to seal the baggie.

3. Record data.

Results: Record in chart form. Calculate amount of water each leaf lost. Average. Graph.

Conclusions:

In paragraph form:

1. Was hypothesis correct? Refer to data that supports conclusion.

2. Why is it important to place the bags around the tree in such a way that the bag is essentially sealed?

3. What could be some of the variables that affected your results?

4. How does transpiration fit into the hydrological cycle.

5. Suggestions for further research?

9. Lab: Chestnut Blight

Background: Discuss information and concepts learned in class that relate to the lab.

Question:

1. Will Sch Mi transfer its genes through fusion to Sch?
2. Will Sch Euro transfer its genes through fusion to Sch?
3. Will Wis transfer its genes to Sch Euro?

Hypothesis: State in "If/Then" form.

1.
2.
3.

Materials:

-a-septic conditions	-Bunsen burner
-6 petri dishes	-potato dextrose agar(PDA)
-bleach solution	-scalpel

-chestnut blight cultures: Sch, Sch MI, Sch Euro, Wis

Methods:

Hypothesis 1:

1. Wipe down work area with bleach solution.
2. Dip scalpel in alcohol, heat scalpel to kill germs, let cool slightly.
3. Cut a small sample (half the size of a fingernail) of Sch Mi an place it right side up on the agar along the side of a new petri dish. DO NOT open either dish all the way. Heat scalpel.

4. Dip scalpel in alcohol, heat, let cool and add a sample of Sch to the same plate, along side the first plug. Heat scalpel. Label plate, Sch Mi x Sch.

5. Heat scalpel, let cool and add a sample of Sch to a new plant. Label dish "recipient strain, Sch."

6. Heat scalpel, let cool and add a sample of Sch Mi to a new plate. Label dish "donor strain Sch Mi."

7. You should have three plates. Put all under light.

Hypothesis 2:

1. Repeat the steps for hypothesis 1 and substitute Sch and Sch Euro.

Hypothesis 3:

1. Repeat the steps for hypothesis 1 and substitute Sch Euro and Wis.

Results: Draw pictures of the plates. Note whether fusion has occurred. Indicate whether genes have transferred.

Conclusions:

1. State whether your hypothesis were correct or incorrect.
2. Refer to specific data that supports your statement in number 1.
3. What were the control groups in each experiment?
4. Suggest applications of your discovery.
5. Make suggestions for further research . It must be a testable hypothesis.

10. Lab: Investigating Soil Microorganisms for Biological Weed Control

Background:

Discuss information and concepts learned in class that relate to the lab.

Question:

1. Do soil microbes inhibit or encourage seed germination of the radish.

Hypothesis: State in "If/Then" form.

Materials:

-bleach solution
-2 sterile Pasteur pipettes
-4 nutrient agar plates
-radish seeds
-plastic ruler
-2 sterile water blanks
-1 sterile spatula
-3 water agar plates
-2 pair sterile forceps
-nutrient agar slants

Methods:

Day 1

<u>Soil Dilution:</u>

1. Add a pinch of soil to 10 ml of sterile water in a capped test tube (first dilution.)
2. Shake well until the soil is evenly distributed throughout the liquid.
3. Using a sterile Pasteur pipette or eyedropper, transfer two drops of first dilution into a second test tube with 10 ml of sterile water (second dilution.)

<u>Isolation of Bacteria--Spread Plating</u>

1. Using a sterile Pasteur pipette, place one drop of the soil solution from the tubes in the middle of the nutrient agar plate. Each tube will require a separate plate. Both tubes should be plated to show the effect of dilution on the microorganisms present.

2. Using the bent end of the sterile hockey stick, draw the stick through the drop and then in a circular motion spread the drop around the plate. Circle the plate with the stick at least twice to evenly spread the drop and the microbes. Use a light touch.

3. Close the plate and seal the edges with parafilm.

4. Label the plates on the bottom with masking tape.

5. Incubate plates for 24-48 hours at room temperature.

6. Observe the bacterial colonies that have grown on the agar. Compare the microbes on the plates from the two dilutions with those from the root impression. Describe colonies. Write this information on the data table.

<u>Isolation of Bacteria--Root Impression</u>

1. Harvest plants, taking care to leave root systems intact.

Waste roots under a steady stream of water to remove all soil and sand particles. Blot roots with paper towels.

2. Waste spatula and scissors in ethanol and blot dry with a clean paper towel.

3. Remove cover of petri plate and lay roots on the agar.

4. Starting at the bottom of root system, gently use spatula to press roots into the agar, leaving a slight

indentation. Work tot he top of the roots. Remove the root from the plate and discard the root. Seal the plate with parafilm.

5. After 24-48 hours, observe the bacteria colonies that have grown along the root impressions. Add information to your data table.

Day 3

Plate examination:

Plates will usually contain a number of colonies of bacteria or fungi with different morphologies (size, shape and color.)

Bioassay

1. Select two colonies from plates. Note any distinguishing morphological features. Record.

2. Prepare an isolate. Use a sterile spatula to transfer on colony from the plate onto a sterile agar plate. Transfer the second colony to a second plate. Use sterile technique.

3. Gently press 10 seeds into the agar with sterile forceps, being careful not to immerse the seeds in the agar. Repeat for control noninnoculated plate. Seal the plates with parafilm.

4. After one week measure the roots inside the plate. Record on data table. Make all observations without opening the plates.

Average root lengths for each treatment. Record.

Conclusions:

1. Did you notice and morphological trends from the different samples? Describe.

2. Did any microbes inhibit or encourage root growth? From which treatment?

3. Application to the real world?

4. Suggestions for further research?

11. Lab: Comparison of Plant Roots of Nitrogen Users and Nitrogen Fixers

Background: Discuss information and concepts learned in class that relate to the lab.

Hypothesis: State in "If/Then" form.

Materials:

-slides	-scalpel	-coverslips
-microscope	-methylene blue	-mortar and pestle
-safety goggle	-corn plant with roots	
-soybean plant with roots		

Methods:

1. Make a comparison of the legume roots and non-legume roots. Which contains nodules? Draw and label the roots on your data sheet.
2. Place a drop of methylene blue on a microscope slide and allow it to dry.
3. Take a portion of the roots that contained the nodules and cut off a nodule with a scalpel.
4. using the mortar and pestle crush the nodule, add a few drops of water, and continue crushing. This is what you will use for the wet smear slide.
5. Use the medicine dropper to get some of the squashed module material. Put one drop of the material on the slide on top of the dried methylene blue and put on a cover slip.
6. Observe the slide under the microscope. As the methylene blue diffuses into the water, tinny organisms that

live within the nodule should become visible. What are these simple organisms? Draw the organisms you see.

7. Repeat the procedure (#2-6) using a piece of root from a plant which lacks nodules.

8. Clean up.

Data: Include drawings of corn and soybean roots and nodule smear under microscope.

Conclusion:

Write in paragraph for as indicated in lab exercise write up directions.

APPENDIX E

APPENDIX E

Student Scores

1. Pre and Post Test Scores

Student Number	Pre Test	Post Test	%Improvement
High Group			
1	28%	69%	**41%**
4	36%	90%	**54%**
14	31%	93%	**62%**
17	39%	92%	**53%**
21	39%	84%	**45%**
ave.			**51%**
Mid Group			
2	31%	71%	**40%**
5	15%	58%	**43%**
7	32%	58%	**26%**
8	27%	0%	**-27%**
9	16%	44%	**28%**
10	12%	0%	**-12%**
11	10%	44%	**34%**
12	8%	63%	**55%**
13	20%	71%	**51%**
16	17%	64%	**47%**
19	53%	78%	**25%**
22	24%	68%	**44%**
23	25%	75%	**50%**
ave.			**37%**
Low Group			
3	24%	59%	**35%**
15	22%	58%	**36%**
18	25%	0%	**-25%**
20	23%	0%	**-23%**
24	**0%**	**0%**	**0%**
6	22%	44%	**22%**
ave low			**16%**
Average	**24%**	**54%**	**31%**

t=4.4
d.f.=22
p>0.001

2. Lab Scores

Stdent Number	Entomology	Plant Physiology	Micro Biology	Average
High Group				
1	37%	25%	0%	**21%**
4	89%	100%	94%	**94%**
14	100%	100%	100%	**100%**
17	100%	100%	100%	**100%**
21	90%	94%	87%	**90%**
ave. high	**83%**	**84%**	**76%**	**81%**
Mid Group				
2	79%	99%	48%	**75%**
5	100%	100%	100%	**100%**
7	21%	67%	0%	**29%**
8	79%	100%	83%	**87%**
9	85%	81%	100%	**89%**
10	35%	67%	67%	**56%**
11	0%	50%	0%	**17%**
12	55%	100%	89%	**81%**
13	93%	100%	96%	**96%**
16	97%	100%	99%	**99%**
19	94%	100%	100%	**98%**
22	39%	94%	87%	**73%**
23	81%	33%	90%	**68%**
ave. mid	**66%**	**84%**	**74%**	**75%**
3	76%	50%	95%	**74%**
15	82%	100%	89%	**90%**
18	54%	25%	36%	**38%**
20	82%	93%	69%	**81%**
24	64%	0%	0%	**21%**
6	37%	67%	74%	**59%**
avg. low	**66%**	**56%**	**61%**	**61%**
Average	70%	77%	71%	

3. Journal Scores

Student Number	Entomology	Plant Physiology	Micro Biology	Nitrogen Cycle	Average
High Group					
1	0%	0%	0%	0%	0%
4	71%	80%	78%	80%	77%
14	100%	100%	103%	106%	102%
17	89%	100%	103%	106%	100%
21	100%	100%	103%	106%	102%
Mid Group					
2	76%	67%	85%	56%	71%
5	76%	97%	100%	100%	93%
6	71%	47%	8%	0%	32%
7	0%	0%	0%	0%	0%
8	78%	100%	90%	83%	88%
9	84%	100%	32%	0%	54%
10	37%	50%	70%	76%	58%
11	0%	37%	15%	0%	13%
12	0%	0%	0%	0%	0%
13	100%	100%	100%	100%	100%
16	89%	100%	100%	100%	97%
19	89%	100%	100%	100%	97%
22	0%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%
Low Group					
3	58%	40%	38%	0%	34%
15	100%	100%	100%	100%	100%
18	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%
24	0%	0%	0%	0%	0%
Average	51%	55%	51%	46%	51%

4. Concept Map Scores

Student Number	Connections Pre	Post	Improved	Total Score Pre	Post	Improved
High Group						
1	0	5	5	12	22	10
4	0	8	8	7	25	18
14	0	5	5	8	22	12
17	2	10	10	11	27	16
21	1	8	7	9	25	16
Mid Group						
2	0	5	5	5	22	17
5	2	2	0	10	7	-3
7	0	0	0	7	17	10
8	0	0	0	1	0	-1
9	0	4	4	5	21	16
10	0	2	2	7	10	3
11	0	3	3	1	20	19
12	0	3	3	0	20	20
13	1	11	10	8	28	20
16	0	2	2	9	19	10
19	0	9	9	5	28	23
22	0	0	0	7	12	5
23	0	4	4	0	17	17
Low Group						
3	0	8	8	10	25	15
15	0	0	0	0	7	7
18	0	0	0	5	7	2
20	0	1	1	7	18	11
24	0	0	0	5	6	1
6	0	0	0	5	8	3
average	0.25	3.75	3.5833333	6	17.208333	11.125

5. Survey Scores

I. End of Unit Survey

Question	Yes	No	Not Sure
1	58%	42%	0%
2	0%	96%	4%
3	62%	38%	0%
4	96%	4%	0%
5	92%	8%	0%

II. End of Year Survey

Question	Yes	No	Not Sure
1	57%	16%	26%
2	11%	89%	0%
3	0%	100%	0%

APPENDIX F

APPENDIX F

Surveys

1. End of Unit Survey

	Yes	No	Not sure
1. Did you find that writing in your learning log helped you understand content better?			
2. Did learning logs help you write better?			
3. Were learning logs worthwhile?			
4. Did lab exercise write ups help you understand content better?			
5. Were lab exercise write ups worthwhile?			

6. List your favorite lab:________________________

7. List your least favorite lab:__________________

Comments:

2. End of the Year Survey

	yes	no	not sure
1. Would you recommend this class to a friend next year?			
2. Was this class too hard?			
3. Was this class boring?			

4. What was your favorite unit in the class?____________

5. What was your least favorit unit in the class?_______

Comments: