Changes in Perceived Self-Efficacy and Attitude Toward Science and Teaching Science in Elementary School

Betsy Ann Sullivan
University of Southern Mississippi

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CHANGES IN PERCEIVED SELF-EFFICACY AND ATTITUDE TOWARD SCIENCE AND TEACHING SCIENCE IN ELEMENTARY SCHOOL

by

Betsy Ann Sullivan

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

December 2011
ABSTRACT

CHANGES IN PERCEIVED SELF-EFFICACY AND ATTITUDE TOWARD SCIENCE AND TEACHING SCIENCE IN ELEMENTARY SCHOOL

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This study was developed in an effort to ascertain if a proposed biological laboratory curriculum as developed and modeled by the instructor would affect the attitudes and perceived self-efficacy towards science, science teaching and ability to learn science of pre-service elementary teachers. Self-regulated learning (SRL) strategies were incorporated as the variation. Attitudinal topics investigated were the perceived ability to learn science and to teach science.

Students in one biology for non-science majors' biology laboratory class at the University of Southern Mississippi participated in this case study. The group participated in the modified laboratory section which utilized SRL activities, including reflections on in-class activities. In addition to these activities, the group worked within the state’s elementary science framework to design and implement science lessons. Password protected on-line surveys were used at the beginning and the end of the course to assess the attitudes, perceived self-efficacy and self-regulated learning level of all students. Interviews with participants were conducted as follow up to ascertain long-term impact of the curriculum.

Student artifacts, researcher observations and follow up interviews were analyzed to identify any changes in student attitude towards and perceived self-efficacy in science and teaching science. Analysis identified a positive change in
students’ attitudes and perceived self-efficacy after participation in the modified laboratory section, indicating moderate success of the proposed curriculum based on SRL.
The University of Southern Mississippi

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LIST OF ABBREVIATIONS

No Child Left Behind.................................................................NCLB

Personal Science Teaching Efficacy Belief Expectancy Scales........PSTEB

Science Teaching Efficacy Belief Instrument - Pre-service............STEBI-B

Self-regulated Learning............................................................SRL

Student Teaching Outcome Expectancy......................................STOE
CHAPTER I
INTRODUCTION

Learning is nothing but discovery that something is possible. To teach means to show a person that something is possible.

Fritz Perlz, Gestalt Therapy Verbatim

This paper describes an investigation related to the development of a biology laboratory section for non-science majors into a hands-on, self-regulated learning (SRL) experience for elementary education majors. The purpose of this study was to determine the effect on attitudes of pre-service elementary education majors who participated in the modified non-science majors’ biology laboratory which focused on the use of SRL, hands-on experiences and the development of practical, easy to use classroom science experiences with direct link to the 2010 Mississippi Science Framework. The activities included in this curriculum were selected to explore the students’ confidence in their ability to teach science in depth. The investigation was housed at the University of Southern Mississippi in the College of Science and Technology within the University and with the permission of the education program for pre-service teachers. The laboratory section that was the focus of this study was one section of the laboratory course that is a co-requisite existing biology for non-science majors’ lecture course. Special attention was given to publications concerning science elementary educator training, the impact of current education law and reform on elementary science education and creation of similar courses designed
to promote science in elementary classroom. In this research, a possible cause and solutions for the lack of student success in science were explored.

The 1989 Education Summit, the National Governors Association led by President George H. W. Bush stated that “by 2002, America will finish first among industrial nations on international Science and Mathematics achievement tests (Vinovskis, 1999, p. 30).” The result of this summit was a systemic reform based on “opportunity to learn (p. 32)” standards called America 2000. While this goal was admirable, the United States did not achieve it. President George H. W. Bush allowed this legislation to die (States’ Impact on Federal Education Policy, 2008). The death of America 2000 opened the door to the development of national standards in education.

In the Trends in International Mathematics and Science Study (TIMSS) (Calsyn, Gonzales, & Frase, 1999; Katsberg, Roey, Jocelyn, & Williams, 2006) research showed that even though students in grades 4 and 8 scored higher than the international average, these students ranked below many other nations. Students in Mississippi are often identified as the lowest in basic education or science education in the nation, as noted in the Fordham Foundation Report (Finn, Julian, & Petrilli, 2006) and The Nation’s Report Card: Science 2005 (Grigg, Lauko, & Brockway, 2006). In national studies, such as the Fordham Foundation Report and Horizons Research (2002), Mississippi students fell in the lowest 5% in basic education. Grigg, Lauko, and Petrilli (2006) identified that Mississippi’s fourth grade students scored as follows on national testing:
Table 1

2005 National Test Results for Mississippi 4th Grade Students

<table>
<thead>
<tr>
<th>Resulting Score Divisions</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mississippi</td>
</tr>
<tr>
<td>Below Basic/ Minimal</td>
<td>55%</td>
</tr>
<tr>
<td>Basic</td>
<td>33%</td>
</tr>
<tr>
<td>Proficient</td>
<td>12%</td>
</tr>
<tr>
<td>Advanced</td>
<td>1%</td>
</tr>
</tbody>
</table>

Students scoring below basic/minimal did not demonstrate mastery of content or skills required for success in the course. Students scoring basic demonstrated a partial mastery of content and skills in the course but have difficulty in more advanced courses. Students scoring proficient showed a solid performance academically and may have found the challenge of advanced courses attractive. Students scoring advanced consistently performed above what was required to be successful in advanced courses (Mississippi Department of Education, 2008). The 2000 Mississippi science standards received failing scores in national assessments (Finn, Julian, & Petrilli, 2006). The state developed new standards for science which were implemented in school year 2010.

It is commonly held that elementary teachers are hesitant to teach science; the concept of teaching science may be viewed as a terrifying idea.
Abell and Roth (1992) reported that many elementary teachers lack self-confidence in teaching science due to a lack of exposure to content. One explanation may be that the courses they are required to take include little science content. Teachers develop their philosophy of teaching science early, perhaps as far back as to their own experiences in elementary school, referred to as cognitive baggage. It is on these experiences in grade school, secondary school, and college that in-service teachers shape their beliefs of science education (Weld & Funk, 2005). Generally speaking, a casual survey of practicing elementary teachers will identify that most would not choose science as the subject they would prefer to teach. Abell and Roth (1992) identified the reasons for this concept as the experiences in-service elementary teachers have had in science and science methodology courses are limited and are often remembered negatively. This negative attitude toward science teaching has a dramatic impact on students’ future in science; students will often adopt the attitude a teacher exhibits toward a subject. Exit surveys of pre-service elementary teachers also identify a negative opinion about the ability to teach science effectively which in turn reflects negatively on their perception of their students’ ability to learn science (Cooper, 2005).

While traditional education classes cover a variety of teaching styles, pre-service teachers are required to take two science courses with laboratory experiences. Currently there is only one science methods course at the university that is required of all elementary education majors. The goal of this study was to provide pre-service elementary teachers with opportunities to understand how
they learn and to apply general biology knowledge laboratory courses in their future teaching.

Research Question

Will there be a change in pre-service elementary education majors’ attitudes and perceived self-efficacy in science and science teaching and content knowledge retention after participation in a biology laboratory section designed to promote positive attitudes toward science through SRL, hands-on investigation, and practical demonstration of classroom technique in relation to the Mississippi 2010 Science Framework?

Definition of Terms

1. Achievement goals: self-reported motivations for task completion
2. Cognitive engagement: metacognition; effort and strategies used to learn
3. Hands-on activity: activity in which student participates and manipulates
4. Learning goals: motivation to increase knowledge
5. Performance goals: motivation to perform before peers or to perform better than peers
6. Science background: prior science content knowledge
7. Science attitude: personal view of science as a content area
8. Self-efficacy in science teaching: personal belief in one’s ability to teach science
9. Self-regulated learning: monitoring one’s own learning and the motivation for learning

Purpose of the Study

Attitudes of the pre-service elementary education majors were assessed using the Science Teaching Efficacy Belief Instrument – Pre-service (STEBI-B) developed by Enochs and Riggs (1990) and subject interviews. Attitudinal topics investigated included personal view of science, attitude toward teaching science, and perceived self-efficacy in teaching science to elementary students. The STEBI-B was analyzed for descriptive variance in participants’ attitudes. The interview, questionnaires and reflection responses provided qualitative data.

Students of this case study were elementary education majors at the University of Southern Mississippi participating in the laboratory which accompanies the biology for non-science majors’ lecture. There was one laboratory section involved in this investigation. All students in the case study were given the opportunity to perform hands-on investigations that compliment the lecture course. The group participated in SRL style experiences to promote learning science and the transition of their in-class experience to their future classroom as well as developing classroom activities based on topics covered in the laboratory section. Assessment of changes in attitude in biology for this investigation was determined through the student reflections, questionnaires and participant interviews. Assessment of changes in perceived self-efficacy in science and teaching science was determined through student responses to the STEBI-B.
Specific Questions of this study were:

1. What are the changes in attitudes toward science in elementary education majors after participating in the modified laboratory section?

2. What are the differences in attitudes towards teaching science in elementary education majors after participating in the modified laboratory section?

3. What are the differences in perceived self-efficacy of elementary education majors in teaching science after participating in the modified laboratory section?

Theoretical Framework

As brain research expands the understanding of how people learn, education methodologies evolve. David Ausubel (1968) noted that the learner is most influenced by previous knowledge in regards to desire to learn. Human constructivism is the theory of learning by building upon previous knowledge. It also incorporates the philosophy that learning is a social event within a classroom where the teachers act as guides and the students are motivated to develop their own knowledge. (Mintzes & Wandersee, 1997). As knowledge is obtained, it is applied in problem-solving situations that further develops knowledge. Constructivism, in its truest goal, promotes understanding of material rather than an exposure to topics in a course (Mintzes, Wandersee, & Novak, 1997). This scaffolding of information promotes self-regulated learning.

As humans are creatures of habit, teachers will teach a subject in the manner in which they were taught the subject whether as a student in grade
school or as a student in teacher training courses (Ginn & Watters, 1999; Wallace & Louden, 1992; Yilmaz-Tuzun, 2007). They will seldom vary their teaching styles. In many elementary education courses, the training of pre-service teachers emphasizes reading, language arts and mathematics as these are the areas which are heavily tested to quantify school effectiveness. Across the nation there has been an increase in the amount of time spent per school day on English/language arts (ELA) and mathematics (Stefanich & Kelsey, 1989; Weiss, Matti, & Smith, 1994). The Center on Education Policy (McMurrer, 2008) reported that on average, school districts increased instructional time in ELA and mathematics by 43% and decreased the amount of instructional time in other subjects by 32%. This reduction was demonstrated by a loss of at least 75 minutes per week in science, social studies, arts, and physical education. Therefore, students may not get adequate exposure to science in elementary grades, resulting in a lack of self-confidence in science. Science and social studies/history appear to be peripheral subjects. As a result, these courses are taken by pre-service teachers as part of their core study and are not developed to demonstrate hands-on inquiry in relation to national and state standards. The lecture component of science classes is usually pure content which involves little student participation other than note taking. The accompanying laboratory, while hands-on, is not designed to encourage SRL. The pre-service teacher is not given opportunity to explore the varied methods involved in designing and teaching science. Lecture is the main method of science content knowledge transfer and therefore would be taught mainly as lecture. Many pre-service and
in-service elementary teachers include science in reading assignments and seldom elsewhere. Students may feel they are unable to understand science and therefore develop the concept that they will not succeed in science. This low perceived self-efficacy in science may inhibit student advancement in the subject.

A self-regulated learner is described by Perry, Phillips and Hutchinson (2006) as one who is aware of his or her own academic strengths and weaknesses, metacognitive, intrinsically motivated and develops strategies to assist in learning subjects. This type of learner adapts lessons and modifies the tasks to meet the individual’s need. A characteristic of a self-regulated learner is setting goals; in this manner the self-regulated learner is identifying what he or she wants to accomplish, including the strategies necessary to meet the goals and monitoring his own learning by consistently reviewing the goals. The self-regulated learner, once he or she understands that he is in control of his or her achievements, will select tasks that are more challenging and those that require more effort. This leads to more time dedicated to learning (Koballa & Glynn, 2007). As educators, it is crucial to develop students toward being self-regulated learners.

In order to assist students in developing SRL skills, teachers must understand what skills are indicative of SRL and model the skills and behaviors (Lombaerts, Engels, & Athansasou, 2007). The skills involved in SRL are a) identifying and making decisions concerning individual learning processes, b) collaboration with peers and obtaining feedback from peers, c) evaluation of own learning, and d) developing and working on complex tasks (Perry, Hutchinson, &
Thauberger, 2007; Perry, Phillips & Hutchinson, 2006). Strong self-motivation is also indicative of SRL. According to Smith, Jussim, and Eccles (1999), teachers who set the expectation of SRL will influence student performance in the subject and thus increase self-awareness in the students. As part of this investigation, pre-service educators were exposed to and participated in SRL activities. The blending of content and pedagogy was important for pre-service teachers to be able to help students in K-8 learn science (Goodman, et al., 2006). He believes that these strategies, if developed in the pre-service educators, will affect the attitude of the subjects toward science in general and the teaching of science to elementary students.

When No Child Left Behind (NCLB, 2001) was enacted, states were able to enforce educational standards with more regulation. At the start of the process, the foci of learning and testing were reading, language arts and mathematics. Since 2001, these were the only courses tested yearly in elementary school. This allowed students to be given enrichment and remediation in reading, language arts and mathematics. Science, social studies, the arts and physical education were reduced in importance. The author of this study attended a staff development meeting in which the superintendent of education for that school system was asked about the time spent in science and social studies. The teacher asking the question was an upper elementary teacher who specialized in science. This teacher’s teaching assignment had been adjusted to decrease science classes and at the time had to devote classes to reading methods. The superintendent stated that if a child could read, then the
child could do anything. It is the author’s opinion that while reading is a fundamental skill necessary to scholarly success, it does not necessarily promote critical thinking skills or process skills that are vital to science achievement.

Self-efficacy is an understanding of one’s belief in one’s own ability to organize and execute tasks required to accomplish goals (Bandura, 1997). It is often discussed in context of self-concept and self-esteem. Both of these are part of self-efficacy; however, they do not fully explain the concept of self-efficacy. Self-efficacy involves an evaluation of one’s ability. One’s self-efficacy may be used as a predictor of performance (Cannon, 1997; Palmer, 2006). For example, an in-service elementary teacher may be exemplary in teaching mathematics. This teacher would therefore have a high, positive self-efficacy towards his or her skill in mathematics. However, when assigned to teach science, this same teacher may express doubts in his or her knowledge of science and ability to teach science. The teacher would demonstrate a low, negative self-efficacy. High self-efficacy is demonstrated through classrooms that are student-centered; the teacher utilizes inquiry as the basis of the science lessons (Lee & Houseal, 2003). It is not just the amount of time in engagement with content that is essential; the manner in which teachers learn is also essential (Lappan, 2000).

In this case study, the elementary education majors participated in a biology laboratory course designed to encourage a positive attitude toward science and science teaching, as well as promote self-efficacy of science comprehension and science teaching. Subjects actively participated in the laboratory section that accompanied the biology for non-science majors’ lecture.
The activities used are annotated along with samples of their self-reflections submitted during the investigation.

Delimitations

The following delimitations apply to this study.

1. The subjects for this study are limited to students enrolled in the university as elementary education majors.

2. The standards utilized in this study are the 2010 Mississippi Science Framework, specifically those for grades kindergarten through eight.

3. The collection of data will be limited to one group enrolled in the laboratory section which complements the biology for non-science majors lecture.

4. The variable of attitude was limited to the Science Teaching Efficacy Belief Instrument-Pre-service (STEBI-B) attitudinal survey and student interviews during this study. The STEBI-B attitudinal survey was developed by Enochs and Riggs (1995). The author developed the interview instrument.

5. Subjects and variables not specified in this statement are considered beyond the scope of this investigation.

Assumption

It is assumed that the subjects provided honest responses to the measurement instruments.
Justification of the Study

When the legislation regarding the No Child Left Behind act was enacted on the state level, the foci of education became reading and mathematics. In an effort to prepare pre-service teachers for the reality of this legislation, many collegiate programs reduced the amount of science and social studies/history courses taken by elementary education majors. The result is that many in-service elementary teachers are now finding themselves teaching science when they feel ill-qualified to teach science. As identified by Jegede, Taplin and Chan (2000), the teacher is the foremost central part of any efficient education reform in order to establish effective national standards. The standards of education referred to by Jegede, Taplin and Chan (2000) are the national science standards. As the teacher is the core of this concept, it benefits global society to produce teachers that are metacognitive, self-regulated learners and have high self-efficacy in learning. Tosun (2000) concluded that "science content knowledge may play a role, but it is not the primary factor that determines the success of a teacher. This should not be taken as to totally dismiss the role of science content knowledge, but, instead, to point to the notion that teacher education programs must be sure to address teacher efficacy beliefs" (p. 29). Providing pre-service educators with mastery opportunities in teaching science will increase individual perceived self-efficacy in teaching science. Courses designed for teacher education must be inclusive of pedagogy, metacognition and content in order to promote high self-efficacy and self-regulated learning (Bleicher, 2006; Yilmaz-Tuzun, 2008).
CHAPTER II
REVIEW OF THE RELATED LITERATURE

Attitude and Self-efficacy in Pre-service Elementary Educators in Science and Teaching Science

Pre-service elementary educators have distinctive views on the topic of learner success in a given subject area. Survey results indicate that pre-service educators believe that students’ inadequacy in science may be the result of poor teaching (Cakiroglu, Cakiroglu, & Boone, 2005). Teachers who do not enjoy the subject matter are less likely to teach that subject effectively (Ramey-Gassert & Shroyer, 1992; Tschannen-Moran, Hoy, & Hoy, 1998). Establishment of teacher education programs that provide risk-free, enjoyable learning environments allows opportunities for mastery in pedagogy and content knowledge which may be later transferred to elementary students through teacher interest (Watters & Ginns, 2000). The increase in self-efficacy highlights the effectiveness of courses that emphasize student-centered learning.

Studies have shown that the impact of a course designed to demonstrate methods of teaching science as well as developing science content knowledge have positive impacts (Downing & Filer, 1999; Eiriksson, 1997; Lumpe, Czerniak, & Haney, 1999; Pajares, 2002; Weld & Funk, 2005). In regard to self-efficacy in science and in teaching science, subjects that were initially displaying low self-efficacy at the beginning of a study increased their levels of self-efficacy to high self-efficacy (Bleicher, 2006; Morrell & Carroll, 2003; El-Deghaidy, 2006; Palmer, 2006; Ramey-Gassert et al, 1996; Woolfolk Hoy, 2000). Johnston (2006)
identified an increase in self-efficacy and attitude toward teaching science when application and kinesthetic methods were incorporated into the lessons. The activities utilized within a course must provide a positive opportunity for mastery of technique and knowledge. The development and presentation of lessons encourage subjects to consider teaching science as an in-service teacher. This changing of a negative attitude towards science teaching to a more positive attitude will have the greatest impact in education (Anderson, et al., 2004; Appleton & Kindt, 1999; Enochs, Scharmann, & Riggs, 1995; Harlen & Holroyd, 1997; Skamp, 1991). The activities in which pre-service educators participate and have successful results and reviews are more likely to be utilized in a formal classroom by the educators in the future. These activities are considered safe and usable (Appleton & Kindt, 2002).

"Beyond representing the substance of a subject, teachers also represent its nature" (McDiarmid, Ball, and Anderson, 1989). Teachers who are confident in their skills are more effective teachers. A Horizon Research survey (Fulp, 2002) reported that fewer than 3 in 10 elementary teachers felt that they were prepared to teach science. It is therefore important to provide pre-service educators with opportunities to master their content areas and develop their teaching skills (Ginns & Watters, 1997; Kagan, 1992; Watters, Diezmann, & McRobbie, 1997). The more time pre-service educators devote toward a subject and methodologies within the subject, the more self-efficacious they will be. There are a variety of factors that influence self-efficacy, including, but not limited to: gender, content area and professional standing (Cannon, 1997). Also, pre-service educators'
experiences in content courses will impact their self-image (Lunn & Solomon, 2000; Skamp & Meuller, 2001). They develop their beliefs in teaching science based on their own in-class experiences (Weld & Funk, 2005). In science, many pre-service elementary educators are required to take a minimal amount of science. In most cases, the course taken is an introductory biology course. As these courses are mainly lecture, this is the method that many use later on (Yilmaz-Tuzun, 2008).

With science curricula constantly undergoing reform, it is essential for educators to maintain constant study. Pre-service educators must be made aware of the various resources available to them for use in the classroom. They must be able to evaluate and apply chosen curricula supplements. Bruner (1977) wrote, “If it [new curricula] cannot change, move, perturb, inform teachers, it will have no effect on those they teach. It must first and foremost be a curriculum for teachers. If it has any effect on pupils, it will have it by virtue of having an effect on teachers (p. xv).” Presentation of supplemental or alternative activities in a curriculum in a course for pre-service educators is therefore essential for their mastery of science knowledge and pedagogy. Bleicher (2006) supports the concept of increasing self-efficacy through interactive and cooperative group designed courses.

Self-Regulated Learning

Pre-service elementary educators’ perceived self-efficacy in learning science is viewed more positively after participation in a course designed to demonstrate content knowledge (Cady & Rearden, 2007). Providing
opportunities to explore content topics through hands-on techniques and then
developing those topics further into student designed lessons provides pre-
service elementary education majors’ opportunities to establish their own identity
in content knowledge and understand that the instructor is not necessarily the
sole provider of knowledge. To increase the student’s awareness of his or her
own learning strategies is [the] key to effective teaching (Ausubel et al., 1978).
How one learns has been the driving force behind current education theories.
Pre-service teachers who are allowed to explore their reasons for studying and
the impact of these reasons on their cognitive engagement help determine how
they will operate as future students and as future teachers (Bhuvaneswari,
Greene, and DeBacker, 2005). With the advances in technology, brain
development has been extensively studied. In complement to this is the
investigation into metacognition, motivation to learn, and perceived self-efficacy
in learning. Studies basing activities on the learner-centered approach with a
focus on content knowledge development and understanding have had varied
success. One such study found that there was little evidence that students
participating in a course designed to increase awareness in science content
knowledge recognized their own control over their learning (Gooday & Wilson,
1996). The authors of the study utilized a learner-centered approach with a focus
on development of content knowledge and understanding rather than the
processes through which individuals learn. This study proceeded to note that an
important feature required in further courses is an emphasis on modeling for the
students the processes involved in the understanding of learning and of teaching science.

Pre-service educators have high expectations of the expert presentations and knowledge of their teachers and tend to emulate the methods of these instructors. Preservice teachers have indicated that the success of learners is centered on the teacher and that good teaching can overcome lower levels of a student’s science background (Cakiroglu, Cakiroglu, & Boone, 2005). The preservice educators will identify more readily than in-service educators the gap between current knowledge and the desired level of knowledge required to become a quality teacher. Though this latter study was conducted on general subject matter, the same is true with those in science content courses. The courses that combine methodology with content provide preservice educators with the opportunity to witness lesson planning, incorporating real world topics, utilization with varieties of methods and evaluations of self-learning (Jegede & Taplin, 2000).

In-service teachers often voice frustration with students’ lack of success. Though they may be presenting information in a timely, hands-on, minds-on manner, their students do not seem to understand or apply the knowledge imparted. Gallagher (2000) identified four possible contributors to students’ lack of success:

1. Students are not aware that tests require more than rote memory applications.
2. Students are not taught how to make sense of the information nor that they should make sense of the information.

3. Students are unable to make connections between new information and previous knowledge nor have they been taught to make these connections.

4. The class does not necessarily emphasize the application of knowledge, either in lessons or on tests.

Teaching for understanding is a technique that is desirable but is often overlooked in the race to gather positive feedback from formal testing. Students are often resistant to this method of teaching. High performing students are attracted to facts and fact recall (Gallagher, 2000). However, once taught how to understand and apply knowledge, students’ are more successful in further studies. This is particularly true for those pre-service elementary educators who feel that science is not comprehensible. As noted by Friedl and Koontz (2001), “We need to tell them how easy it is; and that they will be able to teach it effectively” (p. iii). Pre-service educators also need to understand that though the activity they create is not successful, they can still learn from their mistakes – just as grade school students can learn from their mistakes (Nagle, 2008). With the current trend in science education, instructors must evaluate and challenge the beliefs students hold (Bhuvaneswari, Greene, and DeBacker, 2005). McGinnis, et al (1996), identified that if pre-service educators participate in courses that do not include pedagogical issues in relation to content, then the pre-service educators’ needs are not being met. The ideal course, then, should encourage
students to investigate both pedagogy and content. Table 2 identifies findings of
previous studies designed to increase positive science attitudes, perceived self-
efficacy in science and perceived self-efficacy in science teaching. Yilmaz-Tuzun
(2008) identified that in pre-service educators that the understanding of a subject
and the enabling others to understand the subject are vital to learning and
teaching.

Table 2

Results of Related Studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th>Sample</th>
<th>Focus</th>
<th>Key Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleicher</td>
<td>2006</td>
<td>N = 70</td>
<td>Innovative techniques with novice science learners</td>
<td>Identification of innovative approach in university class setting for science teaching methods courses and self-efficacy</td>
</tr>
<tr>
<td>Cannon</td>
<td>1997</td>
<td>N = 64</td>
<td>Extended science practicum experience and self-efficacy</td>
<td>Increased personal science teaching efficacy beliefs when an extended practicum is used</td>
</tr>
<tr>
<td>Crowther &amp; Bonnstetter</td>
<td>1997</td>
<td>N = 6</td>
<td>Science experiences and attitudes</td>
<td>Positive correlation between science achievement and self-efficacy in science teaching</td>
</tr>
<tr>
<td>Johnston</td>
<td>2006</td>
<td>N = 436</td>
<td>Active learning</td>
<td>Increase in self-efficacy and attitude toward teaching science when learning is active</td>
</tr>
<tr>
<td>Ravindran, Greene &amp; DeBacker</td>
<td>2005</td>
<td>N = 101</td>
<td>Cognitive engagement &amp; epistemological beliefs</td>
<td>Goals and beliefs affect cognitive engagement</td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>N</td>
<td>Findings</td>
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<td>-------------------------------</td>
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<td>--------------------------------------------------------------------------</td>
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<tr>
<td>Rozendaal, Minnaert, &amp; Boekaerts</td>
<td>2005</td>
<td>N = 185</td>
<td>Teacher influence and student motivation</td>
<td></td>
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<td>Beliefs toward science and science teaching</td>
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<td>Achievement directly linked to self-efficacy</td>
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<td>Increase in science attitude and confidence in science when inquiry is used</td>
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<td>N = 166</td>
<td>Self-efficacy toward science teaching</td>
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CHAPTER III

METODOLOGY

The focus of this study was to identify the perceived self-efficacy of pre-service teachers in science and teaching science, as well as their attitude toward science and teaching science. As attitudes and perceived self-efficacy are evolutionary with experience, it was proposed that the developed laboratory curriculum will positively impact perceived self-efficacy and attitude toward science and teaching science. The students in this study participated in hands-on, self-regulated learning experiences that were directly connected to the 2010 Mississippi Science Framework (Appendix A) in a biology laboratory course. Factors responsible for any change were explored. In order to explore these, the study was broken down into more specific components to be examined. All the components were centered on the pre-service teachers’ perceptions of self.

1. Attitude toward science and teaching science (before and after completion of the laboratory section)

2. Perceived self-efficacy in science and teaching science (before and after completion of the laboratory section)

3. Possible types of changes in attitude and perceived self-efficacy experienced by those subjects with low perceived self-efficacy and negative attitude toward science and teaching science as compared to those with higher confidence levels.
4. Possible curricula or activity experiences /factors that might be responsible for any changes in attitude and perceived self-efficacy by the subjects.

This chapter describes the curriculum developed for the study, the qualitative design of the study and the processes of data collection and data analysis.

Curriculum

The curriculum developed for this case study was developed in correlation to the 2010 Mississippi Science Framework (Mississippi Department of Education, 2008) and the National Science Standards for kindergarten through grade 6 and consisted of ten lessons. Each session focused on an aspect of biology with application to the elementary classroom. Differentiated activities within the curriculum were hands-on learning opportunities with emphasis on cooperative learning. The individual sessions are listed and briefly described below. The curriculum developed for each session is found in Appendix B.

The students in the case study participated in the modified biology for non-science majors’ laboratory section, Biology Experiences for Elementary Education Majors, which parallels the traditional laboratory experience. Several techniques for improving the students’ perceived self-efficacy were used throughout the laboratory experience. Hands-on activities and group work were utilized in every class. In many cases, activities involved guided inquiry. Presentations of investigations were given and discussed. The laboratory
experience involved extensive modeling of a variety of teaching strategies found most beneficial to children.

*Simple Observation: Exploring Science*

In session I, students were asked to define the term observation. A discussion ensued on the differences between observing and inferring, allowing students to explore their ideas on each term. Students made observations using their senses as well as utilizing standard laboratory tools of scales, rulers and calculators. Activities in this laboratory session resulted in the development of qualitative and quantitative observations.

*I See You!! Exploring Microscopes*

As the microscope is one of the basic tools of biology, the students were led through an introductory activity that explained the structure and procedure for utilizing a microscope. Enrichment activities included the procedure for making wet mount slides of available materials.

*Tiny Rooms: Exploring Cells*

Knowledge gained in the previous session was applied in session III. After exploring the eukaryotic cell through manipulation of a model, students made slides of plant cells and animal cells. Basic slides of onion skin and human cheek cells were made by each student. Students then viewed slides made by others within the class, noting differences between the slides and discussing techniques utilized to make the slides.
**It’s Not Easy Being Green! Exploring Plants**

Plants are perhaps one of the easiest biology studies in the elementary classroom. Plants are readily available and easily manipulated for classroom experiments and observations. The activities in this session built upon student observations, utilizing prior knowledge as the basis of scaffolding and incorporating new knowledge. Activities included in this session encouraged students to make qualitative and quantitative observations of provided plants. Comparisons were made of leaf structure, leaf area to root area and root types. Additionally, the process of photosynthesis was explained and discussed. To explore pigments in plants, students first used food colors to explore chromatography, followed by an activity of leaf pigment chromatography.

**ID Me! Exploring Classification and Keys**

This session included making observations in application to dichotomous keys. Students began by sorting common items such as those that are part of a classroom (erasers, paperclips, coins, paper items, etc.). Working as a large group, students developed a classification method and justified their grouping device. A discussion on dichotomous keys ensued. Students were then given a basic plant key, developed by the researcher working with a botanist. The developed key was based on native plants and included winter and spring seasonal angiosperms and gymnosperms. Students used the key to identify provided plant specimen.
Spineless Wonders: Exploring Invertebrates

Invertebrate adaptations were the focus of the sixth session of the laboratory experience. Students explored the variations within the invertebrates’ adaptations and needs by 1) observing models (toys) of invertebrates, 2) observing preserved specimen of invertebrates, and 3) comparing the models and their preserved counterpart. To incorporate differentiated teaching methods, students utilized art skills to illustrate their idea of an invertebrate in a given scenario. Music was included in this session as students were assigned an invertebrate group about which they wrote a rap verse.

What’s My Home? Exploring Vertebrates and Their Habitats

Taxonomic grouping of vertebrates was the central theme of session VII. The taxonomic groups of kingdom, phylum, class, order, family, genus, and species were introduced through discussion. Students compared and contrasted adaptations of the phylum Chordata. Upon entry to the laboratory, each student had a picture of an animal clipped to the back of their shirts. By asking questions, students had to identify the animal they represented. The only prohibited question was to ask for the identity of the picture. Once the student successfully identified the animal, she used provided reference material to prepare a brief presentation of the animal and its habitat. Adaptations were further explored as students were given a description of an animal and then drew their impression of the animal. Bird adaptations were then the focus of the final activity in which each student was given a new habitat and had to develop a model of a new bird species based on the required adaptations.
Population Dynamics: Exploring the Ecosystem

Role play was the central activity of this session. Students became part of a simulated food chain in order to explore the interactions within an ecosystem. After discussing the passage of energy through a food chain, a bulletin board simulation of a food web was viewed, and students identified keystone species within a food web as well as the impact depletion of keystone species would have on the surrounding ecosystem. Further exploration of ecological relationships was conducted through use of beads and spoons, illustrating the predator/prey relationship. Graphing skills were incorporated into the final activity.

Who Is To Blame? Exploring Ethics in Science

Ethics is a difficult topic to introduce and explore in elementary education. Elementary students are constantly exploring and developing their own personal morals in relation to what they experience daily. Students of this study were asked to identify benefits and detriments of a science/societal issue. Each student was asked to respond and expound upon the ideas of others in reference to science advancements such as space travel and stem cell research. Activity two in this session was developed around the children’s book *The Lorax* by Dr. Seuss. Students were given a copy of the book to read individually. Students then identified the book character that they believed held the blame for the situation described in the book’s closure. Each student was then assigned a book character and developed an argument for why that character was not to blame in a mock trial. The session ended with a discussion of the hypoxic waters in the
Gulf of Mexico and the cause of the increasing size of this region known as the dead zone. Technology was incorporated into this unit via internet search for information on the hypoxic water area. The National Oceanic and Atmospheric Administration (NOAA) page National Ocean Service was used as the source of information for this discussion.

Outdoor Classroom: Exploring Nature

The final session of the modified biology laboratory course was held at a nearby water source within walking distance of the physical laboratory setting. Students were presented with the protocols for collecting basic field data, including temperature, pH, current, and depth and width of the water source, in a natural area. Students made qualitative and quantitative observations of the water source before collecting aquatic organisms which were then classified using a key. Students evaluated the water quality based on collected data.

Scientific terms were minimized in order to make the pre-service teachers more comfortable with the content. Once students showed mastery of a concept through discussion and responses to researcher questions science terms were introduced. The students then were encouraged to use the science terms in future discussions. The instructor modeled science explanations and demonstrated a low level of complexity in the topic presented. The emphasis of everyday materials, simple concepts and use of hands-on activities was maintained throughout the laboratory experience.
Nature of the Study

Qualitative methodology was most appropriate in this study to allow the subjects’ of the study to explain their thoughts on science and teaching science. As the results of this study were subjective to interpretation, this study was not designed to test prior theories or any hypothesis. Rather, this study was designed to explore and understand pre-service teachers’ construction of meaning and experiences in relation to phenomena. In order to do this, I relied on the students’ own words in questionnaires, reflections, observations, and interviews. The students’ words provided in-depth descriptive data for study. Quantitative instruments were not appropriate to the study as they limit understanding to scales with limited flexibility for understanding changes that may occur. Patton (1987) noted, “Qualitative methods permit the evaluator to study selected issues, cases, or events in depth and detail; the fact that data collection is not constrained by predetermined categories of analysis contributes to the depth and detail of qualitative data (p. 9).” According to Gay (1987), “The primary purpose of a case study is to determine the factors, and relationships among factors, that have resulted in the current behavior or status of the subject(s) of the study. In other words, the purpose of a case study is to determine why, not just what (p. 236).” This study connected student ideas concerning science and their ability to teach science with the biology laboratory curriculum.

With the limited number of students enrolled in this laboratory section, a qualitative case study was most appropriate. Each student involved in the study
was given opportunity to express their ideas and opinions through reflections, discussions and interviews. Categorization of the responses of students occurred after the data was collected and reviewed.

**Theoretical Framework: Grounded Theory**

Grounded theory was introduced by Glaser and Strauss (1967). The authors describe grounded theory as a qualitative method of inquiry that does not use statistical measures. Within a grounded theory study, data are gathered through interviews, conversations, observations, reflections and other sources. The data, once obtained, are coded in an effort to interpret the information gained. The emergent quality of grounded theory study does not test hypotheses; rather, it allows and encourages the researcher to explore theories that may be demonstrated within the research (Glaser 1998).

**Context of the Course**

The biology for non-science majors’ lecture and accompanying laboratory course was component of the pre-service elementary education program. The laboratory curriculum complemented the lecture objectives. The lecture plus the accompanying laboratory were taken for four semester hours, with the laboratory counting as one hour. The existing laboratory curriculum was developed by professors at the University of Southern Mississippi. Students in the case study laboratory participated in guided inquiry activities designed to assist students in understanding key concepts in biology. During each semester, sections of the laboratory were offered to students. Each section consisted of a maximum of twenty students. As the existing laboratory experience was designed to meet the
needs of all non-science majors, there was no direct connection between the laboratory activities and state/national science standards or science teaching standards. The opportunity for pre-service teachers to develop a sample lesson was also not included in the traditional course.

The laboratory curriculum developed for this study attempted to familiarize students with the existing state science framework and national science standards. As this was an introductory biology laboratory, the students were either freshman or sophomores with no or little collegiate science experience. The students had not yet been exposed to subject frameworks. Becoming familiar with the science frameworks early in their college career may promote a comfort level in the perspective teachers. This was interpreted in the case studies as an increase in perceived self-efficacy in teaching science.

The laboratory section was designed with a constructivist approach to education wherein the students built upon existing knowledge and developed content knowledge and pedagogical strategies through active participation. The interaction between students with the material presented was designed to increase comfort level of the students pertaining to science and teaching science. Interaction with activities designed with the 2010 Mississippi science framework allowed students to observe pedagogical methods utilized to promote student understanding.

In this laboratory design, the students were submersed in activities that are examples of how the science objectives may be taught. Group discussions were noted during each laboratory session and were interpreted as to possible
changes in attitude toward science and science teaching. Additionally, group discussions were monitored as students shared experiences they had in the past that had influenced their perceptions of science and teaching science.

Assessment of student learning was not be measured in the traditional format of paper and pencil quizzes during this laboratory. Instead, student learning was assessed through interactive procedures in which students developed products and explained their concepts of the lesson utilized. Assessments were on-going, keeping in line with the constructivist view on education. As the students explored the written laboratory assignment, they were encouraged to extend their thoughts on how the assignment may be further explored within the context of the elementary classroom. Additionally, students wrote reflections on the lesson in both a pre-laboratory exercise and a post-laboratory exercise. These reflections (pre-and post-) were read and interpreted to identify student understanding of the science concept utilized in the laboratory experience.

Research Design

This section describes the participants in the case study, data collection sources and techniques and data analysis methods. A case study format was utilized to allow for rich description of possible changes in each case as the laboratory proceeds throughout the term. Additionally, possible influential factors that may be responsible for the changes were explored.
Participants

The sample for this study included three students that were enrolled in an introductory biology for non-science major's course and laboratory. Two of these had declared majors of elementary education. The third had initially enrolled in elementary education but had changed her major to exercise science.

For this study, I was the instructor/researcher for one laboratory section that met once a week during the semester. This allowed me to have complete access to the students involved in the case study and the artifacts produced within the scope of the laboratory.

Approval to conduct this study was obtained through the Institutional Review Board. Participation in the study was voluntary, with full disclosure of the purpose of the study. Students who agreed to participate in the study were asked to sign a consent form which outlines the purpose of the study and its design. Additionally, the role of the student in context of the study was explained. Those students not wishing to participate had the option of completing an independent research project for credit. Students were assured that their participation in this study or their decision to not participate would not impact their grades.

Prior to registration for semester courses, a letter was sent to the School of Education at the University of Southern Mississippi, explaining the focus of this study. Additionally direct contact was made with the dean of that school to encourage advisors to generate interest in the proposed laboratory. A letter was be sent to the biological sciences laboratory coordinator to request a section of the BSC 101L be designated for this study.
Qualitative data was collected from students with reflections, questionnaires, group discussions, and interviews. The reflections were completed during the laboratory sessions and were used to ascertain knowledge development and student understanding of biological concepts. The group discussions and reflections also indicated student comfort levels with the topics covered within the laboratory experiences.

**Laboratory Structure**

Each session of the modified biological science laboratory section was conducted in the following manner:

1. Students reflected on prior knowledge of the session’s topic and completed open response items.
2. The instructor introduced the session topic and encouraged the sharing of student prior knowledge of the session topic.
3. Students worked as a group or individually to complete tasks given in the curriculum design.
4. Students participated in large group discussion in the application and adaptation of the tasks to elementary science classes.
5. Students identified competencies and objectives incorporated into the laboratory session within the 2010 Mississippi Science Framework.
6. Students reflected on developed information and identified the learning strategies utilized during the session.
Data Collection Methods

The use of a case study design required that multiple data sources be utilized in order to develop a deep understanding of the individual participants. Though this study consisted of a qualitative data sources, one quantitative measurement was included (See Appendix D). This measurement was used strictly as an indicator of student confidence and attitude in science and science teaching. This instrument was administered the first laboratory meeting and the final laboratory meeting.

The instruments, with the exception of the reflections that were utilized within this study and the interviews, were administered via an online website that was password-protected. The password for the site was distributed to the students of this case study at the first meeting of the laboratory section. Using internet connection to the website, the researcher demonstrated access to the website and distributed written instructions to facilitate subject access to the desired survey and interview pages. Students were given a deadline for completing of the pre- survey and pre-questionnaire.

Formal survey. The Science Teaching Efficacy Belief Instrument (STEBI-B) developed by Enochs and Riggs (1990) was the instrument used for the pre- and post-survey to measure the science teaching efficacy of pre-service elementary teachers (See Appendix C). This 23-item, Likert-type instrument was composed of two scales: the Personal Science Teaching Efficacy Belief Expectancy Scales (PSTEB) and the Science Teaching Outcome Expectancy Scale (STOE). Both the PSTEB and the STOE were quantitative measures. The
PSTEB measured efficacy expectations; the STOE measured response-outcome expectancy. The 13 items of the PSTEB questioned subjects about their perceived ability to understand the diverse methods of teaching science, ability to improve as a teacher of science, to understand concepts of science, to explain concepts of science and ability to implement experiments in science. The 10 item STOE questioned subjects' beliefs on their perceived effectiveness of science teaching on students' grades, achievements and interests in science. Each item in the survey was rated by subjects. The rating scale was composed of five choices: strongly agree, agree, uncertain, disagree and strongly disagree. Items were worded either positively or negatively. Each item is scored 5, 4, 3, 2, or 1, in which 5 was the most positive response and 1 was the most negative response.

Enochs and Riggs (1990) conducted a reliability analysis in which the PSTEB produced an alpha coefficient of 0.9 and a STOE coefficient of 0.76. The STEBI-B has been utilized in studies with recurring reliability (El-Deghaidy, 2006; Bleicher, 2004; Ginn et al, 1995).

With permission of Dr. Larry Enochs (Appendix D), the STEBI-B was adapted to an on-line survey that students in the case study completed at the beginning of the first laboratory session (pre-survey). It was administered again during the final laboratory session (post-survey). As this was a case study, the results of the STEBI-B were used as a descriptive measure of any change in student perceived self-efficacy in science and science teaching.

Students of the case study accessed this on-line survey at the beginning of the laboratory session to identify their perceived self-efficacy toward science and
teaching science. As students with perceived low self-efficacy in science and science teaching were of primary importance in this study, a separate analysis of the STEBI-B was used to identify those subjects who were initially negative in their attitude toward science and teaching science. One measure of the effectiveness of this laboratory section was that the negative beliefs / perceived low self-efficacy would be changed to positive beliefs / perceived higher self-efficacy. It was important to analyze both group results and individual results to investigate the impact of the modified laboratory section. A score of three represented a neutral response for an item. As the PSTEB has 13 items, a score of 39 will represent a neutral mark. Scores with one or more standard deviation below 39 represented a negative mark. Scores with standard deviation above 39 represented a positive mark. A higher score would be preferable in a science classroom. An 86% efficacious science teacher would score 56.28. With the limited amount of time spent on elementary science, a teacher scoring 86% would be an attribute, not a hindrance (Cannon, 1997). During the final laboratory session, students completed a post-survey online. Survey results were matched according to anonymous identifiers and compared to identify changes in perceived self-efficacy toward science and teaching science due to participation in the laboratory section.

*Online questionnaires.* Students in this case study were asked to complete a pre/post online questionnaires (Appendix E). Subjects used their anonymous identifiers to log onto a survey website to complete the questionnaire. The questionnaire combined the approach of Merriam (1998) and Zeldin, Britner, and
Pajares (2008) by beginning with a question designed to collect demographic information and was followed by open-ended questions. The open-ended protocol allowed students to compose unique narratives regarding science and their personal experiences. Questionnaire results were matched according to anonymous identifiers and compared to identify changes in attitude due to participation in the laboratory section. Responses of students were compared to identify changes in students’ attitudes toward science and teaching science.

**Student reflections.** Reflections were handwritten by the students in the case study and had two sections: advance and follow-up. The advance section was entitled “Before We Begin,” and the follow-up section was entitled “Bringing It Home” (Appendix F). In the method of SRL, students of this case study identified personal goals of each laboratory activity presented prior to the class meeting and their comfort level with learning the new information. It was essential that this advance section be completed before beginning the activity in order for the subjects to compare their personal goals and comfort levels before and after the activities. The follow-up section of the reflection included the presentation methodology, feedback on the effectiveness of the activities, interpretation of their own perceived learning, and examples of changes they might make as a classroom teacher in order to more effectively present the activities.

Responses to open items of each reflection were analyzed and coded with a combination of objectivist and heuristic codes. Perceived self-efficacy indicators of subject’s ability in science were noted through use of terms. A statement given as a fact in the introductory reflection indicated positive self-
efficacy in understanding science. A statement given hesitantly (I know little or I think) indicated lower positive self-efficacy in understanding science. A statement with negative wordage (“I know nothing…..”) indicated negative self-efficacy in science. Student responses are noted within the analysis of each session.

Observations. During and after each session of the laboratory, observation notes were made by the researcher. These observations chronicled activities utilized within the laboratory experiences, problems that arose, incidental events that impacted the activities, student interactions, perceived changes in student attitude and opinion and so on.

Interviews. Follow up interviews were conducted two semesters after the conclusion of the laboratory experience. The interview probed changes in student attitude and perceived self-efficacy in science and in teaching science. The interview design was semi-structured and followed interview protocol (Appendix G). The time and location of interview was determined by the students to ensure their comfort to talk freely and to allow them to express their points of view. All interviews were digitally recorded and transcribed.

Artifacts. Student artifacts were developed within the scope of the laboratory. These artifacts, such as reflections, drawings, lesson plans, activity products and other assignments were collected throughout the term. These artifacts were not used solely for the purpose of the research. The intent of the artifact development was to allow student to develop and express their understanding of the concepts covered within the laboratory.
Data Analysis

The STEBI-B was examined strictly to identify the changes in student self-efficacy and attitude (pre & post). The information gathered through this instrument was used descriptively within each case.

Qualitative instruments were analyzed to identify repetition in words, phrases and patterns of speech that indicated student confidence and attitude in science and in teaching science. The multiple forms of qualitative instrumentation allowed for a rich description for each student and allowed interpretation of any emergent themes. Independent analysis of individual students was conducted to evaluate possible changes in attitude and perceived self-efficacy in each. Additionally, comparative evaluation between students identified specific activities that may have impacted student opinion of science and in teaching science. The process of analyzing qualitative data involved several cycles of reading and coding student artifacts in order to identify patterns. Upon identification of possible themes within the case study, cross analysis between the individual students was conducted to determine similarities and differences between the students. Students participating in this study were encouraged to review transcripts of the interviews and the individual case analyses to ensure accuracy. Students were encouraged to provide comments, corrections and additional responses to the information provided.
CHAPTER IV

ANALYSIS OF DATA

This chapter presents the individual students involved in this study. Each student's reactions and responses were explored to determine the impact of the curriculum developed for this study. Each student is referred to by an anonymous identifier. The students completed the pre-STEBI-B as an assignment in the first laboratory session, thus allowing the researcher to determine their attitude and perceived self-efficacy toward science and teaching science. The post-STEBI-B was assigned during the final laboratory session. Comparison of pre- and post-STEBI-B allowed the researcher to identify any changes in their attitude and perceived self-efficacy for descriptive purposes. The PSTE score is indicative of self-efficacy in teaching science among the students. The PSTE consisted of 13 items which students responded to on a scale of 1–5, with 1 being the lowest and 5 the highest. The highest score possible on this part of the STEBI-B was 65. A score of 39 (56.5%) would indicate moderately low self-efficacy. A desired score would be 52 (80%) or higher for a science teacher. Table 3 identifies the PSTE raw scores of students prior to and after participating in the laboratory section.
Table 3

*Changes in Student PSTE Scores*

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<th>Raw PSTE Scores</th>
<th>Change</th>
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<tr>
<td>Carrie</td>
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</table>

Note: Raw gain is the difference between scores: + indicates increased perceived self-efficacy, - indicates decreased perceived self-efficacy. * indicates the student did not complete the post survey.

Jane’s results show an increase of 3 raw score points in her perceived self-efficacy, taking her from 70.8% to 75.4%. Annette’s results also show an increase in perceived self-efficacy. Annette’s increase of +1 point take her from 66.1% to 68.0% in perceived self-efficacy. As Carrie did not submit a post survey there is no determined change in Carrie’s perceived self-efficacy.

The STOE score is indicative of their attitude toward teaching science. The 10 items of the STOE were scored in the manner of the PSTE items. The highest possible score on this part of the STEBI-B was 50. The score of an efficacious teacher would be 40 (80%) or higher. A score of 30 (50%) indicates moderately low attitude toward teaching science. Table 4 identifies the STOE raw scores prior to and after participating in the laboratory section.
Table 4

*Changes in Student STOE Scores*

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<th>Student</th>
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<th>Change</th>
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<tr>
<td>Annette</td>
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<td>36</td>
</tr>
<tr>
<td>Carrie</td>
<td>28</td>
<td>*</td>
</tr>
</tbody>
</table>

Note: Raw Gain is the difference between scores: + indicates an increase in attitude toward teaching science, - indicates a decrease in attitude toward teaching science. * indicates student did not submit a post survey.

Jane showed no change in her attitude toward teaching science after the course. Her result of 65% remained consistent in pre and post survey. Annette had an increase of +1 in her attitude toward teaching science, going from 70.0% to 72.0%. As Carrie did not submit a post survey there is no determined change in Carrie’s attitude toward teaching science.

A description of the individual’s pre- and post- attitudes toward science and teaching science, as well as their perceived self-efficacy in science and teaching science is presented based on their responses to qualitative measures and one formal survey, the STEBI-B. The results of both qualitative and the STEBI-B were triangulated to personify each case. Conclusion of this chapter describes a comparison of individual cases involved in this study.
Jane

Jane was a freshman in the elementary education program at the University of Southern Mississippi. At the time of the study she was between the ages of 17 – 19. She identified a desire to be a teacher in special education. She was the younger of the three students involved in the study. Jane registered for this study after a meeting with her advisor in the University’s education program. When asked her reasons for majoring in education she replied,

Well, I’ve always done well with children and teaching them. Ever since I was little, teaching children my age in the neighborhood. I just love kids. I’m drawn to them and drawn to teaching. I teach everything I can.

As with many pre-service teachers, Jane was idealistic in her views of herself as a teacher.

I would like a smaller class because I want to be able to pay attention to every student, not stress about (pause) like trying to get to know them all and all their individual needs because I want to meet every single one of their needs.

She saw her future classroom as activity oriented, with corners dedicated to different subjects. She preferred lower elementary students as they have energy. Jane saw her role in teaching as a story teller, able to reiterate information with emphasis on little known facts, as she referred to them. It is through these little known facts that she would tease her students into becoming self-regulated learners, stirring their interest in a subject so that they would go further on their own. Her desire to teach was clearly evident.
Attitude toward science.

Jane saw science in two ways: play science and technical science. Prior to this laboratory section, she could recall few science experiences. She remembered activities which she described as fun. The fact that she referred to these as play indicated that the activities made no true connection to science for her. Jane showed a lack of confidence in herself when it came to technical science. She stated that she wasn’t good with structure stuff. She viewed math in a similar manner. She was unable to recall science in first through sixth grades.

In grades seven through eight, the science classes, for her,

were very technical. We didn’t do a lot of it. Just words, like vocabulary.

When asked what her opinion of science was before the laboratory section, she replied,

A little scared of it. I was really afraid to take it [biology] here, especially in the college setting, because I don’t know how to do it, like…what I can’t remember. When I did have experience with it, I can’t remember. A little worried that I wasn’t going to know enough. My high school stuff wasn’t that great. I was just worried. A little worried….A little scared of it.

In her pre-questionnaire, Jane responded to an item concerning her ability in science as seen by others with

To be completely honest, not very good things. In high school, I received a D on my report card. I did, however, pass the course
and the SATP (subject area testing program) exam. I haven’t had a lot of experiences with science, so my record is spotty.

In contrast, Jane initially found science intriguing and expressed excitement to learn technical science as she expressed in the first session reflection. She was eager to learn how to start an experiment. Her lack of experience with science tools such as the microscope and balance made her hesitant to touch these instruments at first. Within the laboratory activity she was introduced to the microscope and learned how to use it. She worked independently to master making wet mount slides. At the end of the session she noted in both oral and written form a desire for more time to explore with the microscope and balance. Jane’s enthusiasm to extend her skills was interpreted as a positive change in attitude toward science.

For each laboratory session, Jane began her reflections by answering the open-ended item, what I knew about this topic before beginning this activity…. A common theme throughout her responses was that she knew a bit. She consistently indicated that she was comfortable with learning the information presented and enjoyed working the activities. She noted in the pre-questionnaire, I am very confident on my ability to complete a science course. I am not saying that it is going to be easy, but I will work hard enough to make it happen.

In her post questionnaire, Jane stated that she felt that, as long as she was motivated she could succeed in science. In this statement, Jane had
identified that she was aware of her need to be self-motivated. This was indicative of self-regulated learning, the identification of motivation in learning.

When asked in the post interview if the modified laboratory section altered her opinion of biology she responded,

I’m a lot more confident with it [biology]…. Like, I learned my confidence in how I can teach and how I can learn science. But also how to teach and how I learned. Because I didn’t know anything when I came in.

*Attitude toward teaching science.*

When presented with the scenario of having been hired to teach reading then placed as a science teacher just prior to the beginning of a school year, Jane indicated that she would be disappointed but willing to attempt teaching science.

I would try my best to do...to get knowledgeable as much as I can on how to teach it specifically....

While this statement is not describing a negative attitude toward teaching science, it does indicate that her lack of familiarity with the subject makes her reticent to teach science. She believed that she would teach science if no other option was available and would dedicate time and effort to develop lessons. After participating in the modified laboratory section Jane was more confident in her ability to teach science. She identified activities incorporated into the lab that she was found exciting that would be included within her lessons. The earlier
described scenario was presented to Jane a second time, with the amendment of post laboratory experience. She responded,

Yes. Because of a lot of what we did. I would probably use all that.

With her laboratory experiences Jane had developed a more positive attitude towards teaching science.

*Perceived self-efficacy in science.*

In her earlier statement, Jane repeated the term worry in reference to her success in science. This was indicative of a low perceived self-efficacy in science. Her lack of confidence was evident in her hesitations in the laboratory sections and in interviews and conversations. My observations within the sessions noted that Jane would allow others to speak first, following up on their initial statements with her own ideas.

Though she was an active participant in all activities, Jane’s confidence in her ability to do science made her reticent at first. However, as the semester progressed, Jane became more vocal in her questions and statements. This indicated that her comfort within the setting and the material presented was increasing. The fifth session of the laboratory covered the topic of classification and utilization of dichotomous keys. Jane had no prior understanding of this topic. Her comfort level was not indicated on her reflection. This was interpreted as lack of comfort. In response to the question of prior knowledge, she wrote

I don’t know!

At the closure of the laboratory session, Jane demonstrated an ease in using a dichotomous key. She noted that she learned through participation with
the key, not simply having it shown to her. She found the session fairly easy and suggested changes to utilize the activities more effectively with elementary students. With a successful conclusion to the session, Jane demonstrated an increase in her perceived self-efficacy in science. The confidence she developed led her to explore options she here-to-fore had not considered. She found the session fun.

Jane retained the beginning skills of classification and applied them to the session on invertebrate animals. When she saw the preserved specimens as she entered the laboratory, Jane asked,

Are we classifying again? I really liked that!

Within constructivism the application of learned knowledge was indicative of scaffolding.

_Perceived self-efficacy in teaching science._

Jane indicated in interview that she would be hesitant to teach science. Her perceived self-efficacy as a teacher of science was initially low. As noted in Table 3, Jane’s initial score on the PSTE was 46. A score of 52 would demonstrate a moderate perceived self-efficacy in teaching science. When asked why she was hesitant to teach science, she stated,

There’s so much that I don’t know, and I can’t figure out. They [students] would ask questions, you know, big, broad, general questions, that even I don’t know the answer to, and I wouldn’t feel right, like, not knowing. And so I’d get all tongue-twisted and confused, lose my credibility as a teacher who knows everything.
Jane identified the idea that the teacher must know everything in order to be effective as noted in items 1, 4, 9, 11, 13, and 16 of the pre STEBI-B. This indication of teaching style is teacher-centered. She noted in pre STEBI-B survey that it is through teacher effort that students succeed in science. Jane felt that she would not be an effective teacher due to her lack of content knowledge and process skills (items 5, 14, 23, and 25.)

As a freshman in the education program, Jane had little exposure to the Mississippi science framework. She recalled seeing TSW 3.a in high school science classes but had no connection to what this actually meant. The student will is a frequent beginning to objectives listed on boards within all classrooms. However, most students do not understand the meaning of the numbers and letters that follow. Within this modified laboratory, students were exposed to the current science framework for Mississippi. Jane was asked to identify in multiple grade levels competencies/objectives that were met through the guided-inquiry lessons. She was able to identify these and noted that the competencies/objectives flowed from year to year so that there was cohesion within the framework.

*Participation in Course*

Jane had negative self-efficacy at the beginning of session I, I See You!! Exploring Microscopes. In response to the opening item she wrote, I know little about science to begin with. She made no attempt to define the term observation. She indicated in item three a willingness to learn biology.
I am excited about learning about biology!

This indicated that her attitude toward science is positive and that though she had little prior exposure to methodology, she would enjoy participating in laboratories. In the closing reflection, Jane demonstrated a better understanding of observational procedures.

…in order to conduct or create an experiment, one must be very specific!

In the opening reflection of session II, Jane wrote,

I know very little about using the equipment, but I do know a few facts.

This statement indicated a lack of use in prior science courses. Jane noted that she believed she would learn how to use microscopes safely. This is an indication of self-regulated learning in that she established a learning goal. Her comfort level with the focal topic was high in that she saw the use of the microscope as fun. This indicated that her learning style is bodily-kinesthetic.

In the follow up reflection, Jane illustrated further self-regulated learning in detailing how she gained new knowledge of microscopes. The methodology of identifying microscope parts, manipulating the parts and then application increased her skills. Her increased confidence indicates a positive increase in perceived self-efficacy. She also commented that all members of the case study participated equally, assisting each other throughout the session. She identified that she felt she learned more through group interactions.
In session II (Tiny Rooms: Exploring Cells), Jane had prior knowledge of cells, though her confidence has not high.

I know a bit about cells from my biology class in 9th grade, but I could use a good refreshing!

This statement indicates a self-awareness of her needs. She detailed her goals for this session as how to identify cells and structures inside cells.

Jane identified application of prior knowledge as key to her success in mastering new information.

We delve deeper into learning about how to use the microscopes and also about cells themselves.

In this statement she shows application of scaffolding, the building of knowledge and skills upon previously learned knowledge and skills.

My greatest challenge was preparing the cells. I was still a little rocky with the microscope, however I did learn!

Jane demonstrated an interest in plants at the beginning of the fourth laboratory session. This interest promoted her willingness to advance her knowledge. She stated in response to the open-ended statement, I (am/am not) comfortable with this topic because…., that plants are cool and interesting!

However, when asked about prior knowledge she could only recall the term photosynthesis and gave generalizations as to how plants grow. During the activities Jane commented on learning by doing, recognizing this as the method
by which she best learned. This enthusiasm was carried throughout the activities. Her initial goal was to learn about plants. Jane ended her reflection with,

   Chromatography! Wow! ALL NEW LEARNING [sic]!

   The capitalization of the final three words indicated an excitement in the topic, which was interpreted as a positive attitude toward science. It also was indicative of the identification of processes yet unknown and a willingness to search for new information.

   Jane’s confidence in session V grew. Jane implied negative self-efficacy in this topic in her response to the first reflection item,

   I don’t know.

She set no goals for this activity and did not respond to the item about comfort level. The lack of response reflects a negative self-efficacy and a negative attitude to the topic.

   After completing activities of this session Jane identified again that she successfully learns through participation of hands-on activities and group interaction. This was a reflection of self-regulated learning in that she knew her best learning strategy and capitalized on it. In the final reflection for the session, students were asked to identify what would make the activity better. Jane responded,

   Maybe more diversity? Flowers? Insects?

She referenced her statement to dichotomous key use. This indicates that Jane had learned how to use a dichotomous key and had confidence in using a variety of taxonomic keys in the future.
The subject of macro-invertebrates was the focus of laboratory session VI. Jane indicated that she had minimal knowledge of the topic. Her goal of the session was to learn different aspects of invertebrates and how to identify the invertebrates. When asked about her comfort level with invertebrates, Jane responded,

They’re awesome.

In this statement Jane indicated a positive interest in biology.

Through the activities Jane applied observation skills. The incorporation of an art component allowed her the self-expression needed to develop and express her ideas about macro-invertebrates. Within the activities Jane was able to evaluate her own understanding and identify the steps she needed to learn more. She acknowledged that the activities did present a challenge to her.

Session VII was designed to explore animal adaptations and their habitats. Jane identified limited knowledge in the focus of this session. She identified that

vertebrates have a spine. Adaptation —→ survival technique.

Her goal was to learn specific adaptations for vertebrates. Jane enjoyed the use of crafts in the activities, which complimented her preferred learning style. She recognized that she had fun in the activities and that they were not boring. This positive view of science indicated a positive attitude toward science.

At the beginning of Session IX, Jane was able to define the term ethics but could not directly connect ethics to science. Jane was aware of some science and society issues but was not able to elaborate upon them when asked. Her
goal for this topic was to learn the rights/wrongs of science. In the reading and discussion activity Jane was an active participant, debating the issue presented by the book and enjoying the debate of identifying the culprit of the story. At the closure of the laboratory session Jane was able to express a deeper understanding of ethics in science.

Jane was hesitant to participate in the final session in which the participants visited a local water source to determine water quality. Jane had some prior knowledge about water quality before beginning the activities. She discussed pH and contaminants in the water are physical indicators of water quality before the students visited the water source. Jane learned through the completely hands-on method utilized in the session. Though she believed she was well versed in the topic, Jane recognized during the activities what more she needed to learn and eagerly participated. She became enthusiastic about data collection and was so enthralled with collecting macro-invertebrates that she fell onto the muddy embankment in order to capture macro-invertebrates. The laughter she shared with other students demonstrated the cohesive learning group that had developed during the course.

Responses to Pre and Post Questionnaire

As part of the requirements of this study, Jane responded to a pre and post questionnaire which consisted of questions that allowed her to express her ideas. The first three questions/items of the questionnaire gathered demographic information. Jane’s responses to the remaining questions/items are transcribed in this section.
Question: Have you ever learned from others? If so, give an example of how you did learn from others.

Pre-study response: I learn from others constantly! The prime example is a teacher-student relationship! A professor who has specific and deep knowledge on a subject, like biology and i [sic] use their lectures and activities to make the knowledge mine as well.

Post-study response: i Definitely [sic] have learned from others, i [sic] practically do everyday! in the most classic situation, ill [sic] say the teacher student relationship. I learned a lot from this biology lab. Ms. Betsy would teach me something about Bird Adaptations and i [sic] would learn from her, and then go teach others myself.

Jane’s responses indicated that she views the teacher as the holder of all knowledge. She did not make a connection that she may learn from other students in the course. The inclusion of a specific example of learned knowledge that she later share with peers is indicative of understanding a biology concept that she had not previously noted.

Question: What has been said to you or about you regarding your work in a science course?

Pre-study response: To be completely honest, not very good things, in high school, i [sic] recieved [sic] a D on my report card. I did, however, pass the course and the SATP exam. I havent [sic] had a lot [sic] of experiences with science, so my record is spotty.
Post-study response: I do not exactly know if there has been a lot said about me regarding science courses, but I am assuming if something has been said, it has not been very good. Except for, I think, in this biology lab, I think I excelled wonderfully, in which good things would have been said about me and my science course.

Jane’s admission of being a poor biology student affirmed her lack of confidence in her ability to understand biology and to successfully complete biology activities that demonstrated her knowledge. Within this study she was exposed to diversified teaching methods that allowed her to explore biology within her comfort zone. The result, as Jane saw it, was that she had improved her knowledge in biology and obtained a higher level of confidence. In this new confidence level Jane’s attitude toward biology had changed to a more positive outlook.

Question: What is your opinion of your ability to successfully complete a science course?

Pre-study response: I am very confident on my ability to complete a science course, I am not saying that it is going to be easy, but I will work hard enough to make it happen!

Post-study response: I think as long as I am motivated to do so I can do so.

Jane had confidence that she would become proficient in a subject if she dedicated time to study and practice. She was willing to put effort into her studies in order to succeed. In the post-study response to this question she noted that
she has to be motivated. It is implied that she seeks motivation externally rather than internally. In this she had not reached the level of a self-regulated learner.

Question/item: Relate a memorable story about an experience you have had in science.

Pre-study response: In 9th grade, we dissected [sic] starfish, which i [sic] found very interesting and fun!

Post-study response: Well, most recently i [sic] will talk about when i [sic] taught my biology lab. I had a lot of fun planning the lab and organizing what exactly i [sic] wanted to do for it. I decided on taste, and found a lesson online that was perfect to teach! i [sic] had a lot of fun planning and actually teaching it!

Jane’s memory of dissection indicated that she found hands-on laboratory activities most beneficial, though she only noted the one activity. Again, she remarked that she found this activity very interesting and fun. As a bodily-kinesthetic learner Jane required active participation in order to recognize and retain new knowledge. Jane’s lesson she developed as part of this study was a unit of the sense of taste. Her brief lecture on the sense of taste was accompanied with visual aids and a laboratory activity. The activity allowed the other students and myself to explore our sense of taste. Jane found that the lesson was enjoyable and discovered a motivation to learn through developing a lesson to present.

Question: What will be your area of expertise when you are a practicing teacher? (i.e., reading, language arts, mathematics, science, social studies, art, music)
Pre-study response: Right now my endorsement will be history, but if my science courses go well, i [sic] am considering science as well!

Post-study response: i [sic] think special ed will be my area of expertise. I do not think that double majors get an endorsement, but if that changes i [sic] would like to focus in social studies!

Jane as a freshman in the teacher education program had selected elementary education/special education as her major. Her selection of social studies/history as her primary focus gives her a collegiate learning course to follow. Initially she noted that she would consider science as an optional focus. However her post-study response showed that she no longer considered science as an option.

Question/item: Complete the following statement. Please elaborate your answer.

Science is….

Pre-study response: intrging [sic]! i [sic] do not know much about science, but I am very excited to learn and experiment with it!

Post-study response: Science is fun. As long as it is taught right. I have had some terrible biology teachers who do not make the subject remotely interesting. A little effort could spark some sort of interest. However, if a teacher is excited about teaching their subject, they put alot [sic] of effort into their lessons, and the students get more out of it.

Jane’s admission of having limited science knowledge indicated a low perceived self-efficacy in science. She needed external motivation in order to learn biology and did not believe that her previous biology teachers and given her
that motivation. Within this study Jane fed from the enthusiasm of the teacher and developed an interest that would motivate her to continue studying biology.

Question/item: Complete the following statement. Please elaborate your answer.

I would/would not (choose your response) teach science because….”

Pre-study response: “I would teach science because i [sic] think students can benefit from it early in life, and the experiments could be fun and also mentally stimulating!

Post-study response: I would teach science because there is alot [sic] to be learned from it. Our past, our future and our present. We can learn where we came from, currently there are moral issues we could discuss and also some aspects of our future can be determined from it as well! Plus, as i [sic] learned in this lab, there are simple and fun ways of teaching it that will make the students learn and they wouldn’t [sic] even realize it!

Jane developed a better understanding of teaching methods through this study. Though she state that she would teach science in her pre-study response, Jane only saw science as a fun activity. She noted that science would be stimulating implying the need to use critical thinking skills. In her post-study response Jane recognized the impact of science on society.

Annette

As a freshman in the university, Annette was beginning her studies in elementary education. At the time of this study, Annette was between the ages of 17 – 19. Annette’s focus in education was mathematics. She felt secure in her
understanding of the subject and displayed a confidence when discussing teaching mathematics.

I think math because I really enjoy math, and I’m really good at math. And I think I have the right view on math for children, because to me it [mathematics] is like a puzzle. And if I address the children that way, like it is a puzzle, maybe it will be easier for them to learn.

Her confidence was seen as positive attitude and high perceived self-efficacy in mathematics and teaching mathematics. Annette was aware of the different learning styles of children and sees her future as being an innovative, activity-oriented teacher. She implied in post interview that she was predestined to be a teacher.

I taught my brother how to read....Ever since then I realized how well [sic] I am at teaching and how I can make a connection with every child I’ve met, even a problem child.

In listening to another question where she was to image herself as a teacher, Annette interjected enthusiastically,

Everyday.

Annette taught Sunday school classes for her church, which she described as very small. She had the responsibility for teaching all children that came. The children’s ages ranged from preschool to upper elementary. Annette described how she had to be able to adjust her lesson based on the majority of the children attending. Based on her limited experiences, she had difficulty identifying a
preferred grade level to teach. Annette found positive and negative reasons for
teaching all elementary ages. She was emphatic about not teaching middle
school grades.

In elementary school Annette enjoyed the loose structure found in art. She
found that she could express herself through art. She enjoyed the “mess” she
could make in art. However, as a future teacher she preferred structure within the
classroom. She, as with many pre-service teachers, saw her future self as an
adult figure that will be a friend to the student.

I want to be able to connect with each child individually.... Because
a lot of teachers.... They don't take into consideration that everyone
learns differently. So I want to make a connection with each
individual child so that I can know what I have to do to reach every
child instead of just teaching one way and hoping that it works for
everybody.

In order to make this connection, Annette described an interactive classroom that
would make her students enthusiastic about learning. Her future classroom
would be colorful and organized.

So, when kids walk in, they're not like, ‘Aw, school.’ They're like,
‘Aw, this looks like fun!’

When asked to elaborate on her reason for not choosing art as her focus in
education, Annette explained that art teachers, along with physical education and
music teachers, do not see the students regularly enough to establish interaction
with the students. She wanted to teach the same students daily because she believed she could make the greater impact on the students that way.

Annette was aware of difficulties in education. She had family members that were teachers. She had listened to them and thought through their question, Are you sure you want to do this? Annette expected to have problems in establishing herself as a teacher in her future classroom. She was aware that there were administrative duties and paperwork which will occupy most of her leisure time. Yet Annette still refers back to making a positive connection with her future students.

But, at the end of the day, I know that no matter how tough it is with all the rules, all the craziness of the principal and all that, that if I can teach a child something, I'll be happy.

*Attitude toward science.*

Initially Annette felt that she could do science if she put her mind to it. Annette implied in the questionnaire and in the interview that science did not interest her. She could recall only one teacher in elementary school that incorporated science into lessons. Later experiences in high school did not instill in her an enthusiasm for science. While her attitude toward science was not interpreted as negative, it was not positive either. She often noted a lack of variety within lessons. Science was seen by Annette as rote memory with definitions and reading as the basis of the lessons.

As she became immersed in the laboratory activities, Annette became increasingly enthusiastic about biology. She often noted her part in the activities
was to help others understand the concepts being explored. Annette contributed eagerly to discussions by asking clarifying questions and noting examples from everyday life. Kinesthetic involvement was identified as a reason for her increased interest in biology.

Annette was able to develop a concept and explore beyond the activity, as demonstrated in the plant activity. She identified the xylem and phloem in a celery stalk and contributed by cutting out a phloem for fun, then everyone was doing it to see how it looked.

She made notes to find more information on the vascular system of plants. This indicated a high self-regulated learning situation. She applied critical thinking skills to situations which did not turn out as she expected in order to understand the outcome. She adapted to fluid situations and developed content knowledge.

Science is everywhere we go, and everywhere we don’t. This statement indicated Annette developed a positive attitude toward science.

**Attitude toward teaching science.**

Annette was presented the scenario where she was initially hired to teach mathematics, but due to unforeseen events, she was placed as a science teacher. Prior to the laboratory experience, Annette stated that

I would probably have been very, very nervous.... I honestly didn’t see how you could make it [science] something enjoyable for little kids.

This demonstrated a negative attitude toward teaching science. Annette felt unprepared for the possibility, though she also noted that …
if I have to, I have to.

Her hand movements when discussing this scenario were erratic, showing a lack of confidence in her ability to teach the subject. Prior to participation in this study, Annette rated a 35 (70%) on the STEBI-B STOE component questions. While this was not considered negative, it fell below the desired 40 (80%) in science teachers. Post survey results indicated that Annette’s attitude toward teaching science had increased slightly, 36 (72%).

The post study interview with Annette indicated a change from negative attitude toward teaching science to a more positive attitude. When presented again with the scenario of being asked if she could teach science, Annette replied,

I’d say I can, definitely can, because I was taught a new approach to it.

She identified that the modified laboratory section made teaching science a possibility, though still not her first choice in subject areas.

*Perceived self-efficacy in science.*

Throughout the laboratory experience, Annette indicated through reflected writing a negative to neutral self-efficacy in science. Frequently she noted that she knew not a very broad amount or very basic knowledge. She was comfortable with learning new information. Indeed she continually demonstrated an enthusiasm for learning more about the topics included in the laboratory activities. Annette did not doubt that she could successfully complete any science course as long as she had the right teacher and the right approach. She
described her past experiences with science in grade school as mostly mundane and not very appealing.

After completion of the laboratory experience, Annette had developed a confidence in science that she had lacked previously.

I felt like it [science] was easier to understand, because of the way I think. I think like a child. It also came across as more fun with the games we were able to work into it and being ... I mean you really can’t do that with English...maybe math, making it tolerable, but there’s.... It kind of made me realize that science is much more broad than like math or English or social studies.

The activities in which she participated increased Annette’s comfort level. Where she found science intimidating initially, she now found it enjoyable and interesting. This marks a positive change in perceived self-efficacy in science. Annette indicated high self-regulated learning with her final statement in the questionnaire,

so while I’m teaching the students, I will also be teaching myself.

She believed that she could understand the science content knowledge required to teach elementary students.

*Perceived self-efficacy in teaching science.*

Initially, Annette did not consider teaching science and implied that she would not be successful in teaching science. Her responses on the STEBI-B PSTE indicated a negative self-efficacy in teaching science, rating a 43 (66%). A preferred score was 52 (80%). This stemmed from a lack of confidence in her
ability in science. Annette described her exposure to science in elementary grades as limited. She discussed in detail one elementary teacher that Annette described as a science freak.

I had the same teacher in my fourth grade year and my fifth grade year. Something new they tried, keeping the teacher with you. And she was a science freak. She loved it. And we had the outdoor classroom where we planted gardens and there was like a little pond that we had fish in and ....We did experiments with like batteries and stuff, like we made our little lamps and things, because she worked it herself. Like, it wasn’t a science class that I remember. She just worked it into the lesson. Kind of like you said to do.

Annette obviously admired this teacher, given the enthusiasm within her voice and her hand gestures. The teacher stirred an interest in science for Annette, but subsequent science experiences did not bolster her interest. In high school, Annette saw biology as pedantic, lacking variety in teaching that would have added interest to the subject. For her, biology was memorization.

Annette noted that the enthusiasm of the teacher stirs enthusiasm in students.

If it’s not taught right, it’s very mundane and not very appealing....

With the right teacher and the right approach, I like it.

In response to the PSTE items 1, 4, 9, 11, 3, and 16 of the STEBI-B, Annette indicated consistently pre- and post-survey that it is the responsibility of the
teacher to generate enthusiasm for the subject in order to increase student interest. Given the activities utilized in the modified laboratory section, Annette developed a more positive perceived self-efficacy toward teaching science.

I just feel that before it [the laboratory section], this was me (Annette held one hand up) and this was science (She held up her other hand with a large distance between her hands). Now I’m a little closer to it. I can understand it a little bit better.

Annette referred to her love of art and relayed that love to being crafty. As activities often included a product as alternative assessment, Annette was an active participant in all sessions of the laboratory. She indicated that the use of arts and crafts often made a positive impact on children, allowing them to demonstrate their understanding when they were unable to verbalize their understanding. Annette emphasized student creativity as part of a lesson as essential to learning. She related, again, that the enthusiasm of the teacher was key to student understanding and success.

I really enjoyed going out in the field and learning about invertebrates. I shocked myself when I started to become excited digging for insects.

When asked if she would or would not choose to teach science, Annette responded,

I would choose to teach science because it would be fun and interesting. Science is always adapting and changing, so while I’m teaching the students, I will also be teaching myself.
This statement indicated that Annette developed a more positive self-efficacy in teaching science.

*Participation in Course*

As the first meeting of the laboratory section began, Annette was nervous. Annette indicated negative self-efficacy at the beginning of this session. In response to the item asking about prior knowledge she responded,

Not a very broad amount of knowledge.

In this she identified science as a weakness in her repertoire. Annette additionally noted that she hoped to learn more specific details, inferring procedures in science. Annette found the tasks involved within this session to be specific in detail, yet fun to complete. As the lab progressed from making quantitative and qualitative observations into manipulation of laboratory equipment, Annette lost her nervousness and became more outspoken in discussions.

At the beginning of session II, I See You!! Exploring Microscopes, Annette acknowledged use of microscopes from early high school. She indicated a positive attitude toward science in her willingness to learn more in the details of microscopes. She also indicated positive attitude in the statement,

I love hands-on things.

The manipulation of equipment promoted her learning of the processes involved.

Annette felt she contributed most by helping others find their items in the microscope lens. She was an interpersonal learner that enjoyed social learning. Through this interaction she developed greater confidence in her skills.
The topic of plants was the focus of session IV. Annette indicated that she had limited knowledge of the topic.

Plants provide us with oxygen…. I believe plants can be beautiful and very interesting.

These statements are general in nature, showing a lack of confidence in science. In ending the statement as she did, Annette indicates a willingness to learn more about the topic. Her goal for the lab was to learn more in-depth details. As the activities proceeded, Annette experienced learning not only the parts of plants but also manipulating those parts to get measurements for comparisons. Annette instigated an inquiry activity by cutting cross sections in the stem of plants to investigating the vascular tubes and leading a discussion on the function of these tubes.

Vertebrate adaptations and habitats, the foci of session VII, were unfamiliar to Annette. Annette began by identifying her lack of confidence in the topic,

I don’t know much, but I figure it means vertebrates changing to fit with their environment.

Annette demonstrated her basic understanding of adaptations with this statement. She was applying prior knowledge to identify her goal for the topic. Also indicative of self-regulated learning is the later statement of

[I] always want to learn more.

This indicated that her attitude toward science was positive, though tempered with self-doubt. She was willing to learn.
In working in a small group, Annette was able to assist others in identifying adaptations and their function in the animal. This indicated her greater depth of knowledge and an increased confidence in her ability to teach science.

Population dynamics in the ecosystem were the focus of session VIII. Annette showed basic knowledge of the topic at the beginning of the session. She stated that she knew that in ecosystems animals must coexist with each other to survive. This limited information indicated a need for determining what ecosystem means and what actually interacts within an ecosystem. She was enthusiastic about the subject (Learning is fun!) and had the goal to learn more about ecosystems in general. Annette enjoyed using materials she found interesting within the activities and the physical participation. Annette demonstrated development in critical thinking skills in her statement,

I messed up with the mice issue but [the issue] worked out the same.

This statement was in reference to the activity in which the students graphed data collected during a simulated long-term study of a mouse population in a field. Annette found that alternative methods could develop similar results. Annette demonstrated that she was growing in her understanding of the science process. This would be beneficial in a classroom as one component of the 2010 Mississippi Science Framework was identifying alternative methods and explanations for events occurring within the context of science activities. She would be a more flexible teacher who would allow students to explore in open inquiry.
Annette had little knowledge in terms of ethics in science, the focus of session IX. Annette indicated a negative self-efficacy in this topic in her statement,

I don’t really know much about this topic other than ethics is deeming right and wrong.

In acknowledging this, Annette began self-realization of what she needed and wanted to know. Annette was enthusiastic in the reading of the book and the debate. She explored the application of developing and applying ethics through the story. She found that

fault can be blamed [sic] anywhere.

This awareness indicates an expansion of her metacognition. In discussion, Annette also noted the way in which reading had been applied in the science lesson. Her awareness of integrated lessons began to become clear. She reference how mathematics had been incorporated into previous laboratory activities and found the blend of subjects interesting.

Annette was enthusiastic about session X, water quality indicators. She had knowledge of biological indicators of water quality, having learned about macro-invertebrates in grade school. The physical characteristics appeared to be a new learning angle for her. She also enjoyed the alternative classroom location and eagerly participated. The real life application of measurement appealed to her. Annette indicated that she developed new skills that would be translated into her future classroom.
Response to Pre and Post Questionnaire

Although she was to have completed a pre and post questionnaire, Annette did not complete her submission of the pre-study questionnaire. Her responses to the demographic questions were complete, but she failed to complete the remainder of the questions/items. Annette’s responses to the remaining post-study questionnaire questions/items are transcribed in this section.

Question: Have you ever learned from others? If so, give an example of how you did learn from others.

Post-study response: I learn from others daily.

Annette’s response showed little depth of thought on this item. She did not elaborate on her statement. She listed no examples of how she learns from others.

Question: What has been said to you or about you regarding your work in a science course?

Post-study response: If I put my mind to it I can do it.

This statement illustrates that Annette has a firm belief that she can understand new knowledge. However she indicated that she had to be motivated in order to learn. This motivation had to be internal, as she noted,

If I put my mind to it…. 

Question: What is your opinion of your ability to successfully complete a science course?
Post-study response: I believe I can successfully complete a science course if the proper knowledge is provided to me.

In this statement, Annette implied that the teacher is the center of the classroom as the distributor of knowledge. She did not clarify how the knowledge was to be provided.

Question/item: Relate a memorable story about an experience you had in science.

Post-study response: I really enjoyed going out in the field and learning about invertebrates. I shocked myself when I started to become excited digging for insects.

Annette initially had been hesitant to gather water samples or explore the contents of a dip net. As she stated, once she became engaged Annette became an active learner. She had demonstrated throughout the course that she preferred kinesthetic activities in which she could immerse herself. This final laboratory activity allowed her to explore independently and relate her findings to the group.

Question: What will be your area of expertise when you are a practicing teacher? (i.e., reading, language arts, mathematics, science, social studies, art, music)

Post-study response: My area of expertise will [be] mathematics.

Though she did not select science as her area of expertise, Annette liked the structure of the activities of this developed biology curriculum. As noted in the post interview, she no longer found objectionable. However, science would still not be her primary focus as a teacher.
Question/item: Complete the following statement. Please elaborate your answer.

Science is….

Post-study response: Science is everywhere we go, and everywhere we don’t.

Annette’s idea of science developed as she participated in this study. During session discussions Annette initially had difficulty in defining the term science. She felt science was limited to a classroom or a laboratory. In this statement she had expanded her understanding the idea of science and had recognized the impact of science on daily life.

Question/item: Complete the following statement. Please elaborate your answer.

I would/would not (choose your response) teach science because….

Post-study response: I would choose to teach science because it would be fun and interesting. Science is also always adapting and changing, so while I’m teaching the students, I will also be teaching myself.

As noted earlier, Annette’s ideal teaching subject was mathematics. In this response she had embraced the possibility of teaching science. Annette understood that science is an evolutionary subject whose content changes as advancements are made. As a self-regulated learner, she now found science to be stimulating and anticipated being able to share her appreciation for science with students.

Carrie

Carrie was the oldest member of the study. As a sophomore, Carrie had more experience in the university setting than Jane and Annette. Though she had initially begun as an elementary education major, Carrie had changed her
major just prior to this study to exercise science with a minor in biological science. The reason for the change in her major area of study was, as she described in post interview,

I didn’t like their [instructors] approach to education. I didn’t like their teaching styles. They were teaching me what to teach, not how to teach. I had already passed third grade math – I didn’t need to learn it again. And I felt very belittled by the teachers here in the education department and I just decided to get out.

Though she was no longer a part of the formal education training, Carrie had not dismissed the idea of becoming a teacher. She noted that with a minor in biological science she could obtain an alternative licensure and planned to take the Mississippi teaching exam known as Praxis which is a measure of teacher readiness. However, when asked if she considered applying as informal science educator at a museum or natural area, Carrie responded,

I definitely would. I definitely would.

Carrie was the teaching assistant for the laboratory section. She was encouraged to participate in the study by her biology supervisor. Carrie anticipated developing techniques for teaching the content matter that she would use in other laboratory courses.

Though she was enrolled in formal education for most of her elementary years, Carrie was home schooled for her fifth grade year. From that time Carrie recalled many science projects that were completed, such as building volcanoes, growing plants for study, and outdoor nature experiences. Prior to that year, her
recall of science was limited. In formal education Carrie recalled science lessons in sixth grade and described her teacher as a science enthusiast. She also noted she enjoyed science in middle school. However, when asked about her high school science experiences, Carrie replied,

Not much. I came from a pretty weak background in high school.

My…I went to a very small private Christian school, and they were not able financially to have a strong science program and our science teacher was not so well-versed in sciences.

Through this statement Carrie equated an effective science class with available funding. She referenced this to a hesitancy to teach science because of available funds. She also connected the effectiveness of a science class with the interest of the teacher in science.

**Attitude toward science.**

Due to her past experiences Carrie was initially nervous in regards to learning science. Prior to taking biology at the university level, Carrie had a negative attitude toward science.

I was terrified at first going into a science class. I accidentally got into a biology class. It was a freak of nature. I didn't have enough honors hours and I had to take an honors class and the only one open at 8:00 am was Bio 111. I was like 'I'm going to die!' But I took the class….fell in love with it [biology].

Carrie credited the instructor of that initial biology class for altering her attitude toward science and toward learning science. Through this she identified
that the instructor of a course has a vital impact on student attitude toward the subject, whether the attitude is positive or negative. With the stimulation of her interest in biology, Carrie became a volunteer for the Biology Science Learning Center on the university campus, working with young children. When her enthusiasm was observed by her biology supervisor, Carrie was approached with the option to become a teaching assistant in the biology laboratories. She enrolled in more biology and chemistry classes, setting the foundation for becoming a teaching assistant.

Carrie enjoyed developing the content knowledge that corroborated the experimental data. With her involvement in the Biological Sciences Learning Center, Carrie had developed a very positive attitude toward science.

I really enjoy science. I didn’t know that, to be perfectly honest. I knew that I was good at it. It was something I could conceptualize and could figure out and think it through, but I didn’t really understand how much I enjoyed it until after I took this [modified laboratory section] and how much fun it is to teach.

Attitude toward teaching science.

Carrie had developed a negative attitude toward the formal teacher training program at the university.

I felt very belittled by the teachers here in the education department and I just decided to get out.

When asked if she had talked with her instructors concerning this issue, Carrie replied,
I talked to one of them, and she was very rude. So I said, ‘Goodbye!’
and switched over.
Thus, she ended her teacher training. This negative attitude toward teaching
affected her attitude toward teaching science initially.

Carrie’s perceived attitude of the instructor had a large impact on her
enjoyment of the course and what she learned within the course. In her
responses on the pre STEBI-B survey, Carrie consistently indicated that it is the
teacher’s attitude in science that will provide motivation for students. Within the
post interview, Carrie stated that she did not receive a positive attitude toward
education instructors based on her interpretation of the instructors’ attitudes
toward the students. Through this she conveyed that the teacher has a large
impact on students’ attitude toward a subject. As noted in post interview, Carrie
described her sixth grade teacher as awesome. This teacher challenged Carrie,
prompting her to do more. However, this teacher did not focus on science. As
with many schools, mathematics and spelling were the key subjects.

All of the other subjects were a little bit belittled. When we did
science, I liked science. But that wasn’t done very regularly which
was disappointing for me.

Through the enthusiasm demonstrated by her first biology instructor at the
university, Carrie began to see how teaching science can impact the students’
attitudes toward science. In post interview Carrie was asked how participating in
the modified laboratory section affected her ideas of science.
It was something I could conceptualize and could figure out and think it through, but I didn’t really understand how much I enjoyed it until after I took this and how much fun it is to teach. You know. Like I said, I was, ‘Oh, maybe I could teach reading.’ But no, no, no, no. Not after seeing how you could teach science hands-on and how much fun you can have, and how exciting you can make it for the students, it [teaching science] is definitely something I would consider doing in the future.

To follow up on this statement, I asked Carrie if she believed the modified laboratory section would be beneficial to elementary majors.

Take it. Take it. I went to all my classes – all my elementary - all my education classes and said, ‘Take this lab. Take this lab. Take this lab.’ You know, a lot of them had already taken [BSC] 103 – was the general problem, you know. I was a second semester sophomore and a lot of them had taken it their freshman year just to get it over with. I recommended the lab to anybody and everybody that I met, um, and told everyone about it.

Carrie had contemplated a return to education. Her experience in this study had had a positive impact on her attitude to education in general and to teaching science specifically.

I almost went back to elementary education. I was on the verge via that class [modified laboratory section]. It really showed me that science can be taught in elementary settings. Growing up I hadn’t
really experienced that. So I was like, well, I guess science is just one of those add on to high school classes. And that [modified laboratory section] showed me that, no, you can start it younger, you know. You can do this. You can do that. It [modified laboratory section] really showed me a different way how science could be taught. I really appreciated that.

Within each session of the laboratory experience, Carrie made frequent comments as to how the activities might be modified in order to be used across grade levels. She explored the 2010 Mississippi Science Framework enthusiastically.

Perceived self-efficacy in science.

Carrie had moderate self-efficacy in science prior to participating in this study. She found science enjoyable when exposed to it in elementary, middle, and high school, though she did not feel she had an adequate base for university classes. She described her high school science experience as weak. She felt inadequate for science on the collegiate level. In the on-line questionnaire, Carrie responded to item 6 (What has been said to you or about you regarding your work in a science course?) in a manner demonstrating medium to high perceived self-efficacy. She stated,

I have been told that I have a natural bent toward science, whether that is true or not remains to be seen.
When she enrolled in accidentally in a freshman honors biology class and laboratory section, it was the instructor that brought science alive for her. Carrie explained,

I like the sciences. I like the experiments. I like the learning that comes along with it. I like the understanding of every day things, if that makes sense. Like if I’m going for a walk in the woods, I understand the plants, you know, and I understand the way that this relationship is working or I might understand why this acorn is falling. I like the way it [science] describes the world around us.

Carrie’s perceived self-efficacy in science started at a moderate level, but as she progressed in biology courses she gained a confidence in her ability to understand and apply science, particularly biological science.

*Perceived self-efficacy in teaching science.*

While enrolled as an elementary education major, Carrie considered mathematics as her focus. She had high perceived self-efficacy in mathematics and found comfort in the logical organization of mathematics.

It’s just logical. It makes sense. There is a right. There is a wrong.

As long as you go step by step, you’ll get the right answer. And it’s an interesting way to describe things. You know you need math for science and physics – and – which technically is a science. Math is just so foundational and I feel that once you can conceptualize math you have an easier time conceptualizing other things.
Carrie had stated that she had also considered teaching science as an elementary educator. She found the structure in science comforting. In recalling past science experiences, Carrie focused on hands-on experiments. This statement indicated that Carrie was aware of a variety of teaching methodologies that may be incorporated into lessons. She felt that she would be adequate as a science teacher but was hesitant due to what she saw as incurred cost of teaching science. Carrie was presented with the following scenario during the post interview: She completed the education program and had been hired to teach math. She was told just prior to the beginning of school that she would be teaching science instead. When asked, Carrie responded,

Slight panic, depending on how much time I had to plan. Being thrown into science is a big deal because of budgeting, I feel. You know, science is one of those things that you need a lot of extra stuff. I don’t think I would panic on teaching the material. I feel like I would be capable to teach the concept, to teach the material. I think, for me, it would be more of a panic in time and planning, if that makes sense, figuring out how I was going to do it [teach science] and what would be the best way to do it.

Carrie had a moderate perceived self-efficacy in teaching science. As she had experience being a teaching assistant in the biological sciences laboratory, she had confidence in herself prior to this study. In a final statement on questionnaire, Carrie wrote,

I would teach science because I feel that science is the must fun
of all areas. Also I like science the best and feel that teaching it
would be capitalizing on my strengths.

**Participation in Course**

In our first laboratory session, Carrie demonstrated a high level of
self-efficacy in this session. She stated,

Observation is a key aspect to science. It is the beginning to most
great discoveries.

This generic statement indicates that Carrie had some background in science but
lacked confidence in that she did not attempt to define the term. She responded
to a later item in that she felt comfortable making observations because she had
previous experience with and the word 'simple' is in the title.

The terminology within the reading selection was kept deliberately simple in the
hope of boosting confidence of subject’s in their own abilities. In the closing
reflection, Carrie used the term observation in her responses on how she learned
presented information. The use of the term indicates a greater depth of
understanding. Carrie, when asked what changes she would make to use this
session in a class, responded that she would use greater drama to encourage
her students in making good observations.

During the microscope laboratory session, Carrie demonstrated a high
level of self-efficacy in using laboratory equipment. She recalled previous use of
the microscope but admitted discomfort in the emphasis of expense. This
indicates that she may have had little actual time with microscopes and was not
entirely comfortable in using microscopes. The hands on experience increased
her comfort level. In response to the item of what she would change, Carrie noted that she would use tape instead of water to secure the letter e to the slide. This identifies a problem in her understanding of how to make a wet mount slide. While her comfort level may have increased, her understanding of the process needed to be restructured. This topic was reintroduced at the beginning of session III and clarification was made to the purpose of the water.

In the third laboratory meeting, Carrie indicated high confidence in her abilities for this session.

I am well aquainted [sic] with cells. Though she stated that she knew basic cell structures and types of cells she went on to identify that she wanted to learn more about the structures and how to teach these to younger children. Carrie recognized her limitation in her statement,

There is so much to learn!

Carrie identified that manipulation and participation were her preferred learning strategies.

I feel that I contributed through helping with set up, take down, and finding good specimen.

When asked what changes she would make to use these activities with an elementary class Carrie noted that the activities would need to be adapted. She did not detail how she would adapt the activities.

At the beginning of the plant laboratory activities, Carrie had basic knowledge of topic and also a negative self-efficacy in her statements.
Plants either have seeds or spores. Plants are gymnosperms or anyosperms [sic]. …I get all the plant parts confused.

The strategy of manipulation of materials increased her comfort level with the topic as did the social learning design of the session. Carrie was able to process and utilize newly acquired knowledge as demonstrated in her post-reflection statement,

I learned how to use a dichotomous key.

Her initial goal was to learn about plant anatomy. Through understanding and applying a dichotomous key she was able to go past her goal. Her later statement of improvement for this session was to have more plant samples available to classify. This demonstrates her interest in continuing her learning in this topic.

Carrie’s new understanding of dichotomous keys was applied in laboratory session V. Carrie demonstrated an understanding of why classification occurs and how it occurs. She noted that she was not comfortable with the topic because

I have had very little exposure to classification.

Her goal for this session was to learn how to classify materials. The manipulation of objects and learning by doing allowed Carrie to gain confidence. The social interaction in group setting allowed Carrie to develop her understanding of how classification occurs. Discussing characteristics clarified terminology used in the dichotomous key. In response to the final reflection item, Carrie stated that she would have students make a dichotomous key. This is indicative of her new
knowledge and demonstrates her increased confidence in her ability to know and teach science.

At the beginning of session VII (Spineless Wonders), Carrie was able to recall basic information concerning the topic before beginning activities. She implied a positive interest and indicated she had previous experience with the topic in prior courses. Carrie reflected on the use of interactive games in learning situation. She demonstrated an increased positive self-efficacy in science in that she contributed by speaking up. This growth in confidence in her ability to do and teach science was shown in her response to the final reflection item.

As a teacher, I would make the following changes before I used this activity: making it more age appropriate – for instance for upper level making stiffer requirements.

In identifying this need for change, Carrie showed a willingness to challenge herself to learn more, a characteristic of self-regulated learning.

In Population Dynamics: Exploring the Ecosystem, Carrie expressed previous knowledge. Carrie noted that a previous teacher had shown great enthusiasm for this topic. That enthusiasm was transferred to Carrie.

It begins with bacteria and continues in an intricate web….I have been doing this for a while, but there is much to learn.

The demonstration through activity of how this topic could be incorporated into an elementary classroom was appreciated by Carrie. This indicated that though she had the content knowledge, she did not have application for
classroom use outside of lecture. Her continued enthusiasm was shown in response to the reflection:

I think this activity could have been better if… we could have continued once we were through.

The desire to have more time with an activity demonstrates a high interest for the subject.

Session IX focused on science ethics. Carrie admitted little knowledge in the topic of ethics, though she was able to discuss current science and societal issues. She identified ethics as a hot topic in pop culture.

This indicates that she had not given in depth thought to the topic. She demonstrated a lack of confidence, which in turn indicated a negative self-efficacy. Being a fast reader, Carrie indicated she had little patience waiting for others to complete reading. She participated eagerly in the discussion and debate presented by the reading. Though a children’s reading book was used, Carrie indicated that she would find other grade appropriate books to use within a classroom.

The final laboratory session was designed as a field study at a nearby water source. Carrie indicated lack of knowledge and lack of confidence in the topic of water quality indicators. She had limited exposure to the subject previously, though she knew terms such as alkalinity in relation to water quality. A negative self-efficacy in the topic was noted in her statement,

I am not really sure what all water quality entails.
The use of an alternative class site encouraged learning about the topic.

Carrie demonstrated self-regulated learning in identifying her weakness of staying focused in the traditional classroom. In acknowledging this she is showing awareness of personal learning needs. Carrie was enthusiastic in the laboratory activities utilized and was an eager volunteer in collection macro-invertebrates. Her enthusiasm was shared with the other students within the case study and influenced their own interest in the activities.

Response to Pre and Post Questionnaire

As part of the requirements of this study, Carrie completed the pre study questionnaire which consisted of questions that allowed her to express her ideas. Carrie did not submit a post study questionnaire. Carrie’s responses to the remaining questions/items are transcribed in this section.

Question: Have you ever learned from others? If so, give an example of how you did learn from others.

Pre-study response: I learn a lot of what I know from others. I love to listen and question others about what they know. For instance, I have a good friend who is fascinated with the brain. I have learned a lot from listening to him talk about his interests.

Carrie was an auditory learner, as she implied learning through listening. She had an acute interest in the world around her and actively sought knowledge. Carrie actively initiated discussions within each session and encouraged the other students to participate. Though she was a teaching
assistant, she was an eager participant in the activities. Her enthusiasm for biology contributed to the increased interest of other students in biology.

Question: What has been said to you or about you regarding your work in a science course?

Pre-study response: I have been told that I have a natural bent toward science, whether that is true or not remains to be seen.

Though Carrie had been complimented in the past concerning her ability in science she was not convinced of that herself. She identified in the activities areas of biology in which she had limited understanding. However, she actively sought more in-depth understanding of the subject. Her experience with other biology laboratory sections allowed her to assist other students while they became immersed in activities.

Question: What is your opinion of your ability to successfully complete a science course?

Pre-study response: I am very confident in my ability to complete a science course.

Carrie was not hesitant about her abilities. She understood her preferred learning methods. She was a motivated, self-regulated learner.

Question/item: Relate a memorable story about an experience you have had in science.

Pre-study response: I was able to teach a science course for children during the summer a few years ago. We learned all about the planets by making a human
solar system and we learned all about the different states of water by making ice cream!

Carrie enjoyed teaching children. She sought creative ways to garner children’s attention and became excited about teaching science. Though she no longer participates in the elementary teacher education program at USM, Carrie did not eliminate the possibility of becoming a teacher. She had planned to take the Praxis exam in order to obtain teaching credentials.

Question: What will be your area of expertise when you are a practicing teacher? (i.e., reading, language arts, mathematics, science, social studies, art, music)

Pre-study response: “I hope to be a science teacher someday. Specifically high school biology.”

In this response, Carrie had maintained the option to teach, though she had changed her focus from elementary school to high school. She maintained her current major (exercise science) with a minor in biology. She had a positive attitude toward teaching science.

Question/item: Complete the following statement. Please elaborate your answer.
Science is….

Pre-study response: Hands-on learning.

Carrie understood that most students learn best when actively engaged in a lesson. She identified that science was a subject in which practical application assists learner understanding of a topic. As a future teacher, Carrie would have an active classroom in which the science process is applied regularly.
Question/item: Complete the following statement. Please elaborate your answer.

I would/would not (choose your response) teach science because….

Pre-study response: I would teach science because I feel that science is the most fun of all areas. Also, I like science the best and feel that teaching it would be capitalizing on my strengths.

Carrie’s departure from the teacher education program had dampened her initial enthusiasm for teaching elementary students. However, her involvement in the Biological Sciences Learning Center had shown her that she still could teach informally. Carrie considered a return to the teacher education program. I had encouraged her to discuss her options with her supervisor. I felt that Carrie would make a remarkable teacher in the future.

Analysis

Jane and Annette began the modified laboratory section hesitant about their abilities in science. They found through the activities that they were able to “do science” and developed a more positive attitude toward science. Both became aware of how they learn and recognized their own strengths and weaknesses. The post-interview response in item 1 indicates the student was developing a positive attitude toward teaching science. The positive aspect of the post-interview responses indicates that the students of this case study were aware of their knowledge levels and have confidence in their abilities to learn science. This positive attitude in science is tempered with hesitancy as demonstrated through the phrase provided to me. This indicates the subject(s) are not yet self-motivated to learn more. As noted in the responses to reflection items the
students seemed to surprise themselves with their level of enthusiasm for science, both in participating in a task and in leading a task. Both post-interview responses to item 6 indicate an increased positive attitude toward science and toward teaching science. The pre-interview responses to item 7 initially indicated that science might be selected as an area of expertise. The post-interview responses show a change in this. Reasons for this change may include the awareness of time required to develop activities for science. The initial responses of the students indicate a positive attitude toward science. The follow up responses indicate a greater awareness of science, biology in particular. The last response to item 8 demonstrates that the student is now aware of how the attitude of a teacher toward a subject affects how students will perceive the course. The post interview responses indicate that positive attitudes toward teaching science have been increased through participation in this course.

Jane and Annette showed an increase in perceived self-efficacy towards science and science teaching. Carrie had entered this study with a moderate to high perceived self-efficacy towards science and teaching science. She indicated through the final interview that she now has a greater understanding of methodology.

I do some things….Even if I teach a lab now…. I made them the other day…. I made them do, not exactly what we did, but I made them write stuff down on note cards and brainstorm, do more hands-on critical things, because I know that’s what works…. That was kind of modeled
after what we did, you know, get your hands-on, be thinking, critical
thinking…. So they all really liked it.

The purpose of this case study was to evaluate the impact of a biological
laboratory curriculum designed for elementary education majors on attitudes and
perceived self-efficacies toward science and teaching science. Any change in
attitude toward science and science teaching was measured through responses
to open ended reflection items and pre and post open-ended interview items. Any
change in perceived self-efficacy was measured through responses to the
STEBI-B survey.

Pedagogic methods utilized in this case study encouraged the interaction
of students in learning the nature of science and processes required in science.
Responses to pre- and post- reflection items and interview items indicated
positive attitudes toward teaching science. Responses to pre-reflection items
revealed a lack of confidence in understanding science. Post-reflection items
illustrated a developed confidence in understanding science. Results of the
STEBI-B instrument indicated an increase in perceived self-efficacy.
CHAPTER 5

SUMMARY

The final chapter of this study analyzes the qualitative data collected within the study in relation to the study’s questions, and identifies possible bias within the study and applications of study results. Three questions were for emphasis of this study. Each question will be focused on within this section. The questions investigated within the study were:

1. What are the changes in attitudes toward science in elementary education majors after participating in the modified laboratory section?

2. What are the differences in attitudes towards teaching science in elementary education majors after participating in the modified laboratory section?

3. What are the differences in perceived self-efficacy of elementary education majors in teaching science after participating in the modified laboratory section?

As this was a qualitative study, methods used included interviews, open-ended questionnaires, surveys and weekly reflective writing. Students were also observed during laboratory activities and their reactions and comments were noted for later analysis. The process of analyzing qualitative data involved several cycles of reading and coding student artifacts in order to identify patterns. Cross analysis between the individual cases was conducted to determine similarities and differences between the cases.
Research Question Result Analysis

Question 1: What are the changes in attitudes toward science in elementary education majors after participating in the modified laboratory section?

Qualitative data analysis indicated moderate positive impact of this curriculum on students' attitude toward science. The three students who were the case studies in this research had neutral to negative attitudes toward science. While none of the students had an extreme negative attitude toward science, none had a positive attitude toward science.

All three were hesitant in beginning the biology content but were willing to try. As Annette stated, she felt that she could do biology if it were presented in her preferred learning style. Jane stated that she could not do technical science; indeed, she explained that she was a little scared of it. Annette and Carrie could recall a limited science exposure in their elementary classes while Jane had no recollection of elementary science lessons and did not comment on high school biology other than to say that she passed the state mandated test. Annette did comment on her biology class in high school emphasizing that it was pedantic. Carrie noted that her high school biology class had a teacher that was weak in biology and felt she did not receive a strong biology background from this teacher. All three indicated that they believed that the teacher has tremendous impact on student success in biology.

During the follow up interviews conducted two terms after the laboratory experience, Annette, Jane and Carrie all indicated a more positive attitude
toward science. Jane felt she had developed a confidence in biology that would allow her to teach science in elementary school.

I learned…how I can teach and how I can learn science.

This reversal in her attitude toward science indicated in her statements demonstrates that this laboratory curriculum had a positive impact on Jane. Annette began the course with a neutral attitude toward science. She believed that if she focused on the course work, she would succeed, but she had not found the motivation to consider science as a teaching career option. The curriculum presented included many kinesthetic activities which Annette identified as her preferred learning style. She actively participated in group discussions and became enthusiastic about exploring alternative methods for developing topics/lessons for classroom use. Her statement,

Science is everywhere we go, and everywhere we don’t,

is indicative that her attitude towards science had changed from neutral to positive.

Carrie was a teacher assistant within the modified laboratory section. In interview Carrie explained that her grade school science exposure had left her hesitant in approaching science. However during her freshman year at the university Carrie participated in an honors biology class that excited her. Carrie credited the teacher of the class and connected laboratory experience with giving her confidence to delve further into science. At the beginning of the laboratory of this study, Carrie had a positive attitude toward science.
Question 2: What are the differences in attitudes towards teaching science in elementary education majors after participating in the modified laboratory section?

Attitude toward teaching elementary science was determined through pre- and post- Science Teaching Efficacy Belief Instrument – Pre-service (STEBI-B) survey, pre- and post-questionnaires, and interviews with each student. The STEBI-B survey consisted of 23 questions. While this instrument is of quantitative design, in this study it was used strictly as a descriptive means as to attitude toward teaching science and perceived self-efficacy in science. Ten of the 23 questions explored the attitudes of the students toward teaching science. It would be desirable for teachers of elementary science to have a score of 40 or higher on these ten items. A score of 30 indicated moderately negative attitude toward teaching science.

On her pre- STEBI-B, Jane scored a 32. This placed her as having a moderately negative attitude toward teaching elementary science. This is supported by her statements in questionnaires and interview. Jane stated that she would teach science if no other option was available. She would dedicate time and effort to develop lessons but felt she would not be seen as effective due to her own limited experience and knowledge in science. After participating in the laboratory activities built into the curriculum, Jane gained confidence in her abilities. When asked in the follow up interview if she believed she would be able to teach science effectively, Jane responded that she believed she had a better understanding of science and how to teach it. She noted that she found the
activities exciting and interesting. Her image of how to teach science had changed. While these remarks indicated a positive change in her attitude toward teaching science, Jane’s post- STEBI-B STOE showed no change in attitude toward teaching science.

Annette had a minimal difference in her pre- and post- STEBI-B STOE scores, 35 pre study score and 36 post study score. This change of +1 indicated minimal change in her attitude towards teaching science. Her score of 35 prior to the study indicated she would be 70% efficacious as an elementary science teacher. In her interview statements Annette explained her lack of enthusiasm to teach science was due to her perceptions on how to teach science effectively.

I honestly didn’t see how you could make it something enjoyable for little kids.

This negative statement was upheld by her STEBI-B STOE score. Annette lacked the exposure to science activities and laboratory investigations during her elementary, middle, and high school years. Her experience was limited to lectures and videos. She was bored by her previous science classes and therefore did not consider science worthy of her study. Within this study (curriculum and activities) Annette discovered a new aspect on science. She believed she would be comfortable in teaching science

….because I was taught a new approach to it.

The modeled activities within the curriculum had a positive impact on Annette, though she still did not select science as a primary teaching area.
Carrie’s pre- STEBI-B survey indicated a negative attitude toward teaching science. Her score of a 28 demonstrated the negative attitude. However, during interview Carrie divulged information regarding her perception of the elementary teacher education program. As she had initially been part of the teacher education program within the university, Carrie had negative experiences within that program which led her to change her major study area. She left the teacher education program in favor of exercise physiology with a minor in biological sciences. Her experience within the elementary education program had an overall negative impact on her view of teaching. On pre- and post- STEBI-B Carrie consistently indicated that the instructor had the largest impact on whether or not students were successful in a class. She could recall only one teacher that was a science enthusiast. While she enjoyed this teacher’s class, the amount of time spent on science was minimal.

As she progressed in this study, Carrie contemplated returning to education as a major. This is indicative of a positive change in attitude toward teaching science. In follow up interview Carrie stated,

It really showed me that science can be taught in elementary settings….It really showed me a different way how science could be taught.

Though her attitude toward science was initially positive, her attitude toward teaching had been negative. In her follow up interview statements Carrie is identifying a positive change in her attitude toward teaching science.
Based on the STEBI-B STOE pre- and post-results, the proposed curriculum had no impact on attitude toward teaching science. However, interpretation of questionnaire responses and follow interview statements indicated that the proposed curriculum did have a positive impact on the attitude of students toward teaching elementary science.

Question 3: What are the differences in perceived self-efficacy of elementary education majors in teaching science after participating in the modified laboratory section?

The PSTE items of the STEBI-B indicated the perceived self-efficacy of the students towards teaching elementary science. A score of 39 indicated a low self-efficacy in teaching science while a score of 52 would be a moderately high indicator of self-efficacy in teaching science. Initial results on the PSTE portion of the STEBI-B indicate that all three students had a moderately low perceived self-efficacy in teaching science. Jane had an initial score of 46. This score increased to 49 on the post STEBI-B PSTE. Annette had an initial score of 43 which increased to 44 on the post survey. Carrie’s initial score was 47. She did not complete the post survey. The post PSTE scores of Jane and Annette indicated that the modified biology lab curriculum had a moderately positive impact on their perceived self-efficacy toward teaching elementary science.

Prior to participating in this study, Jane did not believe she had the knowledge required to effectively teach elementary science.

There’s so much that I don’t know, and I can’t figure out. They would ask questions….that I don’t know the answer to, and I
wouldn’t feel right…. 

She identified that the teacher must have confidence in herself in order to be an effective teacher. As Jane’s science exposure prior to this laboratory section had not been positive, she believed she would be ineffectual as an elementary science teacher. She was hesitant to begin group discussions during laboratory sessions and was nervous about topics introduced. However as the laboratory section progressed throughout the term, Jane developed a confidence in herself pertaining to science. She was eager to learn techniques in science and in teaching science. As she presented her activity products to the class she would smile and be enthusiastic in her explanations of her ideas. The lesson she modeled on the sense of taste was well received by other students. Jane began to see how she could teach science to elementary and be successful in the subject, though she still would choose to teach special education classes. The overall impact of the modified curriculum on Jane’s perceived self-efficacy in teaching science was positive.

The pre and post STEBI-B PSTE results for Annette showed minimal difference in her scores. While there was a +1 increase in her perceived self-efficacy in teaching elementary science, Annette preferred to teach mathematics. She believed she had never been engaged in science; therefore she would not be able to engage her students in science. Annette believed in the right teacher and the right approach view of teaching. In this statement Annette implied that she would not be the right teacher for elementary science. The monotonous delivery of science lessons in grade school led Annette towards a negative view
of science in general and reflected upon her idea of teaching science. In the follow up interview Annette stated that the modified curriculum and laboratory experiences had made science more comprehensible. She identified many activities as fun and noted that similar activities would not be conducted in English lessons.

   It kind of made me realize that science is much more broad than like math or English or social studies.

Through the modified laboratory section, Annette developed an interest and confidence in science. This was indicative of a positive change in her perceived self-efficacy toward teaching elementary science. As she stated,

   I would choose to teach science because it would be fun and interesting. Science is always adapting and changing, so while I’m teaching the students, I will also be teaching myself.

Carrie had initially contemplated teaching elementary science, though she indicated she would prefer mathematics over science. Though her attitude toward science was moderately high, her perceived self-efficacy in teaching science was neutral to moderate, according to the pre- STEBI-B PSTE results. She related success as a science teacher to the monetary amount available to the science classroom. Carrie felt that she would be capable of teaching the concept but lacked confidence in how to conduct students in activities and investigations. After participating in this study Carrie stated that she would be an effective science teacher.

   I feel that science is the most fun of all [subject] areas….feel that
teaching it would be capitalizing on my strengths.

Carrie had been a teaching assistant prior to this study and therefore had some experience in teaching laboratory activities and investigations on the collegiate level. After participation in this study, she identified many methods for teaching elementary students science. This was interpreted as a moderately positive impact on her perceived self-efficacy in teaching elementary science.

**Theoretical Implications**

The proposed curriculum for pre-service teachers who are not science majors had a positive impact on attitude toward science and teaching science. Annette and Jane were tentative about biological science prior to the study, identifying it as a difficult subject to learn and understand. Through interviews, reflections, and questionnaires, the students showed change in attitude toward science. In laboratory observations made by the researcher, the students changed from nervousness in participating in a laboratory activity to enthusiastic participants. Yilmaz-Tuzun (2008) identified that in pre-service educators the understanding of a subject and enabling others to understand the subject were vital to learning and teaching. All three students of this study identified that the teacher influenced the success rate of their students. The initial attitude toward teaching science of Jane and Annette was negative to neutral as indicated in the STEBI-B pre-survey, reflections, questionnaires and interview. Cakiroglu, Cakiroglu, and Boone (2005) found that pre-service teachers believed that good teaching can overcome previous lack of success of students in science. Through demonstration of methods incorporated into the laboratory curriculum, the students developed a
confidence in their ability to teach science and therefore had a shift in their attitude toward teaching science. Gallagher (2000) identified that student’s lack of success could be attributed to limited exposure to differentiated teaching methods and a lack of connection between knowledge and application of that knowledge. This proposed curriculum allowed students to apply the content developed within the lecture component of the biology course and apply that knowledge directly to classroom ready laboratory activities.

The curriculum also had a positive impact on their perceived self-efficacy in science and in teaching science. Annette stated that she could only learn science when it was taught in a manner that coincided with her learning styles. On the post questionnaire she noted she now saw how science was more fun. Annette realized that science in a flexible subject that is open to differentiated instruction, not a monotonous subject only to be learned through lecture and reading. Carrie contemplated a return to education as a major during the time of this study. This she credited to her work and observations with the study group. All three case study students identified their lack of science stemmed from limited exposure to science in grade school. As Cakiroglu, Cakiroglu, and Boone (2005) identified, pre-service educators believe that students’ inadequacy in science may be the result of poor teaching. Through group interactions and cooperative learning the students developed confidence in biological science. Bleicher (2006) found an increase of self-efficacy through interactive and cooperative group designed courses. This study reflects the findings of Bleicher.
While all indications show that this proposed curriculum was moderately successful it will be necessary to continue its use in the laboratory situation in order to identify its strengths. McDiarmid, Ball, and Anderson (1989) state that, “Beyond representing the substance of a subject, teachers also represent its nature.” As I, as researcher working directly with the students of the case studies, I may have influenced the students through personal enthusiasm. As I expressed my interest in science and in teaching science, the students became more interested in the subject and became less hesitant to teach science. There is no discernable way to remove teacher attitude from a study of this nature.

Johnston (2006) identified an increase in self-efficacy and attitude toward teaching science when application and kinesthetic methods were incorporated into the lessons. The variety of methodologies incorporated into the activities allowed students new opportunities to master the content of biology and develop skills to be used in future classrooms. Lunn and Solomon (2000) identified that the experiences pre-service educators have impacts their self-image. The activities utilized encouraged students to explore a variety of teaching methods for science. Friedl and Koontz (2001) identified that pre-service teachers would be effective when they became comfortable with the subject. This study allowed students to explore and apply content knowledge within a stress free atmosphere where they did not feel intimidated by other students that were identified as being more proficient in biological science.
**Practice Implication**

Courses designed for teacher education must be inclusive of pedagogy, metacognition and content in order to promote high self-efficacy (Bleicher, 2006; Yilmaz-Tuzun, 2008). The exposure to alternative methodologies for teaching science did have a positive impact the self-efficacy of the students in this research. With the integration of mathematics, reading, English/language arts, and the arts into the activities of the proposed curriculum the students were able to explore the possibility of teaching science. Students indicated through interview responses that they would be more confident in teaching science after participating in this study, though science was still not their primary focus in education. However, the positive responses of the students during the laboratory activities lead the researcher to believe that this introduction to science pedagogy may influence these students to explore more options in teaching science.

**Future Research**

This study identifies the need to conduct more laboratory sections utilizing the develop curriculum in order to establish its final impact on the attitude and perceived self-efficacies of the pre-service teachers toward science and teaching science. As the students of this study experienced integration of multiple curriculum into the activities included in the study they began to realize how varying areas of education overlap and complement each other. Within the scope of biology, the students incorporated English/language arts, mathematics, physical education through kinesthetic activity and art. A follow-up interview with the students of this study after they have begun their teaching practice would
identify the longevity of this curriculum and its final impact on their attitudes and perceived self-efficacy towards science and teaching science of those participating in this study.

Within interviews, one study participant remarked that her reason for leaving the pre-service teacher education program was that she felt belittled by the instructors and the coursework within the program. A future investigation of the pre-service elementary education program’s effectiveness may be conducted through periodic surveys within that program questioning the pedagogical strategies employed within the program. As education approaches a common core it will be critical that pre-service education programs promote integrated courses to demonstrate how to effectively teach across curricula.

As many university students begin their higher education at the community college level the number of students eligible to participate in a course such as the one presented in this study is small. Community colleges offer introductory biology for non-science majors. A future application may be to initiate a biology lab such as this for elementary education majors on the community college level. Though it may not be transferable to a university pre-service teacher program, the early exposure to science teaching methods may influence the pre-service teacher to consider science as an emphasis.
KINDERGARTEN

CONTENT STRANDS:

Inquiry                      Life Science
Physical Science            Earth and Space Science

COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Ask questions and find answers by scientific investigation.
   a. Demonstrate an understanding of a simple investigation by asking questions. (DOK 2)
   b. Compare, sort, and group objects according to size, shape, color, and texture. (DOK 2)
   c. Identify simple tools (rulers, thermometers, scales, and hand lenses) used to gather information. (DOK 1)
   d. Recognize that people have always had questions about their world and identify science as one way of answering questions and explaining the natural world. (DOK 1)
   e. Describe ideas using drawings and oral expression. (DOK 2)
   f. Recognize that when a science investigation is done the way it was done before, very similar results are expected. (DOK 1)

LIFE SCIENCE

3. Understand characteristics, life cycles, and environments of organisms.
   a. Group animals and plants by their physical features (e.g., size, appearance, color). (DOK 2)
   b. Compare and contrast physical characteristics of humans. (DOK 1)
      • The five senses (sight, smell, touch, taste, hearing) and corresponding body parts
      • The six major body organs (brain, skin, heart, lungs, stomach, intestines).
c. Classify parts of the human body that help it seek, find, and take in food when it feels hunger. (DOK 1)
   • Eyes and nose for detecting food
   • Legs to get it
   • Arms to carry it away
   • Mouth to eat it
d. Identify offspring that resemble their parents. (DOK 1)
e. Recognize and compare the differences between living organisms and non-living materials. (DOK 2)

EARTH AND SPACE SCIENCE

4. Understand properties of Earth materials, objects in the sky, and changes in Earth and sky.
   b. Identify and describe properties of Earth materials (soil, rocks, water, and air). (DOK 1)
   c. Collect and display local weather data. (DOK 2)
   d. Describe ways to conserve water. (DOK 2)
   e. Describe the effects of the sun on living and non-living things. (DOK 1)
      • Warms the land, air, and water
      • Helps plants grow
   f. Identify the sun as Earth's source of light and heat and describe changes in shadows over time. (DOK 2)
FIRST GRADE

CONTENT STRANDS:

<table>
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<th>Life Science</th>
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<tr>
<td>Physical Science</td>
<td>Earth and Space Science</td>
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COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Understand how to plan and carry out a simple scientific investigation.
   a. Demonstrate an understanding of a simple investigation by asking appropriate questions about objects, organisms, and events. (DOK 2)
   b. Compare, sort, and group objects according to their attributes. (DOK 2)
   c. Use simple tools (e.g., rulers, scales, hand lenses, thermometers, microscopes) to gather information. (DOK 1)

   - Length, using nonstandard units (e.g., paper clips, Unifix cubes, etc.) and standard units (inches, centimeters)
   - Weight, using a balance scale with and without nonstandard units
   - Capacity, using nonstandard units
   d. Match a simple problem to a technological solution related to the problem (e.g., dull pencil – sharpener, bright light – sunglasses, hot room – fan, cold head – hat, heavy baby – stroller). (DOK 1)
   e. Use diagrams and written and oral expression to describe ideas or data. (DOK 2)
   f. Predict the results of an investigation if it is repeated. (DOK 2)

LIFE SCIENCE

3. Develop an understanding of the characteristics, structures, life cycles, interactions, and environments of organisms.
   a. Classify animals and plants by observable features (e.g., size, appearance, color, motion, habitat). (DOK 2)
   b. Describe the primary function of the major body organs (brain, skin, heart, lungs, stomach, intestines, bones, and muscles). (DOK 2)
   c. Communicate the importance of food and explain how the body utilizes food. (DOK 2)
   d. Chart and compare the growth and changes of animals from birth to adulthood. (DOK 2)
e. Identify the basic needs of plants and animals and recognize that plants and animals both need to take in water, animals need food, and plants need light. (DOK 1)
f. Identify and label the parts of a plant. (DOK 2)

EARTH AND SPACE SCIENCE

4. Develop an understanding of the properties of Earth materials, objects in the sky, and changes in Earth and sky.

c. Observe, identify, record, and graph daily weather conditions. (DOK 3)
d. Categorize types of actions that cause water, air, or land pollution. (DOK 2)
e. Collect, categorize, and display various ways energy from the sun is used. (DOK 2)
SECOND GRADE

CONTENT STRANDS:
Inquiry Life Science
Physical Science Earth and Space Science

COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Develop abilities necessary to conduct scientific investigations.
   a. Formulate questions about objects and organisms and predict outcomes in order to conduct a simple investigation. (DOK 2)
   b. Compare, sort, and group objects according to two or more attributes. (DOK 2)
   c. Use simple tools (e.g., rulers, thermometers, scales, hand lenses, microscopes, balances, clocks) to gather information. (DOK 1)
      - Length, to the nearest inch, foot, yard, centimeter, and meter
      - Capacity, to the nearest ounce, cup, pint, quart, gallon, and liter
      - Weight, to the nearest ounce, pound, gram, and kilogram
      - Time, to the nearest hour, half-hour, quarter-hour, and five-minute intervals (using digital and analog clocks)
   d. Collect and display technological products (e.g., zipper, coat hook, ceiling fan pull chain, can opener, bridge, apple peeler, wheel barrow, nut cracker, etc.) to determine their function. (DOK 1)
   e. Create line graphs, bar graphs, and pictographs to communicate data. (DOK 2)
   f. Infer that science investigations generally work the same way in different places. (DOK 2)

LIFE SCIENCE

3. Develop and demonstrate an understanding of the characteristics, structures, life cycles, and environments of organisms.
   a. Describe and categorize the characteristics of plants and animals. (DOK 2)
      - Plant parts (leaves, stems, roots, and flowers)
      - Animals (vertebrates or invertebrates, cold-blooded or warm-blooded)
   c. Identify the cause/effect relationships when basic needs of plants and animals are met and when they are not met. (DOK 1)
d. Compare the life cycles of plants and animals. (DOK 2)
e. Investigate and explain the interdependence of plants and animals.
   (DOK 2)
   - Herbivore, carnivore, or omnivore
   - Predator-prey relationships

**EARTH AND SPACE SCIENCE**

4. Develop an understanding of the properties of Earth materials, objects in the sky, and changes in Earth and sky.

c. Collect, organize, and graph weather data obtained by using simple weather instruments (wind vane, rain gauge, thermometer) and explain the components of the water cycle. (DOK 2)
d. Distinguish how actions or events related to the Earth’s environment may be harmful or helpful. (DOK 2)
THIRD GRADE

CONTENT STRANDS:
Inquiry
Life Science
Physical Science
Earth and Space Science

COMPETENCIES AND OBJECTIVES:

INQUIRY

1. **Apply concepts involved in a scientific investigation.**
   a. Identify questions and predict outcomes that can be examined through scientific investigations. (DOK 3)
   b. Describe familiar objects and events using the senses to collect qualitative (e.g., color, size, shape) information. (DOK 1)
   c. Select and use simple tools (e.g., rulers, thermometers, scales, hand lenses, microscopes, calculators, balances, clocks) to gather information. (DOK 1)
   - Length, to the nearest half of an inch, foot, yard, centimeter, and meter
   - Capacity and weight/mass, in English and metric systems
   - Time, to the nearest minute
   - Temperature, to the nearest degree
   d. Draw conclusions and communicate the results of an investigation. (DOK 2)
   e. Communicate data by creating diagrams, charts, tables, and graphs. (DOK 2)
   f. Ask questions and seek answers to explain why different results sometimes occur in repeated investigations. (DOK 2)

LIFE SCIENCE

3. **Describe the characteristics, structures, life cycles, and environments of organisms.**
   a. Research and explain diverse life forms (including vertebrates and invertebrates) that live in different environments (e.g., deserts, tundras, forests, grasslands, taigas, wetlands) and the structures that serve different functions in their survival (e.g., methods of movement, defense, camouflage). (DOK 2)
   b. Identify and describe the purpose of the digestive, nervous, skeletal, and muscular systems of the body. (DOK 1)
c. Investigate the relationships between the basic needs of different organisms and discern how adaptations enable an organism to survive in a particular environment. (DOK 2)
d. Illustrate how the adult animal will look, when given pictures of young animals (e.g., birds, fish, cats, frogs, caterpillars, etc.) (DOK 2)
e. Recall that organisms can survive only when in environments (deserts, tundras, forests, grasslands, taigas, wetlands) in which their needs are met and interpret the interdependency of plants and animals within a food chain, including producer, consumer, decomposer, herbivore, carnivore, omnivore, predator, and prey. (DOK 2)
f. Recognize that cells vary greatly in size, structure, and function, and that some cells and tiny organisms can be seen only with a microscope. (DOK 1)

EARTH AND SPACE SCIENCE

4. Develop an understanding of the properties of Earth materials, objects in the sky, and changes in Earth and sky.

c. Gather and display local weather information such as temperature, precipitation, clouds, etc., on graphs and use graphs of weather patterns to predict weather conditions. (DOK 3)
   • Instruments (wind vane, rain gauge, thermometers, anemometers, and barometers)
   • Cloud types (cirrus, stratus, cumulus)
   • Water cycle (evaporation, precipitation, condensation)
d. Identify the causes and effects of various types of air, land, and water pollution and infer ways to protect the environment. (DOK 3)
FOURTH GRADE

CONTENT STRANDS:
  Inquiry
  Life
  Science
  Physical Science
  Earth and Space

COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Explain and use skills necessary to conduct scientific inquiry.
   a. Form hypotheses and predict outcomes of problems to be investigated. (DOK 3)
   b. Use the senses and simple tools to gather qualitative information about objects or events (size, shape, color, texture, sound, position, change). (DOK 1)
   b. Demonstrate the accurate use of simple tools to gather and compare information (DOK 1)
      • Tools (English rulers [to the nearest eighth of an inch], metric rulers [to the nearest centimeter], thermometers, scales, hand lenses, microscopes, balances, clocks, calculators, anemometers, rain gauges)
      • Types of data (height, mass/weight, temperature, length, distance, volume, area, perimeter)
   d. Use simple sketches, diagrams, tables, charts, and writing to draw conclusions and communicate data results. (DOK 2)
   e. Interpret and describe patterns of data using drawings, diagrams, charts, tables, graphs, and maps. (DOK 2)
   f. Explain why scientists and engineers often work in teams with different individuals doing different things that contribute to the results. (DOK 2)
   g. Draw conclusions about important steps (e.g., making observations, asking questions, trying to solve a problem, etc.) that led to inventions and discoveries. (DOK 3)

PHYSICAL SCIENCE

2. Use the properties of objects and materials, position and motion of objects, and transfer of energy to develop an understanding of physical science concepts.
a. Recognize that materials may be composed of parts that are too small to be seen without magnification. (DOK 1)

**LIFE SCIENCE**

3. **Analyze the characteristics, structures, life cycles, and environments of organisms.**

a. Describe the cause and effect relationships that explain the diversity and evolution of organisms over time. (DOK 2)
   - Observable traits due to inherited or environmental adaptations
   - Variations in environment (over time and from place to place)
   - Variations in species as exemplified by fossils
   - Extinction of a species due to insufficient adaptive capability in the face of environmental changes

b. Compare characteristics of organisms, including growth and development, reproduction, acquisition and use of energy, and response to the environment. (DOK 2)
   - Life cycles of various animals to include complete and incomplete metamorphosis
   - Plant or animal structures that serve different functions in growth, adaptation, and survival
   - Photosynthesis

c. Distinguish the parts of plants as they relate to sexual reproduction and explain the effects of various actions on the pollination process (e.g., wind, water, insects, adaptations of flowering plants, negative impacts of pesticides). (DOK 2)

de. Analyze food webs to interpret how energy flows from the sun. (DOK 2)

f. Describe the structural and functional relationships among the cells of an organism. (DOK 2)
   - Benefit from cooperating
   - Vary greatly in appearance
   - Perform very different roles

**EARTH AND SPACE SCIENCE**

4. **Develop an understanding of the properties of Earth materials, objects in the sky, and changes in Earth and sky.**

d. Describe how human activities have decreased the capacity of the environment to support some life forms. (DOK 2)
   - Reducing the amount of forest cover
• Increasing the amount of chemicals released into the atmosphere
• Farming intensively
FIFTH GRADE

CONTENT STRANDS:

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<tr>
<td>Science</td>
<td>Physical Science</td>
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<td>Earth and Space</td>
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COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Develop and demonstrate an understanding of scientific inquiry using process skills.

   a. Form a hypothesis, predict outcomes, and conduct a fair investigation that includes manipulating variables and using experimental controls. (DOK 3)
   b. Distinguish between observations and inferences. (DOK 2)
   c. Use precise measurement in conjunction with simple tools and technology to perform tests and collect data. (DOK 1)
      - Tools (English rulers [to the nearest one-sixteenth of an inch], metric rulers [to the nearest millimeter], thermometers, scales, hand lenses, microscopes, balances, clocks, calculators, anemometers, rain gauges, barometers, hygrometers)
      - Types of data (height, mass, volume, temperature, length, time, distance, volume, perimeter, area)
   d. Organize and interpret data in tables and graphs to construct explanations and draw conclusions. (DOK 2)
   e. Use drawings, tables, graphs, and written and oral language to describe objects and explain ideas and actions. (DOK 2)
   f. Make and compare different proposals when designing a solution or product. (DOK 2)
   g. Evaluate results of different data (whether trivial or significant). (DOK 2)
   h. Infer and describe alternate explanations and predictions. (DOK 3)

LIFE SCIENCE

3. Predict characteristics, structures, life cycles, environments, evolution, and diversity of organisms.
a. Compare and contrast the diversity of organisms due to adaptations to show how organisms have evolved as a result of environmental changes. (DOK 2)
   - Diversity based on kingdoms, phyla, and classes (e.g., internal/external structure, body temperature, size, shape)
   - Adaptations that increase an organism’s chances to survive and reproduce in a particular habitat (e.g., cacti needles/leaves, fur/scales)
   - Evidence of fossils as indicators of how life and environmental conditions have changed

b. Research and classify the organization of living things. (DOK 2)
   - Differences between plant and animal cells
   - Function of the major parts of body systems (nervous, circulatory, respiratory, digestive, skeletal, muscular) and the ways they support one another
   - Examples of organisms as single-celled or multi-celled

d. Distinguish between asexual and sexual reproduction. (DOK 1)
   - Asexual reproduction processes in plants and fungi (e.g., vegetative propagation in stems, roots, and leaves of plants, budding in yeasts, fruiting bodies in fungi)
   - Asexual cell division (mushroom spores produced/dispersed)
   - Sexual reproduction (e.g., eggs, seeds, fruit)

e. Give examples of how consumers and producers (carnivores, herbivores, omnivores, and decomposers) are related in food chains and food webs. (DOK 1)

EARTH AND SPACE SCIENCE

4. Develop an understanding of the properties of Earth materials, objects in the sky, and changes in Earth and sky.

   d. Describe changes caused by humans on the environment and natural resources and cite evidence from research of ways to conserve natural resources in the United States, including (but not limited to) Mississippi. Examples of Mississippi efforts include the following: (DOK 2)
      - Associated Physics of America, a private company located in Greenwood Mississippi, develops ways to convert a variety of agricultural products into efficient, environment-friendly and cost-effective energy sources.
      - The Natural Resource Enterprises (NRE) Program of the Department of Wildlife and Fisheries and the Cooperative Extension Service at MSU educate landowners in the Southeast about sustainable natural resource enterprises and compatible habitat management practices.
      - The Engineer Research and Development Center of the Vicksburg District of the U.S. Army Corps of Engineers provides quality engineering and other professional products and
services to develop and manage the Nation’s water resources, reduce flood damage, and protect the environment.
SIXTH GRADE

CONTENT STRANDS:

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<th>Life Science</th>
<th>Earth and Space Science</th>
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COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Conduct a scientific investigation utilizing appropriate process skills.

   a. Design and conduct an investigation that includes predicting outcomes, using experimental controls, and making inferences. (DOK 3)
   b. Distinguish between qualitative and quantitative observations and make inferences based on observations. (DOK 3)
   c. Use simple tools and resources to gather and compare information (using standard, metric, and non-standard units of measurement). (DOK 1)
      - Tools (e.g., English rulers [to the nearest one-sixteenth of an inch], metric rulers [to the nearest millimeter], thermometers, scales, hand lenses, microscopes, balances, clocks, calculators, anemometers, rain gauges, barometers, hygrometers, telescopes, compasses, spring scales)
      - Types of data (e.g., linear measures, mass, volume, temperature, time, area, perimeter)
      - Resources (e.g., Internet, electronic encyclopedias, journals, community resources, etc.)
   d. Analyze data collected from a scientific investigation to construct explanations and draw conclusions. (DOK 3)
   e. Communicate scientific procedures and conclusions using diagrams, charts, tables, graphs, maps, written explanations, and/or scientific models. (DOK 2)
   f. Evaluate the results or solutions to problems by considering how well a product or design met the challenge to solve a problem. (DOK 3)
   g. Infer explanations for why scientists might draw different conclusions from a given set of data. (DOK 2)
   h. Recognize and analyze alternative explanations and predictions. (DOK 2)
LIFE SCIENCE

3. Explain the organization of living things, the flow of matter and energy through ecosystems, the diversity and interactions among populations, and the natural and human-made pressures that impact the environment.

a. Describe and predict interactions (among and within populations) and the effects of these interactions on population growth to include the effects on available resources. (DOK 2)
   - How cooperation, competition and predation affect population growth
   - Effects of overpopulation within an ecosystem on the amount of resources available
   - How natural selection acts on a population of organisms in a particular environment via enhanced reproductive success
b. Compare and contrast structure and function in living things to include cells and whole organisms. (DOK 2)
   - Hierarchy of cells, tissues, organs, and organ systems to their functions in an organism
   - Function of plant and animal cell parts (vacuoles, nucleus, cytoplasm, cell membrane, cell wall, chloroplast)
   - Vascular and nonvascular plants, flowering and non-flowering plants, deciduous and coniferous trees
c. Distinguish between the organization and development of humans to include the effects of disease. (DOK 2)
   - How systems work together (e.g., respiratory, circulatory)
   - Fertilization, early cell division, implantation, embryonic and fetal development, infancy, childhood, adolescence, adulthood, and old age
   - Common diseases caused by microorganisms (e.g., bacteria, viruses, malarial parasites)
d. Describe and summarize how an egg and sperm unite in the reproduction of angiosperms and gymnosperms. (DOK 1)
   - The path of the sperm cells to the egg cell in the ovary of a flower
   - The structures and functions of parts of a seed in the formation of a plant and of fruits
   - How the combination of sex cells results in a new combination of genetic information different from either parent
e. Construct a diagram of the path of solar energy through food webs that include humans and explain how the organisms relate to each other. (DOK 2)
   - Autotrophs and heterotrophs, producers, consumers and decomposers
• Predator/prey relationships, competition, symbiosis, parasitism, commensalisms, mutualism
SEVENTH GRADE

CONTENT STRANDS:

Inquiry  Life Science
Physical Science  Earth and Space Science

COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Design and conduct a scientific investigation utilizing appropriate process skills and technology.
   a. Design, conduct, and draw conclusions from an investigation that includes using experimental controls. (DOK 3)
   b. Discriminate among observations, inferences, and predictions. (DOK 1)
   c. Collect and display data using simple tools and resources to compare information (using standard, metric, and non-standard measurement). (DOK 2)
      ● Tools (e.g., English rulers [to the nearest one-sixteenth of an inch], metric rulers [to the nearest millimeter], thermometers, scales, hand lenses, microscopes, balances, clocks, calculators, anemometers, rain gauges, barometers, hygrometers, telescopes, compasses, spring scales, pH indicators, stopwatches)
      ● Types of data (e.g., linear measures, mass, volume, temperature, area, perimeter)
      ● Resources (e.g., Internet, electronic encyclopedias, journals, community resources, etc.)
   d. Organize data in tables and graphs and analyze data to construct explanations and draw conclusions. (DOK 3)
   e. Communicate results of scientific procedures and explanations through a variety of written and graphic methods. (DOK 2)
   f. Explain how science and technology are reciprocal. (DOK 1)
   g. Develop a logical argument to explain why scientists often review and ask questions about the results of other scientists’ work. (DOK 3)
   h. Make relationships between evidence and explanations. (DOK 2)

PHYSICAL SCIENCE

2. Develop an understanding of chemical and physical changes, interactions involving energy, and forces that affect motion of objects.
a. Identify patterns (e.g., atomic mass, increasing atomic numbers) and common characteristics (metals, nonmetals, gasses) of elements found in the periodic table of elements. (DOK 2)
b. Categorize types of chemical changes, including synthesis and decomposition reactions, and classify acids and bases using the pH scale and indicators. (DOK 2)
c. Compare the force (effort) required to do the same amount of work with and without simple machines (e.g., levers, pulleys, wheel and axle, inclined planes). (DOK 2)
d. Describe cause and effect relationships of electrical energy. (DOK 2)
   • Energy transfers through an electric circuit (using common pictures and symbols)
   • Electric motor energy transfers (e.g., chemical to electrical to mechanical motion) and generators

e. Distinguish how various types of longitudinal and transverse waves (e.g., water, light, sound, seismic) transfer energy. (DOK 2)
   • Frequency
   • Wavelength
   • Speed
   • Amplitude

f. Describe the effects of unbalanced forces on the speed or direction of an object’s motion. (DOK 2)
   • Variables that describe position, distance, displacement, speed, and change in speed of an object
   • Gravity, friction, drag, lift, electric forces, and magnetic forces

LIFE SCIENCE

3. Distinguish the characteristics of living things and explain the interdependency between form and function using the systems of the human organism to illustrate this relationship.

a. Assess how an organism’s chances for survival are influenced by adaptations to its environment. (DOK 2)
   • The importance of fungi as decomposers
   • Major characteristics of land biomes (e.g., tropical rainforests, temperate rainforests, deserts, tundra, coniferous forests/taiga, and deciduous forests)
   • Adaptations of various plants to survive and reproduce in different biomes

b. Classify the organization and development of living things to include prokaryotic (e.g., bacteria) and eukaryotic organisms (e.g., protozoa, certain fungi, multicellular animals and plants). (DOK 2)
c. Evaluate how health care technology has improved the quality of human life (e.g., computerized tomography [CT], artificial organs, magnetic resonance imaging [MRI], ultrasound). (DOK 3)
d. Compare and contrast reproduction in terms of the passing of genetic information (DNA) from parent to offspring. (DOK 2)
   - Sexual and asexual reproduction
   - Reproduction that accounts for evolitional adaptability of species
   - Mitosis and meiosis
   - Historical contributions and significance of discoveries of Gregor Mendel and Thomas Hunt Morgan as related to genetics
e. Compare and contrast how organisms obtain and utilize matter and energy. (DOK 1)
   - How organisms use resources, grow, reproduce, maintain stable internal conditions (homeostasis) and recycle waste
   - How plants break down sugar to release stored chemical energy through respiration

EARTH AND SPACE SCIENCE

4. Describe the properties and structure of the sun and the moon with respect to the Earth.

d. Conclude why factors, such as lack of resources and climate can limit the growth of populations in specific niches in the ecosystem. (DOK 2)
   - Abiotic factors that affect population, growth, and size (quantity of light, water, range of temperatures, soil compositions)
   - Cycles of water, carbon, oxygen, and nitrogen in the environment
   - Role of single-celled organisms (e.g., phytoplankton) in the carbon and oxygen cycles
g. Research and evaluate the use of renewable and nonrenewable resources and critique efforts in the United States including (but not limited) to Mississippi to conserve natural resources and reduce global warming. (DOK 3)
   - How materials are reused in a continuous cycle in ecosystems, (e.g., Mississippi Ethanol Gasification Project to develop and demonstrate technologies for the conversion of biomass to ethanol)
   - Benefits of solid waste management (reduce, reuse, recycle)
   - Conserving renewable and nonrenewable resources (e.g., The Recycling and Solid Waste Reduction Program in Jackson, MS)
Eighth Grade

CONTENT STRANDS:

Inquiry
Physical Science
Life Science
Earth and Space Science

COMPETENCIES AND OBJECTIVES:

INQUIRY

1. Draw conclusions from scientific investigations including controlled experiments.

   a. Design, conduct, and analyze conclusions from an investigation that includes using experimental controls. (DOK 3)
   b. Distinguish between qualitative and quantitative observations and make inferences based on observations. (DOK 3)
   c. Summarize data to show the cause and effect relationship between qualitative and quantitative observations (using standard, metric, and non-standard units of measurement). (DOK 3)
      • Tools (e.g., English rulers [to the nearest one-sixteenth of an inch], metric rulers [to the nearest millimeter], thermometers, scales, hand lenses, microscopes, balances, clocks, calculators, anemometers, rain gauges, barometers, hygrometers, telescopes, compasses, spring scales, pH indicators, stopwatches, graduated cylinders, medicine droppers)
      • Types of data (e.g., linear measures, mass, volume, temperature, area, perimeter)
      • Resources (e.g., Internet, electronic encyclopedias, journals, community resources, etc.)
   d. Analyze evidence that is used to form explanations and draw conclusions. (DOK 3)
   e. Develop a logical argument defending conclusions of an experimental method. (DOK 3)
   f. Develop a logical argument to explain why perfectly designed solutions do not exist. (DOK 3)
   g. Justify a scientist’s need to revise conclusions after encountering new experimental evidence that does not match existing explanations. (DOK 3)
   h. Analyze different ideas and recognize the skepticism of others as part of the scientific process in considering alternative conclusions. (DOK 3)

LIFE SCIENCE
2. Compare and contrast the structure and functions of the cell, levels of organization of living things, basis of heredity, and adaptations that explain variations in populations.

a. Analyze how adaptations to a particular environment (e.g., desert, aquatic, high altitude) can increase an organism’s survival and reproduction and relate organisms and their ecological niches to evolutionary change and extinction. (DOK 3)

b. Compare and contrast the major components and functions of different types of cells. (DOK 2)
   - Differences in plant and animal cells
   - Structures (nucleus, cytoplasm, cell membrane, cell wall, mitochondrion, and nuclear membrane)
   - Different types of cells and tissues (e.g., epithelial, nerve, bone, blood, muscle)

c. Describe how viruses, bacteria, fungi, and parasites may infect the human body and interfere with normal body functions. (DOK 1)

d. Describe heredity as the passage of instructions from one generation to another and recognize that hereditary information is contained in genes, located in the chromosomes of each cell. (DOK 2)
   - How traits are passed from parents to offspring through pairs of genes
   - Phenotypes and genotypes
   - Hierarchy of DNA, genes, and chromosomes and their relationship to phenotype
   - Punnett square calculations

e. Explain energy flow in a specified ecosystem. (DOK 2)
   - Populations, communities, and habitats
   - Niches, ecosystems and biomes
   - Producers, consumers and decomposers in an ecosystem

f. Develop a logical argument for or against research conducted in selective breeding and genetic engineering, including (but not limited to) research conducted in Mississippi. Examples from Mississippi include the following: (DOK 3)
   - The Animal Functional Genomics Laboratory at Mississippi State University
   - The Stoneville Pedigreed Seed Company in Stoneville, MS
   - Catfish Genetics Research Unit at the Thad Cochran National Warm Water Aquaculture Center in Stoneville, MS

g. Research and draw conclusions about the use of single-celled organisms in industry, in the production of food, and impacts on life. (DOK 3)

h. Describe how an organism gets energy from oxidizing its food and releasing some of its energy as heat. (DOK 1)
APPENDIX B

BIOLOGY LABORATORY CURRICULUM

I. Simple Observation: *Exploring Science*

Overview
What is science? If you ask five people sitting around you, you will probably get five different answers. Within your group discuss science and develop a definition for “science.”

One process of science is a method for solving problems or discovering answers. The beginning of this process is to make observations. You have heard of this so-called scientific method before. Have you ever competed in a science fair? Written a science lab report? These events use the scientific method to find answers to problems.

The science process has steps.
1. **Observation.** Observe the events/area. Observation is an essential first step. The observations you make will allow you to identify the problem.

2. **State the problem.** Write the problem out in sentence/question form. Be very clear about the problem.

3. **Hypothesis.** Most everyone remembers the classic definition: an educated guess. But what does that mean? Once you have identified the problem, you must do background research. Go to the library and use the books available. Search the internet for reliable information about the problem. The hypothesis must be testable; you must be able to run an experiment on the hypothesis.

4. **Experiment.** An experiment is a series of steps which will allow you to collect data. The goal of the experiment is to gather data that will either support your hypothesis or provide a reason to reject your hypothesis. The steps of an experiment must be written in clear, concise statements.

5. **Conclusion.** Was your hypothesis correct? How do you know? A written conclusion is where you explain whether or not the data supports your hypothesis. It is very important to note that a hypothesis is never proven wrong. There is always the possibility that human error or chance interfered with the experiment. If the data does not support the hypothesis, we say that we reject the hypothesis.
Observations
Observations are made using the senses and by making measurements. There are two types of observations: qualitative and quantitative.

Quantitative observations are those that can be measured in units. For example, the length of an unsharpened pencil is 19 centimeters. Length is a quantitative observation, as are volume, density, mass, weight, etc.

Qualitative observations are those that cannot be measured in units. For example, the flower is red. Red cannot be measured in units. Neither can smell.

Activity 1: Observing
The instructor will place an object on a table for all to see. In the space below write observations about the object. List them as quantitative or qualitative. For your quantitative observations, you may make approximate measurements. Include a rough drawing of the object to illustrate your observations.

<table>
<thead>
<tr>
<th>Quantitative Observations</th>
<th>Qualitative Observations</th>
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</table>

What is the object which you are observing?

Inference occurs when you take observations and derive an answer or explanation for an event. It is an interpretation of data or events and put into perspective based on what is already known.

When a researcher tests the water in a lake, he is getting only samples of that water to test. He may test the water’s pH, dissolved oxygen content, or heavy metal content. From his results he may infer that all the water in the lake would have the same results as his sample.
What did you infer about the mystery object?

_____________________________________________________________

What could you have done that would give you better observations?

Activity II. Writing Steps
Experiments are steps taken to provide data that will either prove or reject the hypothesis. Each step of an experiment must be clearly written so that other researchers may follow the steps to repeat the experiment.

Imagine that you have made radio contact with another planet and have met the inhabitants of that planet. You are asked, “What is your favorite snack?” At first you cannot think of a response. Then the obvious, simplest snack food comes to your mind – a peanut butter and jelly sandwich! Then these friendly aliens ask you for instructions on how to make this wonderful snack.

Write out the steps for making a peanut butter and jelly sandwich. You do not have to use all the lines provided. You may need to add lines, if you find ten lines are not enough.

1. ___________________________________________________________
2. ___________________________________________________________
3. ___________________________________________________________
4. ___________________________________________________________
5. ___________________________________________________________
6. ___________________________________________________________
7. ___________________________________________________________
8. ___________________________________________________________
9. ___________________________________________________________
10. ___________________________________________________________

Share your list with your team. Make any changes to your list. Turn in a copy of your instructions to the instructor.

Now let’s make a sandwich. The instructor will give the “alien” on the other end of the radio signal the instructions you’ve written. This alien will do exactly as you’ve instructed.

Were the results what you intended? What happened?

If you were to write the procedure again, what would you add or change?
Activity III. Using Laboratory Equipment

Measurements (quantitative observations) are part of most experiments. Understanding how to properly use available equipment to make measurements is also critical to the success of an experiment.

A measurement is a number with an attached unit, such as 3 meters. A meter is a measurement of length. Other measurements include grams (mass) and liters (volume). Each of these is measured with equipment found in all science labs. Mass is determined using a balance scale. Mass is not the same as weight. Mass is the amount of matter in an object. Weight is the measure of the pull of gravity on an object.

Balance scale
To use a scale, you must first make sure that the riders are on 0. Next check the pointer. It should point to 0. If it does not, the scale must be adjusted so that the pointer does indicate 0. This is called “zeroing” the scale.

For this activity, your group will be given a “mystery” object. Keep your object hidden from the other groups.

The idea of the scale is to have an equal mass on both pans. Place your object the left pan of the scale.
Describe the object.
______________________________________________________________

Are your descriptions quantitative or qualitative? _______________________

What did the pointer do? Of course, since there is more mass on the left pan, it lowered toward the table. This is the pull of gravity on the object’s mass. Our next step will be to place masses on the right pan until the pointer returns to zero. This process may take some time. Masses will be added / taken away before you have determined the mass of the object.

What is the mass of the object?
________________________________

Metric ruler
How do you use a ruler? We all know how to use one….or do we? In science, the metric system is used to make measurements. The first step is to place the ruler by the object so that one end of the object is at the 0 line of the ruler. The 0 line is not always the end of the ruler. This is a common measurement mistake of students: using the end of the ruler as the 0 line. To identify a length, it is best to look directly down at the opposite end of the object.
What is the length of your object? ________ cm
What is the width of your object? ________ cm
What is the height of your object? ________ cm

**Volume**
To find the volume of the object, multiply its length x its width x its height. The unit for the volume measurement will be cm$^3$. (cm x cm x cm)
What is the volume of your object? ________ cm$^3$

**Density**
Density is the amount of matter found in a certain space. In other words it is the mass in a volume. To determine density, simply divide the mass by the volume. The formula for doing this is

\[
\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{or} \quad \frac{m}{V}
\]

The unit for density is a derived unit. It is a combination of two original units. In this case, mass is measured in grams. Volume is measured in cm$^3$. The derived unit for density would be g/cm$^3$.

When you’ve completed these measurements, place your object back into its box. Give the box to the instructor who will then remove it from view. Try doing this without a calculator.
What is the density of your object? ______

Now check your math using the calculator.

Once all groups have turned in their objects, the groups will complete the chart listed on the board. Fill in this chart as you go.

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Mass (g)</th>
<th>Length (cm)</th>
<th>Width (cm)</th>
<th>Height (cm)</th>
<th>Volume (cm$^3$)</th>
<th>Density (g/cm$^3$)</th>
</tr>
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</table>

Can you match the mystery object with the group that originally had the object? How can this be done? You just have to repeat the measurements on each object (including your own – if you leave it off, then the other groups will know which one was your original object!)
How accurate were you in matching each object with the group that measured that object?

_______________________________

Did the measurements help you to identify each groups object?

_______________________________

How important are quantitative observations in science? Explain your answer.

________________________________________________________________

________________________________________________________________

Why would having only qualitative observations not be beneficial in science?

________________________________________________________________

________________________________________________________________

Is mathematics a part of science? Certainly scientists need the measurement and calculation skills in order to correctly measure and identify objects. We will continue using mathematics as we explore more biology.

Mississippi 2010 Science Framework (2008) connections:

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Competency Number</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>1</td>
<td>c. Identify simple tools used to gather information.</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>c. Use simple tools to gather information</td>
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<tr>
<td>2</td>
<td>1</td>
<td>c. Use simple tools to gather information</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>c. Select and use simple tools to gather information d. Draw conclusions and communicate results of an investigation.</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>b. Use the senses and simple tools to gather qualitative information about objects or events. c. Demonstrate the accurate use of simple tools to gather and compare information. d. Use simple sketches, diagrams, tables, charts, and writing to draw conclusions and communicate data results. f. Explain why scientists and engineers often work in teams with different individuals doing different things that contribute to the results.</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>b. Distinguish between observation and inferences.</td>
</tr>
</tbody>
</table>
c. Use precise measurement in conjunction with simple tools and technology to perform tests and collect data.
e. Use drawings, tables, graphs, and written and oral language to describe objects and explain ideas and actions.

| 6  | 1    | b. Distinguish between qualitative and quantitative observations and make inferences based on observations.
c. Use simple tools and resources to gather and compare information.
d. Analyze data collected from a scientific investigation to construct explanations and draw conclusions.
e. Communicate scientific procedures and conclusions using diagrams, charts, tables, graphs, maps, written explanations, and/or scientific models. |
| 7  | 1    | b. Discriminate among observations, inferences, and predictions.
c. Collect and display data using simple tools and resources to compare information.
d. Organize data in tables and graphs and analyze data to construct explanations and draw conclusions. |
| 8  | 1    | b. Distinguish between qualitative and quantitative observations and make inferences based on observations.
c. Summarize data to show the cause and effect relationship between qualitative and quantitative observations.
d. Analyze evidence that is used to form explanations and draw conclusions. |

1. What do you notice about the objectives?
2. What is the theme of these objectives?
3. Is there a “flow” between the grades? Describe the flow.
II. I See You!! *Exploring Microscopes*

Microscopes are common tools of science. When you break down the term microscope, you find the root word “-scope” and the prefix “micro-.” You’ve heard the phrase, “Scope it out.” What is the person doing when using this term? The person is simply looking around. We can infer that scope means to look. The prefix “micro-” means small, as in tiny. We use microscopes to examine small specimens that we cannot see clearly with our eyes. Microscopes magnify specimens so that details can be seen.

This tool of science has a great history. We didn’t always have this tool. Just how did it come to be and who developed it? When did all this take place? Write what you know here: __________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

Don’t feel bad if you didn’t have much to write. Not many people do know the history of the microscope. We will not focus on the who and when; we’ll explore the how. It all begins with a drop of water.

**Activity I: Just a Drop**

Place a piece of newsprint on the table in front of you. Cover the newsprint with a square of clear plastic. Using a dropper, place a drop of water on the plastic of a word. Explain what you see.

________________________________________________________________

________________________________________________________________

________________________________________________________________

The letters may seem distorted through the water drop. Water acts as a magnifier. As light passes through the water, the curved surface of the water drop increases the size of the letters. This is magnification.

Once glass was created, rounded pieces were used to assist people in reading. It was soon used to increase the size of objects for intense scrutiny. Some of the original magnifiers were glass orbs filled with water. Later, solid glass orbs were used to help people see. These lenses became mounted into frames in the 1200’s and were called spectacles. This happened in Italy. It was not long before this original idea throughout the civilized world.

How does a microscope work? Light passes through a lens. As it does, the lens bends the light. When we add another lens the light is bent again. By changing the distance between the lenses, we can see a magnified image of the specimen.
Modern Microscopes

Today we use microscopes called compound light microscopes. It is compound because it has more than one lens. As we discuss the microscope, fill in the spaces with the names of the microscope’s parts.

Activity II: Slide Construction

A slide is usually made using a rectangular glass or plastic slide, a square cover slip, and a specimen. The type of slide that we will be making is called a wet mount slide. As the name implies, we will be using water to mount the specimen. This simple science skill is one that is always a hit in most classrooms. The materials you will need for this activity are:

- glass slide
- cover slip
- scissors
- paper towel
- newspaper
- pipette
- tweezers
- water
Caution! Handle the slide and the cover slip by the edges only. Fingerprints will smear. If the slide or cover slip need cleaning, use the provided tissue to wipe them.

1. Find a lower case "e" in the provided newspaper. It should be the normal reading font size and should be a black "e" on a white background.

2. Cut out the "e" only.

3. Place the e on the slide so that you can read it.

4. Put one drop of water on the e. If the e turns upside down, use the tweezers to reposition it.

5. Use the tweezers to lift the cover slip and hold it at a 45º angle over the slide. Position the cover slip so that the e will be in the middle of the cover slip once the slide is made. Look at this example.

6. Lower the cover slip into place over the letter e.

7. If there is an excess of water, use the edge of a paper towel to pull the water out. If you have air bubbles, use the eraser end of a pencil to gently tap on the cover slip. This will force the air bubbles out.

8. Place the slide onto the microscope so that you can read the letter e by looking at the stage.

9. Check the microscope. Is the low power objective (4x) directly below the body tube? If not, rotate the revolving nose piece so that the low power objective is in the light path. Adjust the amount of light for your eyes.

10. Use the coarse adjustment to bring the stage as close as possible to the objective lens.

11. Look through the ocular. Use the coarse adjustment ONLY knob to bring the specimen (letter e) into focus. Draw the image you see exactly.
How does this different from how the e looks normally?

________________________________________________________________________

12. Without moving the coarse adjustment, rotate the revolving nosepiece so that the 10x objective is in the light path. Use the fine adjustment to bring the e back into focus. Draw what you see.

How is this different than the 4x objective view?

________________________________________________________________________

13. Carefully rotate the 40x objective into the light path. Use the fine adjustment to bring the e back into focus. Draw what you see.

How is this different than the 10x objective view?

________________________________________________________________________

How does the field of view change as you switch from low power (4x) objective to high power (40x) objective?

________________________________________________________________________

Select other letters from the newspaper. Make wet mount slides with these letters.
What letter(s) would not be useful in this activity?

Why?

________________________________________________________________________
How might a dry mount (making a slide without adding water) appear different in a microscope? ________________________________________________
________________________________________________________________

Other factors affect your success in viewing a specimen. The thickness of the specimen is also critical to the slide. The specimen must be thin in order for light to travel through it. The amount of light also affects how well you see the specimen.

Activity II: Microscope Inquiry Lab

Now that you have mastered the basics of microscopy (the use of microscopes) you should try your skill with different materials.

This part of this lab is geared toward inquiry. Inquiry is identifying a question and developing an answer through experience. Within your group discuss a possible question that you will now investigate using the microscope. (Need a hint? Look at the factors that affect microscopic viewing.)
Our question:
________________________________________________________________
________________________________________________________________

Our experiment steps: (If more room is needed, write the steps on notebook paper.)

Our results: (Use drawings if they will help explain your answer.)

Prepare to report your group’s findings to the class. Develop a presentation with visual aids.

In the elementary classroom, compound light microscopes may not be available. Simpler microscopes are available at low costs. These often come with prepared microscope slides that can be used within a unit.
Mississippi 2010 Science Framework (2008) connections:
Review the competencies listed below.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Competency Number</th>
<th>Objective</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>c. Use simple tools (e.g. rulers, scales, hand lenses, thermometers, microscopes) to gather information.</td>
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<tr>
<td>2</td>
<td>1</td>
<td>c. Use simple tools (e.g. rulers, scales, hand lenses, thermometers, microscopes) to gather information.</td>
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<td>c. Use simple tools (e.g. rulers, scales, hand lenses, thermometers, microscopes) to gather information.</td>
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<td>4</td>
<td>1</td>
<td>b. Demonstrate the accurate use of simple tools to gather and compare information. d. Use simple sketches, diagrams, tables, charts, and writing to draw conclusions and communicate data results.</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>c. Use precise measurement in conjunction with simple tools and technology to perform tests and collect data. e. Use drawings, tables, graphs, and written and oral language to describe objects and explain ideas and actions. h. Infer and describe alternate explanations and predictions.</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>c. Use simple tools and resources to gather and compare information (using standard, metric, and non-standard units of measurements).</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>c. Collect and display data using simple tools and resources to compare information (using standard, metric, and non-standard measurement). h. Make relationships between evidence and explanations.</td>
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1. What do you notice similar between grades? ____________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

2. Why are these similarities important between the grades? ____________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

3. What part did you play in this lesson today? Were you actively involved or were you an observer? ____________________________________________
__________________________________________________________________________________
III. **Tiny Rooms: Exploring Cells**

Last class we explored how to use a microscope. Today we will use that skill to see tiny rooms called cells.

Robert Hooke is credited with first identifying cells. Using a compound microscope, he looked at cork cells from a tree. He thought that the specimen in his ocular resembled the tiny rooms that were found in a monastery. These tiny rooms were called cells. Robert Hooke chose to use this term to describe what he saw. His discovery has led many to explore the “tiny rooms” that make up living things. After additional work by other scientists, the cell theory was accepted. There are three parts to the cell theory:

1. The cell is the simplest unit of life; it is the building block of life.
2. All living things are made of cells.
3. Cells may only come from existing cells.

There are two types of cells: prokaryote and eukaryote. The prefix “pro-” means “before in time.” Prokaryotes are the earliest known cells. They preceded eukaryotes. Prokaryotes are the simplest forms of life.

Prokaryotes are single-cell (unicellular) organisms that have a cell wall, cell membrane, cytoplasm, ribosomes, and circular DNA which is usually attached to the cell membrane. Many have cilia or flagella to help them move. Look at this illustration:

As you and your group read through the passage below, label the parts of the prokaryote above:

**Tour of a Prokaryote:**
As we approach the prokaryote we see that it has a cell wall that surrounds the cell and acts as protection for the cell. It also gives the cell its shape. Ordinarily,
most things would not be able to enter through the cell wall. It is very selective about what enters and exits the cell. Just inside the cell wall is a cell membrane. This thin barrier allows certain substances to pass through. It is semi-permeable. Once past the cell membrane, we find ourselves floating in a thick gel-like substance called cytoplasm. We can see through it enough to notice some darker objects floating in the cytoplasm. These dark circular objects are the ribosomes. In prokaryotes, the ribosomes make proteins that the cell needs to maintain its life. As we travel through the cytoplasm we approach a large circular object. We can see that it is a band that has been looped around and attached to the cell membrane. This is the DNA of the prokaryote. The DNA has the instructions for making proteins.

Tour of a Eukaryote:

Eukaryotes are larger and more complex than prokaryotes. They have many more “working parts” called organelles. Much like organs in our bodies, the organelles all have specific jobs. Look at the chart below. Fill in the information that you can recall.

<table>
<thead>
<tr>
<th>Organelle</th>
<th>Job (function)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleus</td>
<td>The “control center”: it contains instructions for the cell</td>
</tr>
<tr>
<td>Cytoplasm</td>
<td>The “filler”: this gel-like substance fills out the cell</td>
</tr>
<tr>
<td>Cell membrane</td>
<td>The “gateway”: this membrane allows only certain substances to enter or exit the cell</td>
</tr>
<tr>
<td>Cell wall</td>
<td>The “frame”: this gives support and shape to plant and fungi cells</td>
</tr>
<tr>
<td>Ribosomes</td>
<td>The “workers”: these make proteins that are used by the cell to make new organelles</td>
</tr>
<tr>
<td>Mitochondria</td>
<td>The “powerhouse”: breaks down sugars to give the plant energy</td>
</tr>
<tr>
<td>Endoplasmic Reticulum</td>
<td>The “highway”: this connects the cell membrane with the nucleus and is the main path of transport for substances in the cell</td>
</tr>
<tr>
<td>Golgi Apparatus (aka: Golgi Body or Golgi Complex)</td>
<td>The “receiving and distribution center”: this receives large proteins from the ribosomes and separates them so that other organelles can use the proteins</td>
</tr>
<tr>
<td>Vacuole</td>
<td>The “warehouse”: this is a storage facility</td>
</tr>
<tr>
<td>Lysosome</td>
<td>The “garbage collector”: this takes in</td>
</tr>
</tbody>
</table>
waste such as old cell parts and breaks them down

In this lab, you will not see most of these organelles. They are too small to be seen with our microscopes.

Materials needed for today’s laboratory:
- microscope
- slides
- cover slips
- sharp edge (knife, razor blade, etc)
- onion section
- tooth pick
- iodine
- water
- pipette
- tweezers
- methylene blue
- paper towel

Caution! Use gloves, goggles, and aprons for this lab. Sharp objects will be used.

If you have a digital camera, you can use it today to take photos.

We will all explore the same question today:
What is the difference between plant cells and animal cells?

Review the materials list above. How can we explore the differences between plant and animal cells? Obviously we will use the microscope.

How can we make a slide out of an onion section? It is definitely too thick to put on as it is, so what is our solution? Look at the onion section from the side. It is made of layers. Remove one of the layers. Break the layer from the outer curve in to the inner curve. You will find a thin skin. This is what we will use to make our slide. (Remember, the thinner the specimen the easier it is to study it with a microscope.)

Task #1: Make a wet mount slide of the onion skin using stain
1. Prepare your slide for a wet mount by placing 1 drop of water on the slide.
2. Using the sharp edge, cut a cm² section of onion skin. With the tweezers, place cut onion skin on the drop of water.
3. Add 1 drop of iodine on top of the cut onion skin.
4. Place the cover slip onto the slide.
5. Use absorbent paper to remove excess iodine stain.
6. Observe the onion skin through the microscope under low power. Draw what you see.
7. Change to the high power lens. Draw what you see.

Now you see larger images of the cells. Inside are circular objects. What are these?

Why is the image larger? If you said that the image is larger because you are using a lens with greater magnification, you’re right. What happens to the field of view? Field of view is the circle of light that you see when you look through the ocular. There may not appear to be a change, but actually the field of view has changed. As the magnification increases, the field of view decreases. In other words, as you increase the size of the image, the field of view narrows toward the center of the image.

Task #2: Making an animal cell slide

1. Gently rub the inner cheek lining with one end of a toothpick. Do not dig into the cheek. A gentle rub is all it will take.

2. Wipe the end of the toothpick on the center area of a dry slide.

3. Use another toothpick to make a second rub on the inside of a cheek and wipe the end of the second toothpick onto the slide in the same area.

4. Drop one drop of methylene blue on the slide in the area of the rubs.

5. Place the cover slip onto the slide.

6. Use an absorbent paper to remove excess stain.
7. Find the animal cells using the low power objective. Draw and describe what you see.

Find an area where the cells are not clumped together. It is best if there are fewer cells. Place cells in the center of the field of view. If the cells are not directly in the center, then they will not appear in the field of view on higher power objectives.

8. Switch to the high power objective and bring the cells into focus. Draw and describe what you see.

Based on your results, what are the differences between plant and animal cells?

________________________________________________________________
________________________________________________________________
________________________________________________________________

Both of these (animal and plant cells) are eukaryotes. They have a true nucleus and membrane-bound organelles. The main differences between plant and animal cells are:

1. Plant cells have a cell wall made of cellulose. This was the heavy, dark outline of the onion cell specimen.

2. Plant cells have chloroplasts. Chloroplasts have chlorophyll, the green pigment that plants use to trap sunlight for photosynthesis. This was not seen in the onion cell specimen. The bulb part of the onion grows underground and therefore will not have chloroplasts.
3. Plant cells have a central large vacuole that regulates the water use for a plant. Animal cells will have smaller vacuoles used to temporarily store wastes and water.

Mississippi 2010 Science Framework (2008) connections:
Review the competencies listed below.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Competency Number</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>c. Use simple tools (e.g. rulers, scales, hand lenses, thermometers, microscopes) to gather information.</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>c. Use simple tools (e.g. rulers, scales, hand lenses, thermometers, microscopes) to gather information.</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>c. Use simple tools (e.g. rulers, scales, hand lenses, thermometers, microscopes) to gather information.</td>
</tr>
</tbody>
</table>
| 4           | 1                | b. Demonstrate the accurate use of simple tools to gather and compare information.  
d. Use simple sketches, diagrams, tables, charts, and writing to draw conclusions and communicate data results. |
| 5           | 1                | c. Use precise measurement in conjunction with simple tools and technology to perform tests and collect data.  
e. Use drawings, tables, graphs, and written and oral language to describe objects and explain ideas and actions.  
h. Infer and describe alternate explanations and predictions. |
| 6           | 1                | c. Use simple tools and resources to gather and compare information (using standard, metric, and non-standard units of measurements). |
| 7           | 1                | c. Collect and display data using simple tools and resources to compare information (using standard, metric, and non-standard measurement).  
h. Make relationships between evidence and explanations. |

1. What did you notice similar between grades?
________________________________________________________________
________________________________________________________________

2. What is different between grades?
________________________________________________________________
________________________________________________________________
3. What was your role in doing this laboratory exercise?
________________________________________________________________
________________________________________________________________

4. Which is the best way for you to learn: as an observer or as an active participant?
________________________________________________________________
________________________________________________________________

5. Did this laboratory experience add to what you already knew about cells?
___________ Explain: ________________________________________________
IV. It’s Not Easy Being Green! *Exploring Plants*

Think of the color green. Quickly, list three organisms that are green.
__________________________, ____________________________,
________________________

Did you list frog, grasshopper, and plant? Possibly you listed others, but chances are that you listed one or more plants, either in general or with specific names, i.e. mint. Its green color is very important to a plant. We will explore this as well as other features of the plant in this session.

Breathe in. Breathe out. Breathe in. Breathe out. What are we breathing in?
____________________

What do we breathe out? ______________________

Breathing is essential for life, but do all living things (called organisms) inhale oxygen and exhale carbon dioxide? At first we may think of organisms that live in the water as not breathing, but we need to understand what “breathing” actually is.

Breathing is a gas exchange. It is trading one important gas for another. In our bodies, we breathe in oxygen. This oxygen is used to change sugars into energy. One of the leftover substances is carbon dioxide. If carbon dioxide builds up in our blood, it can lead to death. Therefore we must get it out of our bodies through exhaling. Most water organisms go through this same process which is called respiration. They take oxygen from the water and give off carbon dioxide. Plants, however, are another story. Do plants breathe? If we call “breathing” gas exchange, yes, they do. Plants take in carbon dioxide, use it to make their food, and release oxygen as a waste product. This process is called photosynthesis. Plants also change the sugars they make into energy when they grow and make flowers and fruit. Therefore, plants also breathe in oxygen and give off carbon dioxide. They conduct photosynthesis in their organelles called chloroplasts and respiration in the organelles called mitochondria.

What makes a plant a plant? Think of any plant and draw it in the space below. Label the parts of the plant.

Share your drawing with your group. Did all in your group draw the same plant? Your group probably has four different plants drawn. There are thousands of different plants. There are some plants that are yet to be discovered! However, all plants share basic structures: roots, stems, and leaves.
Leaves
We'll start our exploration of plants with the most obvious part – leaves. We see them every day. Look at the provided leaf specimens. Use your senses of sight, touch, smell, and sound to make discoveries about these leaves.

*Caution! Never taste anything in the lab unless specifically told to do so.*

Fill in the data table below with your observations.

<table>
<thead>
<tr>
<th>Leaf</th>
<th>Color</th>
<th>Shape</th>
<th>Texture</th>
<th>“Shine”</th>
<th>size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnip Leaves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine Needles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnolia leaves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Leaves come in a variety of sizes, shapes, colors, textures, and "shine." These traits are often used to identify the type of plant being studied. Leaves are a large part of our diet. From our samples, which are edible?

____________________________________________________________________

What are some other leaves that you have eaten?

____________________________________________________________________

Leaves provide us with a food source, but their purpose is much greater. Leaves trap sunlight and change carbon dioxide and water into sugar and oxygen. Next, we'll go to the opposite end of the plant – the roots.

Roots
Roots are another source of food. What food have you eaten that may be a root? Carrots are the first to come to most people’s minds.

Why do plants have roots?

____________________________________________________________________

____________________________________________________________________

In this activity you will work with a partner. You and your partner will need the following materials:

Large piece of paper (newspaper sheet)  Potted plant
Marker  Ruler
Place the sheet of paper on the table. Put your hand (palm down) over the soil surface of the potted plant, placing the stem between your fingers.

*Caution: Do not pull on the stem. It breaks easily.*

Holding the potted plant over the paper, carefully turn the plant upside down. (The paper will catch dropping soil.) Gently wiggle the plant and soil back and forth in the pot until the plant is free of the pot. Set the pot aside.

Turn the plant right side up and gently shake it so that the soil comes loose. Return the soil to the pot.

Look at the roots. At first they may seem a tangled mess, but study them more carefully. What do you see? Make a drawing of the roots.

Roots have a branching pattern, very similar to the top of the plant.

Lay the plant on its side on the paper. Using the marker, trace the outline of the plant onto the paper. Label the roots stems and leaves on your outline. Set the plant gently back into the pot.

Using the metric ruler, measure the width and height of the leaf outline and the root outline. Do not include the stem in your measurements.

Root area: Width ______________ cm   Height ______________ cm

Leaf area: Width ______________ cm   Height ______________ cm

How do the two areas compare?
________________________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

In most plants the root area is equal to or greater than the leaf area. Why do plants need such a large spread of roots? Discuss this in your group and develop two reasons for the large spread of roots.

1. ___________________________________________________________________

   ___________________________________________________________________

2. ___________________________________________________________________

   ___________________________________________________________________

Actual reasons:
Types of roots
Many plants have a single large root (called a tap root) that grows deep into the ground. Smaller roots will grow from this tap root. A carrot is a classic example of a tap root. When you bite a carrot, it will usually have a sweet taste. The carrot stores food for the plant, hence the sweet taste.

A second type of root is fibrous root. Smaller plants will have this type of root. These spread out, some may grow deep. Generally, fibrous roots are found on plants that live in areas where there is too much water or too little water.

Which type root does your potted plant have? __________________________

Connecting Root to Leaf
Twenty-four hours before class, celery stalks were placed in water colored with food coloring. Roots absorb water and nutrients from the ground. This is a very simple activity that is always a success in classrooms.

Leaves capture sunlight and conduct photosynthesis. The roots need the sugar made during photosynthesis. The leaves need water and nutrients. How do these substances get from one location to the other?

Water and nutrients move through a plant similarly to the way water moves into and out of a house. Pipes bring water into your house and then into specific rooms. More pipes take waste water out of your house. Plants, too, have a series of pipes. These however are not made of metal or plastic. Plants are living things made of cells. The plant “pipes” are made of two special cell types, xylem and phloem. Xylem cells are stacked end to end making them look like a straw. These cells have openings in the cell walls (called pits) that allow water and nutrients to move from the root to the leaf. Phloem cells also are stacked and have openings in the cells walls. Water does not travel through this “pipe.” The path of the phloem is opposite to the path of the xylem. Xylem transports up the plant, so phloem must transport __________ the plant. Phloem connects the leaf to the root. What is made in the leaf and is needed by the root? __________________________

Xylem and phloem are usually found in bundles. This bundle is referred to as vascular tissue. The tougher xylem surrounds the living phloem. Let’s look at some of these.

Remove the celery stalk from the beaker and set it on the paper. Describe what you see.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
What became stained with the food color, xylem or phloem?

Explain the reason for your choice.

Use the provided sharp edge at the cut end of the celery stalk to carefully cut beneath a colored tube in the celery. Lift the tube gently. As you lift you will see that it will come loose from the rest of the celery, making that connection from root to leaf.

Use the blade to cut several cross sections. Draw what you see as you look at the cross section.

The vascular bundles are organized and spaced throughout the plant stem. Remember, the outer cells of this bundle are the phloem, which transports food from the leaf to the root.

**Plant Food**

Let’s return to the fact that most plants are green. What structure inside the plant cell gives a plant its green color?

Chloroplasts are cell organelles that contain the pigment chlorophyll. Chlorophyll traps sunlight. Sunlight contains all colors of light. Chlorophyll traps all colors but green light. The green light is reflected and is picked up by our eyes.

Plants need food. Their roots hold them in the ground, so they cannot move around and hunt. Plants are adapted so that they can make their own food through photosynthesis. First let’s look at the word. “Photo-” refers to light, “-synthesis” means to make. When you connect these terms, you have “make light.” Plants cannot make light; they can, however, use the light to make food. Plants use the energy in light to combine carbon dioxide and water. This is the “inhale” part of their gas exchange. Plants “exhale” oxygen. They also make sugar. Some of this sugar is used by the plant to keep itself alive — it provides energy for the plant and is used to make cell parts. Most of the sugar is stored for later use.

To sum up photosynthesis, we can write its formula:

\[ \text{carbon dioxide} + \text{water} + \text{energy} \rightarrow \text{sugar} + \text{oxygen} \]
We use the sugar and oxygen to keep ourselves alive. The exchange of carbon dioxide for oxygen is a cycle we participate in with plants. We harvest the plants for our food. We cannot live without the plants.

**Chromatography**

Chromatography is a process where colors are separated from a substance. ("Chrom-" means color.) Materials needed for this activity are:

- food coloring (yellow, blue, green, red)
- filter paper
- beaker
- ruler
- water
- pencil
- tape
- water
toothpicks

Caution: Do NOT use ink on the filter paper. *Why not use ink?*

Refer to the diagram to the side in order to complete the set up of this activity. Using a pencil, draw a line 2 cm from the bottom edge of the filter paper. Draw 4 small circles on the line, making sure that the circles are small and have a cm distance between them. Label the circles by placing these letters below each circle: R, Y, B, G. Use a toothpick to place a small dot of redfood color inside the circle labeled R. Do the same with the yellow, blue and green food colors, using a different toothpick each time. Allow the color to dry and reapply the colors. Curl the paper so that it forms a cylinder. The line with the color dots should be at the bottom. Apply a small piece of tape vertically to hold the edges of the paper together. Add a small amount of water to the beaker. The level of the water must be BELOW the line on the filter paper. Place the paper inside the beaker so that it stands without touching the sides of the beaker. What happens? _______________________________________________________________________

When the water level has reached the top of the paper (or has stopped moving) remove the filter paper from the water and allow it to dry. To dry, remove the tape so that the paper may open. Using the pencil, draw a line at the top of the water level. Place a piece of tape on the top of the paper and attach the paper to the side of the table. While it hangs it will dry.

After drying, lay the paper on the table and locate the top of each color that has separated out during the activity. Using the ruler, measure the distance the color has traveled from its point of origin to the top of its color. Complete the data table below with your information. (Remember: In science, the SI units are used. Make your measurements in centimeters.)
The next step is to measure the distance that the solvent traveled. To do this, you must measure from the line near the bottom of the paper to the top of the solvent line. What is this measurement? _____________ cm

To calculate $R_f$ value:

$$R_f = \frac{\text{Distance traveled by color}}{\text{Distance traveled by solvent}}$$

Use this area to calculate the $R_f$ value for each color seen.

Red:

Blue:

Yellow:

What did you discover about green?

This same process is used to identify unknown substances. Colors often separate in very specific ways. Our next activity will use chromatography, but instead of water being our solvent, we will use nail polish remover (isopropanol or acetone). Our colors will come from the leaves we used earlier.

Other materials include: a plastic knife, filter paper, pencil, ruler, beaker, tape

Set up the filter paper strip as before. Lay one leaf on the paper. Using the dull side of the plastic knife, firmly rub a line on the 2 cm mark from the edge of the paper.

The mark you make must be a single line of green across the paper. Label the strip at the bottom with the leaf name. Why is it necessary to label?
Labeling is part of “good science.” It helps us keep accurate records during our experiments.

Once the strip is dry observe the results. How many colors did the chromatography show? __

What does each of these colors indicate?
_________________________________________

Depending on the time of year, the results may show 1 to 4 colors. Each color is a pigment found in the leaf. Photosynthesis takes place in the chloroplast of plant cells. Inside the chloroplast, pigments trap energy from sunlight. Pigments absorb certain colors of light in the light spectrum. The color you see is actually the light that is not absorbed; it is the light that is reflected to our eyes. Plants need different pigments in order to get as much light energy as possible.

There are 3 main types of pigments: chlorophyll, carotenoids, and phycobilins. Chlorophyll is the best known pigment. There are several kinds of chlorophyll. Chlorophyll “a” is the most important as it makes photosynthesis possible. All chlorophyll has a green color.

Carotenoids may be red, orange or yellow. Phycobilins may be red or blue in color.

Based on this information, how many pigments are found in the leaf of the leaf you used? __ What pigments are most likely shown? ______________________

Would the leaves from other plants have the same pigments? How would find the answer to this question? Briefly describe an experiment that you could conduct to find the answer.

Mississippi 2010 Science Framework (2008) connections:

Using the provided Mississippi 2010 Science Framework, complete the chart below by identifying the competencies and objectives that these activities best fit.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Competency Number</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
If more space is needed, insert additional pages.
V. ID Me! Exploring Classification and Keys

People tend to classify everything in order to better understand its purpose. Take a moment and think about your home. In your mind, enter your bedroom and go to your chest of drawers. How do you have the contents organized? This drawer will hold your socks. That drawer may hold your shirts. This is one of the many ways we use classification. It is much easier to find your items of clothing when you have a system that is organized. Biologists organize living things in order to understand how they function, as individuals, as a species, and in a community.

Activity I: Sorting
The simplest way to organize is by grouping. Your group will be given a bag of items. Your first task is to develop as many ways to classify the items as possible. Make a list of the methods your group uses to classify the items.

This is the beginning of a classification key. The items you were given have similarities and differences. With each grouping your team developed, you were really asking a “yes” or “no” question. For example, one of your groupings may have been “Is the item orange?” As you observed each item you would divide the items into two groups: 1) yes, it is orange or 2) no, it is not orange. From these two original groups, you could still further divide the items into smaller and smaller groups by asking more “yes” or “no” questions. Choose one of the methods you developed. Write that question here:

________________________________________________________________

Sort the items by this question. Next, set aside the items that are in your “no” pile. Look only at the “yes” pile. How can you separate these into two smaller groups? What question will you ask in order to separate these items? Keys are developed in a manner similar to this.

Dichotomous keys focus on the special traits (characteristics) that make each object unique from the others. You might separate the members of this class into groups such as male and female. The dichotomous key might look like this:

Go to
1. A. Male ……………………………………………………………….. 2
   B. Female ……………………………………………………………….. 3
2. A. Brown hair…………………………………………………………….. 4
To use the key, start with # 1. Pick the characteristic that fits the object, and then follow the line to the number on the right. This number represents another characteristic to help identify the object. Let’s try using a simple dichotomous key.

Activity II: Alien ID

Study the “alien” below. The goal is to put a name with the alien.

Alien A:

Go to

1. The body is round ............................................. 2
   The body is square ............................................. 5

2. The head is round ............................................. 3
   The head is square ............................................. 8

3. 2 eyes .......................................................... 4
   3 eyes .......................................................... 10

4. Triangular pupils ................................. Betty Bloop
   Circular pupils ................................. Freda Floop

5. The head is round ............................................. 6
   The head is square ............................................. 11

6. 2 eyes .......................................................... 7
   3 eyes .......................................................... 13
7. Triangular pupils ..................... Kendal Kloop
   Circular pupils ...................... Cindy Cloop

8. 2 eyes .................................................. 9
   3 eyes ............................................. 14

9. Triangular pupils ..................... Debbie Doop
   Circular pupils ...................... Glen Gloop

10. Triangular pupils ..................... Herbie Hoop
    Circular pupils .................... Jerry Joop

11. 2 eyes ................................................ 12
    3 eyes ............................................. 15

12. Triangular pupils ..................... Teddy Toop
    Circular pupils ..................... Lenny Loop

13. Triangular pupils ..................... Minny Moop
    Circular pupils .................... Nancy Noop

14. Triangular pupils ..................... Orly Oop
    Circular pupils .................... Penny Ploop

15. Triangular pupils ..................... Randy Roop
    Circular pupils .................... Sandy Soop

What is the name for Alien A?

____________________________________________

Let’s identify some more aliens.
Alien B: ________________________ Alien C: _____________________
**Activity III: Real World Key**

Let’s apply what we’ve learned to a “real” key.

Plant leaves are excellent organisms to begin our use of keys. Leaves come in a variety of shapes and structures.

1. Leaves linear, needle-like or stiff scales ........................................... 2
   1a. Leaves with broad flat surfaces
       .................................................................................................................. 4

2. Leaves long needles clustered by 2 or 3 in bundles ......................... 3
   2a. Leaves scale-like, stiffly pressed against the twig ....................... **Eastern red cedar**, *Juniperus virginiana*

3. Leaves clustered by 2 in bundles; twigs without rough brown scales........... **Spruce pine**, *Pinus glabra*
   3a. Leaves clustered by (2) 3 in bundles; twigs with rough brown scales........... **Loblolly pine**, *Pinus taeda*

4. Leaves with entire margins ........ **Southern magnolia**, *Magnolia grandiflora*
   4a. Leaves with spiny or toothed margins .................................................. 5

5. Leaf edges with sharp spines ....................... **American holly**, *Ilex opaca*
   5a. Leaf edges with occasional saw-like teeth ..... **Southern wax-myrtle**, *Morella cerifera*

You will receive leaves from a variety of plants. Use the key above to identify the leaves.

Leaf Sample #1:
Name______________________________________________________________

Drawing of Leaf Sample #1: Label the characteristics that helped you identify this leaf.

Leaf Sample #2: Name

Drawing of Leaf Sample #2: Label the characteristics that helped you identify this leaf.
Checking your work
Now that you have identified the two leaf samples, read more about them. All samples are from trees common to Mississippi and can be easily found in any wooded area.

**Spruce pine, Turkey pine**
*Pinus glabra* Walter
Pine Family, Pinaceae

Description: Medium to large trees. Bark dark, thin, with small plates. Branches drooping, forming thick horizontal branch tips. Branches retained year to year. Twigs smooth. Leaves in clusters of 2s in bundles; dark green and twisted. Cones less than 6 cm long on a short stalk. Seeding from September to October.

Habitat: Low woods, bottomlands of large rivers, moist hardwood slopes.
Southeastern range: Georgia, Florida, Alabama, Mississippi (statewide)
Remarks: Least valued pine tree of the region because of its abundance of knots (branch scars). The retention of branches makes this an attractive yard tree.

**Loblolly pine**
*Pinus taeda* L.
Pine Family, Pinaceae

Description: Large trees. Bark red, with medium-sized plates. Branches shed from the main axis of the trunk. Twigs scaly. Leaves in clusters of 3s in bundles, but occasionally only in 2s; light green in color. Cones up to 13 cm long; prickles on cone scales are stout and upward angled. Seeding from October to November.

Habitat: Low woods, bottomlands of rivers, moist hardwood slopes, old fields in original range. Now widely planted in off-site habitats.
Southeastern range: Georgia, Florida, Alabama, Mississippi (statewide), Virginia, Tennessee
Remarks: The most widely planted pine tree of the region because of its rapid growth.
**Eastern red cedar**  
*Juniperus virginiana* L.  
Cedar Family, Cupressaceae

Description: Medium trees. Bark brown, shreddy in narrow linear strips. Branches retained year to year, until very old in age. Leaves are short scales in close overlapping pairs, forming 4-sided twigs. New leaves are longer, flat, pointed and in whorls of 3s. Leaves blue green to yellow green (prairies). Foliage fragrant. Cones small and inconspicuous on tips of short branches, appearing as a black, chalky “berry.”

Habitat: Old fields and woods on dry soils.  
Southeastern range: throughout  
Remarks: An incredibly durable wood, cedar is usually used to line closets to prevent moths.

**Southern wax myrtle, bayberry**  
*Morella cerifera* (L.) ?  
Myrtle Family, Myricaceae

Description: Shrubs or small trees. Bark dark gray, smooth, but with visible horizontal rings. Branches retained year to year. Leaves evergreen, oblanceolate or elliptic, to 8 cm long. Leaves gray green, heavily dotted with resinous glands on both surfaces, and fragrant. Leaf margin serrate to entire. Flowers imperfect. Fruits drupaceous, white, globose. Flowering in April. Seeding from August to October.

Habitat: Sandy woods, pinelands and down into marshes.  
Southeastern range: Georgia, Florida, Alabama, Mississippi (statewide), Virginia  
Remarks: In the past, candles were scented with wax of the berries. Now this shrub is used more for landscaping. The retention of branches makes this an attractive yard tree.
**Southern magnolia, bullbay**  
*Magnolia grandiflora* L.  
Magnolia Family, Magnoliaceae

Description: Medium to large trees. Bark dark, smooth. Branches retained year to year. Twigs smooth, with encircling leaf scars on older growth. Leaves evergreen, up to 3 dm long, glabrous and shiny above, rusty hairy beneath. Flowers large, up to 10 inches across. Petals creamy white. Numerous stamens and pistils, which form a “cone” fruit. Flowers fragrant, lemon-scented. Fruit an aggregate of follicles. Seeds red. Flowering May through June. Seeding in the fall.

Habitat: Swamp forests, maritime forests, low woods, moist hardwood slopes. Southeastern range: Georgia, Florida, Alabama, Mississippi (statewide), Virginia

Remarks: Magnolia flowers generate heat (low level), which provides a “motel” for its pollinators, particularly beetles. This is the state flower and tree of Mississippi.

**American holly**  
*Ilex opaca* Aiton  
Holly Family, Aquifoliaceae

Description: Medium to large trees. Bark pale gray and smooth. Branches retained year to year. Twigs smooth. Leaves evergreen, dull above, elliptic up to 10cm long, dentate with few to many sharp spine0-tipped teeth or sometimes entire and with only a apical spine. Flowers imperfect. Flowers with 4 white petals. Fruit a red to orange drupe. Flowering April to June. Seeding from September to October.

Habitat: Low woods, bottomlands of large rivers, moist hardwood slopes. Southeastern range: throughout

Remarks: The wood of this species is white throughout (even the heartwood), and was once used as the “ivory” keys on cheap pianos. Often used now in landscaping, and still a popular Christmas decoration.
Mississippi 2010 Science Framework (2008) connections:
Using the provided Mississippi 2010 Science Framework, complete the chart below by identifying the competencies and objectives that these activities best fit.

<table>
<thead>
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</table>

If more space is needed, insert additional pages.
Did this lesson clarify your understanding of classification?
________________________________________________________________________________________

In your own words, what is classification?
________________________________________________________________________________________

________________________________________________________________________________________

Why is classification considered a necessary skill in science?
________________________________________________________________________________________

________________________________________________________________________________________

How is classification used in other curricula?
________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________
VI. Spineless Wonders: Exploring Invertebrates

Overview
The water found in nature seems very peaceful. We find it relaxing to sit near and listen to water. Yet beneath the surface are busy organisms that struggle day and night for survival. If you look at the surface of the water, you see bugs darting across its surface. Underground, the worms move through the soil. Snails and slugs leave a trail of slime as they move above ground. Mosquitoes and flies buzz as they move their wings...unless they get caught in a spider’s web. What do all these have in common? They are examples of spineless wonders.

Activity I
Imagine that you are a very small creature that lives in water. You do not have an internal skeleton. What special features would you have that might help you to survive? List these.

Think about how you look as a water creature. What would be the shape of your body? Draw an image of yourself as a water creature in the space below. Use the provided color pencils to create yourself in your environment. Be prepared to display and explain your drawing.

Creature name:
Where in the water I live:
What I eat:
What eats me:
How I move:

What makes an animal an animal?
There are characteristics that all animals share. These are:
• Heterotrophic: Animals must obtain their food and digest it in order have the nutrients needed to stay alive.
• Multicellular: Animal bodies are made of more than one cell.
• Eukaryotic: Animal cells have a nucleus and other organelles (small pieces that act like organs in a cell).
No cell wall: Animal cells do not have a cell wall. The presence of a cell wall would make an animal too stiff to move around.

Putting into one sentence
Members of the animal kingdom are multicellular, heterotrophic eukaryotes whose cells do not have cell walls.

Write a simple interpretation for this sentence.

Animal Survival

Food
All animals need food. There are a variety of ways that animals can get food. We most often think of large animals that stalk their prey. What about the other animals? How do these animals get food? Describe their digestive system.

Fly

Earthworm

Jellyfish

Sponge

Breathing
All animals need to take in oxygen and remove carbon dioxide. Not all animals have lungs like ours. How else might an animal breath?

Circulation
Nutrients and oxygen must be taken throughout the body of animals. In larger organisms a circulatory system is the main method of transport. However, in some animals a process called diffusion is used. Diffusion is the movement of molecules from cell to cell. Animals that are only a few cells thick would use diffusion.

Why wouldn’t a large animal, such as yourself, use diffusion instead of a circulatory system to move nutrients and oxygen?

Excretion
Getting rid of wastes (excretion) is a big deal. If wastes are not removed, they could build up and kill the animal. Most animals have a system to take care of this problem. Usually it is the opposite end of the digestive system. However, some simple animals do not have a digestive system. These animals use
diffusion to move nutrients and wastes. They may have a single opening which acts as a mouth – and as a way to get rid of wastes. Yes, they have a “poopy” mouth!

Moving
Most animals are able to move around by legs, wings, fins, or wiggling. Muscles are needed for movement. If an animal has muscles, it usually will have a skeleton. Muscles move the bones of the skeleton for movement. Some animals in their adult stage are not able to move. They anchor themselves onto a rock. The young of these animals do move around, usually in water. Other animals are subject to currents in the water. Still others without skeletons use them to push against soil or water to move.

Give an example of animals that move in the following ways: (Think beyond the ordinary.)
Walk __________________________
Swim ____________________________
Fly _____________________________
Crawl ___________________________
Jump/hop _________________________

Body Shape

If you were to draw a line down a person's body, you would see symmetry. Symmetry refers to an evenness seen on each side of a dividing line. People have a bilateral symmetry. In other words, one side of our body is a mirror image of the other. Another type of symmetry is radial symmetry. Where have you heard the word radial before? Think of bicycle tires. There is a center hub with spokes that come out to reach the outer edge. With radial symmetry, the center of the animal is the hub. If we divided it with lines (like the spokes of a tire) each section of the animal is exactly like the other sections.

Some animals are asymmetrical. Their bodies as shaped so that no matter how you divide it, there is no repetition in the body pattern. In other words, there is no front or back, no right or left side.

Activity II

What are invertebrates? If we break down the word into its base parts we have the following: in (without) and vertebrate (backbone). Put these together you have the definition: organisms without a backbone. Many people would consider these “bugs and slugs.” The invertebrate group is large and varied, so we will limit our study to select phyla.

Study the information in the table below. Based on what you have read, make a sketch of what you think this animal will look like.
<table>
<thead>
<tr>
<th>Macroinvertebrate Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porifera</td>
<td>Sessile: As an adult this animal is attached to a single spot. No mouth. Asymmetrical (no front, back, left, or right). Many pores. Water circulates through the body at all times. Filter feeder. No tissues or organ systems.</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Soft body. Often has external shell. 4 body parts: foot, mantle, shell, visceral mass (organs). Aquatic or terrestrial. Needs moisture. Shells may be single or two parts (bi-valve).</td>
</tr>
<tr>
<td>Phylum</td>
<td>Characteristics</td>
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<tr>
<td>------------------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Annelida</td>
<td>Little rings around body (segmented) Long, narrow body Bristles on segments Complex, organ system</td>
</tr>
<tr>
<td>Arthropoda</td>
<td>Segmented body Tough outer skeleton (exoskeleton) Jointed legs Complex, organ system Moves in a variety of ways: fly, crawl, walk, jump, swim Molting: removal of exoskeleton during growth Found in most environments</td>
</tr>
<tr>
<td>Echinodermata</td>
<td>Spiny skin Internal skeleton (endoskeleton) No front or end Most have 5 part radial symmetry Tube feet</td>
</tr>
</tbody>
</table>

Now let's go for the real thing…. You will now work with preserved specimens. Each group will be assigned an invertebrate to study. Compare your sketch to the actual animal. How close were you in your interpretation? There is such a variety of organisms within each phylum that it is difficult for even the most experience taxonomist to identify all invertebrates.

Models are often used in science. They are easier to keep, less messy, and have less of a “yuck” effect. These are advantages of using models. What would be a disadvantage to using a model in place of the real thing?

**Activity III**

Let's rap about it! You will be assigned one of the invertebrates from this study unit. You will right a rap verse about that invertebrate. The rap must include five facts about your invertebrate that makes it unique from other invertebrates. Your rap may be specific to an organism or generic for the phylum. We will all use the same chorus.

Chorus:

We live in the world
All around,
In water, in trees
Even deep in the ground!
We live in the ocean
   Or out in a lake.
We’ve got no skeleton
   No bones to break!
Some have legs
   And walk on the ground.
Others have shells
   Some just hang around.
People don’t know
   If the like us or not –
But fact is fact
   You need us a lot!

In this space identify the 5 facts that you will use and compose your verse.

Mississippi 2010 Science Framework (2008) connections:
Select competencies and objects to which this week’s activities correlate.

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1. For what grade level would this lesson be most appropriate?

2. Can the activity be used in multiple grade levels?

3. What changes would you make to these activities?

4. What other curricula is made a part of this unit study?

5. What science skills are used in this unit study?
VII. What’s My Home? Exploring Vertebrates & Their Habitats

Overview

Earlier we studied invertebrates – organisms without backbones. Our focus this session will be the vertebrates – organisms that do have backbones. Any animal that has a skeleton inside the body is a vertebrate. All vertebrates have a spinal column that surrounds and protects the spinal cord. However there are differences between vertebrates. These differences (called adaptations) allow the organism to survive in its home.

“Home is where the heart is.” This is a very nice sentiment, but what really makes up a home for a vertebrate? What do animals really need to survive? There are four basic requirements for animals: food, water, shelter, and space in which to move. Depending on what is found in each home (habitat) vertebrates have adaptations to help them survive.

Think about the different habitats where animals are found. There is the water (aquatic), trees/air (arboreal), underground, and surface land. Would an animal that lives in trees need fins? Obviously not, as fins are used for movement in water. Would a water animal need feet? Possibly, depending on how the animal moves. Turtles have feet!

With the billions of different types of living organisms on Earth, biologists have developed ways of naming and classifying them according to their similarities and differences (adaptations).

The system most used by scientists puts each living thing into seven groups (called taxons). These taxons are organized from most general to most specific. From largest to smallest, these groups are:

- Kingdom (most general and largest)
  - Phylum
  - Class
  - Order
  - Family
  - Genus
  - Species (most specific and smallest)

Kingdoms are huge groups, which include millions of kinds of organisms. All animals belong in one kingdom called Kingdom Animali. All plants are in another called Kingdom Plantae. There are five kingdoms in the classification system most widely used. This system contains animals, plants, fungi, prokaryotes, and
protoctists (the last two are different sorts of one-celled organisms). Other systems have six or more kingdoms.

Species are the smallest groups. A species is made of all the animals of the same type; they are able to reproduce and have young of the same kind.

The lion belongs to the following groups:

- **Kingdom Animalia** (includes all animals)
  - **Phylum Chordata** (includes all vertebrate animals, as well as some other more primitive ones)
  - **Class Mammalia** (includes all mammals)
  - **Order Carnivora** (includes carnivorous mammals, from bears to raccoons to harbor seals)
  - **Family Felidae** (includes all cats)
  - **Genus Panthera** (includes the great roaring cats: lions, tigers, jaguars, and leopards)
  - **Species leo** (lions)

Scientists usually identify organisms by their species and genus names. If you think of all the different languages on this planet, you can understand that translation could be a problem during discussions. One organism may be called by a different common name in each area it is found. For example, the mountain lion is also called panther, puma, catamount and cougar. By calling by scientific nomenclature all scientists will know it as one specific animal, *Puma concolor*.

**Activity I: Who Am I?**

In this activity, you will explore the types of vertebrate animals. Each participant will have a picture of a vertebrate animal attached to the back of his or her shirt. You will not be able to see the picture attached to you nor will you tell other participants what animal is attached them.

You may approach all the participants in the room and ask each ONE question. Remember: no one is allowed to tell you exactly what picture is on your back, so select your questions carefully. Make a list of questions below that you will ask.
Your goal is to:
1) identify the habitat of your animal ______________________________________
2) identify the characteristics that help your animal survive ______________________________________
3) identify the animal ____________________________________________________________

You will have a time limit of 5 minutes to complete your goal.

Vertebrate animals are grouped into two groups: cold-blooded animals and warm-blooded animals. Warm-blooded animals (endothermic) regulate their own body temperatures; these are able to maintain a warm body temperature even in cool weather. Cold-blooded animals (ectothermic) depend on their habitat to keep their body temperatures stable. These are not able to control their own body temperature. When the habitat is cold, the animal is cold.

Some examples of cold-blooded animal groups are fish, amphibians, and reptiles.

The habitat for fish is water. These animals have special adaptations that help them survive. Fish breathe oxygen through gills. Fish use fins to move. Most fish lay eggs.

Amphibians are ectotherms that live both on land and in water. When on land, amphibians breathe with lungs and through moist skin. When they are in water, they breath through gills. Three types of amphibians are frogs and toads, salamanders, and caecilians. Caecilians are primitive amphibians that resemble earthworms. They are found in the tropical regions, not in Mississippi.

Reptiles breathe with lungs, therefore they are air breathers. They have scales that covers their skin. Most lay eggs, though some keep their eggs inside and seem to give live birth. Reptiles include snakes, turtles and tortoises, crocodiles and alligators, and lizards.

Mammals and birds are the only two warm-blooded animal groups. Birds have feathers and wings. They lay eggs, and most can fly. There are some birds like penguins and ostriches that cannot fly. Bird feathers are designed for specific habitats, as are their legs and feet.

Most mammals have body hair. Most mammals give birth to live young, except the platypus which lays eggs. Mammals provide their young with milk. Mammals live in most habitat types, water, land, and arboreal.

Activity II: Adaptations

Read the description of a vertebrate animal below.
This animal has a long tail that it uses to grip and hang on. It has a long nose. The animal comes in a variety of colors. It has bony plates that act as armor to protect the animal. Males of this species have a pouch; the females do not have a pouch. The animal moves slowly by using fins. Do you have an idea? Draw the animal you think is being described.

This animal is well adapted to survive in its environment. It uses its tail to grip onto sea grass and coral. It has gills which are used to obtain oxygen from water. Once it is mated, it is mated for its life. These animals eat small shrimp. The young may eat up to 10 hours per day in order to get the energy they need to stay alive.

Did you draw a seahorse? If so, you have a good sense of animal adaptations. Adaptations are related to the habitat of the organisms. You would not find seahorses living in trees or in a desert. Its fins are designed for use only in water. Its tail allows it to stay in one location so that the water current will not carry it off into an area where it would easily be preyed upon.

Birds are often used to discuss adaptations. There are differences in bills, feet, feather shape, and coloration that allow us to easily compare bird adaptations. The type of bill a bird has determines what the bird eats. Examples of these bills are cracker, shredder, chisel, probe, strainer, spear, tweezer, and Swiss army knife. What would each bill allow a bird to eat? Look at the chart below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Shape</th>
<th>Adaptation</th>
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<tbody>
<tr>
<td>Cracker</td>
<td>short, thick bills used by seed eaters to crack open seeds</td>
<td>examples: cardinals, sparrows</td>
</tr>
<tr>
<td>Chisel</td>
<td>long, hard like bills boring into wood hunting for insects,</td>
<td>example: woodpeckers</td>
</tr>
<tr>
<td>Probe</td>
<td>long thin bills used for dipping into flowers to search for nectar</td>
<td>example: hummingbirds</td>
</tr>
<tr>
<td>Strainer</td>
<td>long, flat bills used to strain small animals and plants from water</td>
<td>examples: ducks, geese</td>
</tr>
<tr>
<td>Spear</td>
<td>long, spear-like bills used for fishing</td>
<td>examples: herons, kingfishers</td>
</tr>
<tr>
<td>Tweezer</td>
<td>thin, pointed bills used by insect eaters</td>
<td>examples: warblers, robins</td>
</tr>
</tbody>
</table>
Like bills, bird feet also are adapted for their environments. By each foot example below, identify its use. To make it easier, here is a list of the different types (not in order with the pictures): climbing, grasping, perching, running, scratching, swimming

A)______________________________________________________________

B)______________________________________________________________

C)______________________________________________________________

D)______________________________________________________________

E)________________________________________________________________

F)________________________________________________________________

The instructor will give your group a set of cards. On these cards are bills, feet, and birds. Create sets of these by identifying which bill and feet goes with each bird. Lay these out on your table. The instructor will identify any problems seen in your sets.
Activity III: Designing by Habitat

Habitat is home for wildlife. It includes both living and nonliving things. Living things (biotic) include other organisms, such as animals, plants, and bacteria. Nonliving things (abiotic) include water, air, rock, and soil.

Each type bird is able to survive in a specific habitat based on its adaptations. When the habitat changes, the bird can do one of three things: adapt to the new environment, travel to a better habitat, or die. This is true of all life forms. One strategy used by teachers is the imaginary field trip. This activity will involve your imagination.

You and your group are scientists that have discovered a new type of bird. This bird has never been seen by anyone and is unique for its habitat. Your group must present this bird to your peers at a science conference. You are the experts on the bird and must provide your peers with all important information, including 1) common name, 2) scientific name, 3) what it eats, 4) what eats it, 5) bill shape, 6) feet, and 7) coloration.

The instructor will give each group a specific habitat. Your group will make a model / drawing of the bird you have “discovered.” Prepare a presentation giving all the important information about your bird. Remember, this bird has NEVER been seen before, so it should NOT resemble any existing bird.

Mississippi 2010 Science Framework (2008) connections:
Select competencies and objects to which this week’s activities correlate.

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</table>
1. Can the activity be used in multiple grade levels?

2. Imagine that you are teaching. How would you change these activities for your classroom?
VIII. Population Dynamics: Exploring the Ecosystem

Overview

In this lab we have explored the variety of life on our planet. In this session we will explore how organisms interact in the ecosystem to form communities. In order to do so, we must go over terms.

- **Species** – a group of individuals usually sharing characteristics that can reproduce to produce fertile offspring
- **Population** – all members of a species in a certain location at a certain time
- **Community** – all the populations in a region at a certain time
- **Ecosystem** – all of the biotic and abiotic parts of an area
- **Predator** – organisms that hunt and feed on other organisms
- **Prey** – organisms that are hunted and eaten
- **Herbivore** – animals that feed on plants
- **Carnivore** – animals that feed on other animals
- **Omnivore** – animals that feed on both plants and animals

*Activity I: Energy Flow*

All living things must have energy in order to carry out life processes (respiration, movement of molecules across the cell membrane). We get energy by eating. The food is digested and the molecules are absorbed by the blood and transported to cells. The question is, where did the energy come from? Let’s trace a meal backwards to figure out where energy comes from.

Let’s say that our most recent meal included a hamburger with lettuce, tomato, pickles, and cheese.

What is the source of the hamburger patty? ____________________________________________

What does this animal eat? ____________________________________________

What is the source of the cheese? ____________________________________________

What does this animal eat? ____________________________________________

What type organism are lettuce, tomatoes, and pickles? ____________________________

Based on your answers to these questions, what is the main source of our energy? ___________
Plants use photosynthesis. The energy needed to start this process comes from the sun. Therefore the sun is our ultimate source of energy. Organisms that can use energy to create a food source (such as a sugar) are called autotrophs. Plants are autotrophs; they also are called producers. Animals are not able to make their own food and are called heterotrophs. Another name for animals is consumers.

Energy flow in the Environment

![Energy flow diagram]

Solar energy → Autotroph (Producer) → Heterotroph (Consumer)

As the plants absorb energy from the sun, they use the energy in the process of photosynthesis. The result of photosynthesis is the production of oxygen and glucose (sugar). The glucose is stored in the plant in a variety of ways. We use the stored glucose as a direct food source (fruits and vegetables) or as an indirect food source (cows, chickens, pigs).

Think of a robin. What does it eat? What eats a robin? Each link in a food chain contains producers or consumers, predators or prey. Make a flow chart for a food chain containing a robin. Label the producers and consumers, predators and prey.

The robin will eat insects. The insects will have eaten plants. A snake might eat the robin. The food chain would look like this:

Sun → plant → grasshopper → robin → cat

The plant is the producer (autotroph). The grasshopper, robin, and cat are consumers (heterotrophs). The plant would have the most energy. It will use some of the energy to keep itself alive, storing the remainder of the energy. The grasshopper eats the leaf on the plant. The grasshopper will only receive a fraction of the total energy of the plant. The grasshopper uses the energy to stay alive. It, too, will store some of the energy for later use. When the robin eats the
grasshopper, it will receive even less energy. The cat, at the far end of the food chain, would get the least amount of energy from its food. The next activity will illustrate this concept.

Energetic Links

Each of you will act as a part of a food chain. You will be given a sign to wear.

You will either be a “grasshopper,” a “robin,” or a “cat.” There are more grasshoppers than robins. There will be just one cat. You will move in the same method as the organism of your sign. Those who are labeled “grasshopper” will squat low and will hop from leaf to leaf in search of food. Those labeled “robin” will swoop down to collect grasshoppers. The cat will stalk and pounce on the robin. These actions will not take place at one time, but will be staggered to allow food to be consumed.

Follow-up questions:

How did this activity demonstrate energy flowing through a food chain?

In your job, how did this make you feel?

What did you learn from this activity?

Did you enjoy this activity? Why or why not?

Activity II: Adding to the Mix

The flow of energy is much more complicated than just a single food chain. In our example, we had robins eating only grasshoppers. What else might a robin eat? Answers may include worms, caterpillars, spiders, and other invertebrates.

Besides a cat, what else might eat a robin?

This extension of a food chain is called a food web and might look like this:

![Food Web Diagram]

The overlapping in the food web adds stability to the ecosystem. However, when a part of the ecosystem is lost, it will affect the whole web.
The instructor will give each group a set of cards. Organize the cards into a food web. Draw the food web in the space below.

What are the producers?
What are the consumers?
What are the predators?
What are the prey?

Choose one of the consumers to remove from the web. What will happen to population of the other species?

A keystone species is one that, if removed from the food web, would cause a dynamic shift in the structure of the community which could lead to the extinction of other species that rely on that one species. At one time, the American alligator was an endangered species. As a major predator in the food web the alligator helped to control the population of other species through predation. What happened to the population of the alligator’s prey?

**Activity III: Ecological Relationships**

In this activity we will collect data and plot graphs to illustrate the changes in populations. There are many types of relationships within an ecosystem.

- **Predator / Prey:** one organism hunts and feeds on another organism. Example: _______________________________________________________

- **Communalism:** two organisms share the same niche, one benefits but the other is not harmed. Example: _______________________________________

- **Parasitism:** one organism lives in or on another organism, drawing its energy source from that organism, slowly killing it. Example: _______________________

- **Mutualism:** two species live together where both benefit. Example: _________________________________________________________________

- **Competition:** two or more organisms vie for the same resources. Example: ___________________________________________________________________
In this next activity, we will simulate a predator/prey relationship.

“Not a creature was stirring, not even a mouse…. ” This familiar line has a lot of hidden meaning. In the poem it implies that even the mice were asleep. In nature, however, mice do not stir when a predator is nearby. The activity in which you will now participate is the interaction between mice and a natural predator, the weasel.

Instead of going to their habitat, we will simulate a meadow by using a box. The weasel is the spoon, and the mice will be the wooden beads.

There are six rules to this simulation that you must follow:

1. Each trial represents a generation. Each generation must have at least 10 mice.
2. The population of the mice in the meadow is determined by the size of the meadow. Overpopulation will cause disease.
3. In each generation there must be at least 1 weasel.
4. For the weasel to survive, it must capture at least 5 mice.
5. For each 5 mice captured, the weasel will produce one offspring.
6. The surviving mice (not captured by weasel) will double its numbers.

The first four generations of predator-prey relationships is described below.

Follow the directions.

**Generation 1:**

Place 10 mice (beads) in the meadow (box).
The weasel in this generation will only capture 2 mice. To do this, use the spoon to scoop through the box and collecting 2 beads.
Put the captured mice in a small container to the side of the meadow.
How many offspring will the weasel have? None. According to the rules, the weasel must collect 5 mice in order to reproduce. There is no change in the number of predators. We began with one predator; we still have just the one predator.

Table 2 will record the changes in mouse population. We began with 10 mice in the meadow. The ending population was 8. This is a change of −2.

**Generation 2:**

According to the rules, the surviving mice will double their number. At the end of generation 1 there were 8 mice in the meadow. Add 8 more beads to double this population.

The weasel did not reproduce, so there is still only 1 predator in the meadow.
This generation the predator will capture 4 prey. Use the spoon to collect 4 beads and place the beads in the small container.

Complete the data tables with the information from this generation.

**Generation 3:**

No predators reproduced from the previous generation (only 4 mice were captured).

Add the appropriate number of beads to the meadow. (Remember, you are doubling the mouse population.)

This time the predator will capture 6 mice.

Fill in the data tables.

**Generation 4:**

In the last generation, the weasel captured 6 mice. It needed 5 mice in order to reproduce. This time you will scoop through the meadow twice to simulate two predators. In the first scoop (1st predator) you will scoop up six beads. Scoop through the box a second time to represent the second predator. This time collect 5 beads. Record the data in the tables.

**Generations 5 – 14:**

Now that you have the general idea for this activity, the following generations will be on your own pace. Keep in mind the six rules.

For each of these generations make one random scoop (no set number of beads) for each weasel. Remember to complete the data tables.
# Predator Count by Generation

<table>
<thead>
<tr>
<th>Generation</th>
<th># of Predators at beginning of each generation</th>
<th>Predator at the end of each generation</th>
<th>Change in the predator population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
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<td>3</td>
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<td>4</td>
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<td>1</td>
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<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>1</td>
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<tr>
<td>6</td>
<td>7</td>
<td>8</td>
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<td>7</td>
<td>8</td>
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<td>9</td>
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</tr>
<tr>
<td>12</td>
<td>13</td>
<td>14</td>
<td>1</td>
</tr>
</tbody>
</table>

# Mice Population

<table>
<thead>
<tr>
<th>Generation</th>
<th>Beginning Mouse Population</th>
<th>Final Mouse Population</th>
<th>Change in Mouse Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>8</td>
<td>-2</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>8</td>
<td>24</td>
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<tr>
<td>4</td>
<td>64</td>
<td>16</td>
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<tr>
<td>5</td>
<td>128</td>
<td>32</td>
<td>96</td>
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<tr>
<td>6</td>
<td>256</td>
<td>64</td>
<td>192</td>
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<tr>
<td>7</td>
<td>512</td>
<td>128</td>
<td>384</td>
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<td>8</td>
<td>1024</td>
<td>256</td>
<td>768</td>
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<tr>
<td>9</td>
<td>2048</td>
<td>512</td>
<td>1536</td>
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<td>10</td>
<td>4096</td>
<td>8192</td>
<td>4104</td>
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<tr>
<td>14</td>
<td>65536</td>
<td>131072</td>
<td>65536</td>
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</tbody>
</table>

Remember, at the beginning of each generation, the surviving mice reproduce and double their numbers.
Now let's create graphs for our data. In this first graph, you will show the change in the predator population over the generations. Because this is measuring a change over time, you will make a line graph.

Graph 1: ________________________________

Title

Generations

Describe the change in the predator population over the generations.
_____________________________________________________________
________________________________________________________________
________________________________________________________________
_________________________________

What caused the changes in the predator population?
_____________________________________________________________
________________________________________________________________
________________________________________________________________
_________________________________

This second graph will show the changes in the mouse population.
Graph 2: _______________________________________________________

Generations

Describe the changes in the mouse population.
________________________________________________________________
________________________________________________________________

What caused the change in the prey species?
________________________________________________________________
________________________________________________________________

The third graph will combine the first and second graphs. This will be a multiple line graph. In order to understand the meaning of the lines you will need two different colors, one color to represent the predator line and the other to represent the prey line. First, copy the line of Graph 1 onto this graph. In the Legend box, use the color you chose to represent the predator to mark a line next to the word Predator.
Next, copy the line of Graph 2 onto this graph. Again, mark the color you use next to the word Prey.

Graph 3: ____________________________________________________________

Generations

Look carefully at the two lines on the graph. Is there a pattern? ________
Describe the pattern, if any.
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
What happens to the prey population when the predator population increases?
____________________________________________________________________
____________________________________________________________________
Why might the predator population decrease when the prey species decreases?
____________________________________________________________________
____________________________________________________________________
Mississippi 2010 Science Framework (2008) connections:
Select competencies and objects to which this week’s activities correlate.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Competency Number</th>
<th>Objective</th>
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</tbody>
</table>

1. Can the activity be used in multiple grade levels?

2. What changes would you make to improve these activities for an elementary classroom?
IX. Who is to Blame? Exploring Ethics in Science

Overview

Science is a process for finding out new information. Every day a new medical procedure is developed or a new medicine is made or a new species is found or….you get the idea. Certainly we see these as beneficial to our lives. However, we must ask ourselves, “Is it truly beneficial to all life or the planet?”

Science does not have an opinion. It is neutral. It is up to us how the science is used. This is where we get into a debate on ethics. Consider the science of rocketry. When you think of rockets, what do you think of? Has this been beneficial or detrimental? In the chart below, list ways that the rocket has impacted man.

<table>
<thead>
<tr>
<th>Beneficial to People</th>
<th>Detrimental to People</th>
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<tbody>
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</table>

So what is the final verdict about rocketry? Without rockets, we’d have never walked on the moon or developed the new medicines that can only be made in a low gravity environment. We would never have launched the Hubble Space Telescope that is allowing us to study far parts of the universe. Yet rockets have been used as a weapon.

Another example is the development of TNT. When Alfred Nobel first developed it, it was to be a useful tool in mining. It became the basis for many weapons. His creation made him very wealthy. Nobel felt deeply about this event. As a result, he established the Nobel Prizes which are still awarded to this day. The idea behind the prize is to acknowledge the work of those who have benefited human life. We all will admit that the weapons kill, yet if he had not developed TNT Nobel would not have had the money to award the work of others.
There are many debates that take place daily on these and other issues in science. We have to consider, though, that the impact of science does not only affect humans. It can affect other life forms as well as the planet itself.

**Activity I**

One of the best books for debating environmental conditions is *The Lorax* by Dr. Seuss. Most people see the stories of Dr. Seuss as children’s stories. However, Theodore Geisel (a.k.a. Dr. Seuss) was brilliant at weaving a moral into his stories.

Your task as a group is:
- Read *The Lorax*
- Summarize the plot
- Identify the moral of the story
- Identify the “villain”
- Describe the Lorax (character) in terms of his belief

You will be given a copy of the book to read within your group. As you read, make a time line that shows the chain of events that occur in the story. Develop your timeline below.
What is the main theme of this book?

Every habitat has native and non-native (invasive) species. Native species are those that are found historically in the area. Here, in Mississippi, we have long-leaf pine trees, short-leaf pine trees, mockingbirds, gopher tortoises, mosquitoes, and many more species that are native to the area. In the book there are species that are native to the area. What are these species?

An invading species is one that is not naturally found in an area, but is either brought to the area or migrates into an area. These often cause problems for the native species. There is an increase in competition for food, water, and shelter. In some cases, like the zebra mussel, the native species gets crowded out. In Mississippi, examples of non-native (invading) species are fire ants, armadillos, and privet hedge. What is the invading species in this book?

What happened when the invading species came into the natural area describe in the book?

When a non-native species takes over, the native species can be harmed to the extent of the species being listed as endangered. Define endangered.

Habitat degradation happens when the habitat is changed so that it cannot repair itself. This is happening at an increasing rate of the past century. Today we are going to explore this through debate.

In your opinion, who was at fault in *The Lorax*? Discuss this with your group. Explain your choice.

What is the moral of the story?

In recent years, with the onset of increased global warming and climate change, we have begun to understand that what we do (even as a single person) does have an impact.

**Activity II**

Your group will be assigned a character from *The Lorax*. You will be the team of lawyers that must defend your client against the charge of causing the endangerment of native species and possibly their extinction. You group may develop visual aides to help in your defense of the character.
One member of your team must be the character that will be defended. This person will wear a name tag to identify the character being portrayed.

The Lorax (instructor) will moderate the debate.

First your group must prepare a statement of innocence to be read by the “client.”

Each character will be allowed to make a 4 minute maximum introductory statement as to their innocence. As you listen to each character, write down questions that you would like to pose that specific character.

<table>
<thead>
<tr>
<th>Character</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onceler</td>
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<tr>
<td>Onceler's family</td>
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<tr>
<td>First person to buy a thneed</td>
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<tr>
<td>General public that buys thneeds</td>
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</tbody>
</table>
All questions will be presented after the opening statements have been read.

Select one person from your group to ask questions of the characters. This will be the lawyer that represents your client. The other members of your group will become the jury that will decide who ultimately is at fault.

After listening to the defense of the characters, who do you believe is at fault for the environmental degradation? Why?
What are ethics? *Webster’s Dictionary* defines ethics as “the discipline dealing with what is good and bad and with moral duty and obligation, a theory or system of moral values, the principles of conduct governing an individual or a group.” As we see with our debate, not everyone shares the same ethics.

What do you think of science? Is it good or bad? Complete the chart below by identifying ways science has benefited and harmed people.

<table>
<thead>
<tr>
<th>Beneficial to People</th>
<th>Detrimental to People</th>
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Has science changed societies? If you say “yes,” explain and give an example.

How does history view science? Has it always been welcome?

Many detrimental events occurred due to human actions. Who makes the decision to go ahead with an event? We do. In a democratic society such as ours, we compromise to reach the best decisions. This occurs through the legal division of our democracy. History is riddled with examples of this.

The goal of the human genome project was to identify the genetic structure of humans. Once this was successfully done, scientists turned to identifying specific
genes that lead to specific traits. Now we have identified the gene that causes breast cancer. Is this beneficial or detrimental?

Would you want to know if you have that gene? Why or why not? How would this affect your life goals?

Everyday we make choices regarding our ethics. The choices are not easy. Many of us started making these choices in upper elementary or middle school. Peer pressure drives us toward poor choices in many cases. What we have to establish is our own ideas and beliefs.

We cannot see or predict the future; we can only predict the outcome of our work. As future teachers you will have a tremendous influence on your students. It is a heavy responsibility. You will help them identify their own ethics, possibly through debates like we had in this class or through review of current events. Your students must be able to understand the science occurring in the event in order to make choices about the event. Their choices will influence their vote on legislation.

**Activity III**
You have used fiction to understand ethics. You will now explore a real life situation.

In the Gulf of Mexico, there is an area called the dead zone. Sounds dramatic, right? This is an area with little to no organisms in it. It is found below the mouth of the Mississippi River and extends toward the Louisiana/Texas border. It is south of the barrier islands that protect our coastline.

What may be possible causes for this dead zone? Discuss this in your group. Write the possibilities below.

1. ________________________________________________________
2. ________________________________________________________
3. ________________________________________________________
4. ________________________________________________________
5. ________________________________________________________

Which of these do you think the most likely cause of the dead zone?

Actually, there is a natural dead zone. However, human actions have caused a change. Each year the dead zone has been increasing in size. The first group to notice this phenomenon was those who made their living by fishing. They had identified a problem. The next step was to do research on what was already known. They turned to science.
What could scientists do? They could do population counts. They could do water quality testing much like we’ve done in this course. Once the known information was identified, then a hypothesis was developed as to the cause of the dead zone.

The focus of scientific research was water quality. Many different contaminants were identified in the dead zone. Among them were phosphorus, nitrogen, and potassium. Now the question was how did these chemicals get into the water in such large amounts?

What are your ideas for this?

Remember that the dead zone is below the mouth of the Mississippi River. How does water flow in a river? It flows from the head of the river to the mouth of the river. What is the range of the Mississippi River?

The Mississippi River is but one piece of a large river system. Most of the United States east of the Rocky Mountains drains into the Mississippi River. In the historical flood plain of these rivers is land that is mostly used for agriculture. The large farms use insecticides and fertilizers to boost their crops. Farmers want larger crops in order to sell for profit. Is this wrong?

We cannot blame farmers for wanting to make a good living for their families. This is a choice we all make. What does this have to do with the dead zone?

Along the river system are major areas of industry. These industries originally built in their location because the river seemed a great way to dispose of unwanted waste. The Clean Water Act of 1972 limited what could be placed in the water, but did this happen too late? Was this a possible cause of the dead zone?

It would be a financial burden into the millions to reduce the dead zone. Who should be responsible for reducing the dead zone? The fishermen who harvest their livelihood there? Those that live closest to the zone? Those who inadvertently caused the zone? Identify your choice below and explain your reason. Include the method that would be used to enforce the clean up of the dead zone.
Mississippi 2010 Science Framework (2008) connections:
Select competencies and objects to which this week’s activities correlate.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Competency Number</th>
<th>Objective</th>
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<tbody>
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</tbody>
</table>

1. Can the activity be used in multiple grade levels?
2. What changes would you make to these activities to use them in a classroom?
3. What learning skills were involved in *The Lorax* activities?
4. What was your role in the activities?
X. Outdoor Classroom: *Exploring Nature*

XI.

Almost everyone enjoys being outside, especially if they are having fun. In today's lab we are going to explore what is found outside, particularly water. We want to know what is in the water and the quality of the water.

Water is essential to life on Earth. It makes up part of our atmosphere. It maintains the temperature of our planet, keeping us cool in daytime and warm at night (compared to other planets). It makes up most of our body. All plants and animals must have water in order to stay alive. You can go longer without food than you can without water.

The quality (health) of the water affects the natural area around the water. All life takes in water. If the water is poor, then the natural area will show signs of decay, such as dead trees or brown grass surrounding the water and little to no living animals in the immediate area.

There are many professions dedicated to monitoring the quality of water. They check temperature, stream flow, turbidity (clarity), pH (a measurement of acid or base level), and the plants and animals that live in and around the water. As we explored earlier, all living things have adaptations that help them to survive in a habitat. Most water macroinvertebrates, however, are limited in their habitat. Their home must be within certain ranges of pH, temperature, stream flow, and other quality levels. Our goal this lab is simple: determine the quality of a local water source based on pH, stream flow, turbidity, and life forms present.

As we are going outside, each group will be responsible for taking and returning needed equipment.

As we get to the water source, take 5 minutes to make observations about the area surrounding the water. Write your observations here. You may include a sketch of the area.
Activity I: Characteristics of the Water Source
Stream flow, or current, influences life in the water. Different adaptations are needed to survive no current, gentle current, and strong current. Also important are the depth of the water, and width of the water.

For this activity, your group will need the following: tape measure, twine or flags, stop watch, fishing weight, floatable ball, and a calculator.

1. One person will take one end of the measuring tape and pull it to ____ meters. Another group member will hold the base of the tape at the “starting point.” (Distance should be determined by the length of the water source. If you have a stream you can measure up to 100 feet. Determine the length after viewing the water source.) Mark both the start and stop points with a flag. If possible stretch a line across the water at the “stopping point.”

2. Per group:
   • One group member should be at the starting point with the ball, ready to drop it in when indicated.
   • A second group member should be at the stopping point ready to say stop when the ball passes the stopping point.
   • A third group member will be the time keeper. This person will hold the stop watch, telling when to drop the ball into the water, starting the stop watch at that time and stopping it when the member at the stopping point says stop.
   • A fourth group member is the recorder and will write down the measurements of time and distance and will complete the calculations. Other group members will use this data to complete their own lab pages.

3. Follow the steps above 3 times. Determine the average rate of stream flow. Use the data table below to record your observations.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of water source (meters)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (seconds)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stream Flow: Distance/Time</td>
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</tbody>
</table>

Based on the data, what is the average length of water? ________________ meters
Based on the data, what is the average time of travel? ________________ seconds
Based on the data, what is the average speed of the current? ________________ meters/second
4. One group member will hold one end of the measuring tape and carefully wade across the stream. Another group member will hold the other side of it. This will give us a width for the stream. Select three areas within the length of the water source. *Mark these with a flag so that your group can come back to the same sites to do observations.* Make a measurement at each of these locations.

<table>
<thead>
<tr>
<th>Site</th>
<th>Width Measurement (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<tr>
<td>2</td>
<td></td>
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<td>3</td>
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<tr>
<td>Average</td>
<td></td>
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</tbody>
</table>

5. Develop a plan for measuring the depth of the water. Where should you measure for depth? How will you find average depth? Write out your plan here and develop a data table for recording your measurements. *(Hint: measure in multiple spots to get an average)*

6. Summarize your data:
*The water that we are studying has an average current speed of ____________, an average width of __________________________, and an average depth of __________________________.*

Activity II: Abiotic Water Characteristics

Now that you have a good description of the water, we will explore the chemical properties of the water.

Your group will need the following materials: thermometer and pH paper.

The temperature of water is important to the life in the water. Many water organisms, both vertebrate and invertebrate, are very sensitive to changes in temperature. These organisms are ectothermic, meaning that their body temperature is determined by their surroundings. There is an optimal temperature range needed for their survival.

Most people know how to use a thermometer. It reads much like a ruler, from 0 to the highest range noted. Our temperature scale that we will use is Celsius. You usually hear temperature measured in Fahrenheit. You will take measurements on both scales in order to see the comparison between the two scales.
Select 3 sites along the water source to run the following tests.

1. Lower the thermometer into the water until it is mostly submerged.
2. Wait approximately 30 seconds.
3. Remove the thermometer from the water and quickly read the temperature. **Important note: Do NOT shake the thermometer. This will cause a false temperature reading.**
4. Repeat these steps at 2 other locations.
5. Complete the data table below and find the average temperature.

pH is a measurement of the amount of acid or base in the water. The pH paper you will use at each of your sites will change color to indicate what is in the water. The pH scale runs from 1 to 14. Seven is the midpoint on that number scale. A measurement of 7 is a neutral reading. The pH strip will remain the yellow color you took out of the container. If the pH paper turns orange or red, there is acid in the water. The darker the shade of red, the stronger the acid in the water. If the pH paper turns green or blue, there is base in the water. The darker the shade of blue, the stronger the base in the water.

When using pH paper, be careful to take out only one test strip at a time and recap the container. This will prevent the remaining strips from becoming contaminated.

6. At each site lower one end of a pH strip into the water. Hold it in the water for 20 seconds.
7. Remove the pH strip from the water and allow it to air dry.
8. Compare the end of the pH strip to the color chart on the container. Write the number indicated by the color in the data table. Calculate the average pH.

<table>
<thead>
<tr>
<th>Site</th>
<th>Temperature (°F)</th>
<th>Temperature (°C)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is there a relationship between temperature and pH? If so, explain the relationship.
Activity III: A Hunting We Will Go!

Materials needed: dip nets, collection containers, magnifying lenses, macroinvertebrate guide

An important indicator of water quality is aquatic macroinvertebrates. In other words, we are looking for water bugs. These organisms live in all areas of the water. Each group will each have a collection device and will collect macroinvertebrates. Each group will also have collection containers for holding macroinvertebrates as you collect them. It is important to sample macroinvertebrates at different locations within your study area. Use the three sites

1. Put water into the collection containers. Label each container for the site you are sampling. At each site, take samples from the surface, the mid region, and the sediment at the bottom.
2. As one group member collects macroinvertebrates with the dip net, other group members should use the provided guide to identify and count the number of macroinvertebrates.
3. If a group member chooses to go into the water to collect samples, it is important that this person keep their shoes on!

Make a data table here to record your populations.
Key to Macroinvertebrates:
1. The macroinvertebrate has jointed legs………………………………2
   The macroinvertebrate does not have jointed legs………………….15

2. The macroinvertebrate has more than 6 legs…………………….3
   The macroinvertebrate has 6 legs……………………………………5

3. The macroinvertebrate has a body like a shrimp and moves fast……4
   The macroinvertebrate has a body that is wider than it is tall and moves
   slowly……………………………………………………….. sowbug

4. The macroinvertebrate has a fan shaped tail and appears shrimp-
   like……………………………………………………………….. crayfish
   The macroinvertebrate has a shrimp-like body that is taller than it is wide, no
   tail……………………………………………………………….. scud

5. The macroinvertebrate has a long, narrow body……………………6
   The macroinvertebrate has a disk or oval shaped body…….water penny

6. The macroinvertebrate has either no tail or one that is one thin strand….7
   The macroinvertebrate has a tail made of 2 or more parts…………13

7. The macroinvertebrate has a soft, unplated abdomen………………8
   The macroinvertebrate has a hard plated abdomen……………….12

8. The macroinvertebrate has pairs of filaments extending from the
   abdomen………………………………………………………9
   The macroinvertebrate does not have filaments extending from the
   abdomen…………………………………………………….caddisfly larva

9. The macroinvertebrate has no gill tufts on the abdomen…………….10
   The macroinvertebrate has gill tufts on the abdomen and one pair of hooks
   on the side of its tail which appear to be short forks. … hellgrammite
   (dobsonfly)

10. The macroinvertebrate has a short, forked tail………………….fishfly larva
    The macroinvertebrate has a long tail that is a filament or a point….. 11

11. The macroinvertebrate has a pointed abdomen with 4 hooks
    extending…………………………………………………………..whirligig beetle larva
    The macroinvertebrate has a single long tail filament……. alderfly larva

12. The macroinvertebrate has large eyes and a wide abdomen…………
    …………………………………………………………dragon fly larva
The macroinvertebrate has a hard stiff body, the tail may have hooks or filaments.............................. riffle beetle larva

13. The macroinvertebrate has no gills on its abdomen......................14
The macroinvertebrate has gill on the SIDE of its abdomen..mayfly larva

14. The macroinvertebrate has three, paddle like tails............damselfly larva
The macroinvertebrate has two thin tail filaments............stonefly larva

15. The macroinvertebrate does not have a distinct head...............16
The macroinvertebrate has a distinct head..............................23

16. The macroinvertebrate has no legs or appendages......................17
The macroinvertebrate has legs or appendages......water snip fly larva (Atherix)

17. The macroinvertebrate has a hard shell..............................18
The macroinvertebrate does not have a hard shell..................20

18. The macroinvertebrate has two shells that are connected with a hinge.......................................................clam or mussel
The macroinvertebrate has a single spiral or coiled shell........19

19. The macroinvertebrate shell opens to the right when held with the opening to the bottom........................................gilled snail
The macroinvertebrate shell opens to the left when held with the opening to the bottom..............................lunged snail

20. The macroinvertebrate has eye spots and an unsegmented, flat body..............
.............................................................................planarian
The macroinvertebrate has a body with segments.......................21

21. The macroinvertebrate has a soft, plump body similar to a caterpillar..
............................................................................Cranefly larva
The macroinvertebrate has a worm-like body..............................22

22. The macroinvertebrate has a thin body that is segmented or thread-like.......................................................aquatic worm
The macroinvertebrate has a segmented body with suckers at each end..........................................................leech

23. The macroinvertebrate does not have legs or appendages.........planarian
The macroinvertebrate does have legs or appendages.......................24

24. The macroinvertebrate has a body that is wider at the back end........black fly larva
The macroinvertebrate has a body that is the same width at both ends................................. midge fly larva

Aquatic Macroinvertebrates as Water Quality Indicators.

<table>
<thead>
<tr>
<th>Water Quality</th>
<th>Indicator Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>stonfly larva</td>
</tr>
<tr>
<td></td>
<td>adult riffle beetle</td>
</tr>
<tr>
<td></td>
<td>gilled snail</td>
</tr>
<tr>
<td></td>
<td>planarian</td>
</tr>
<tr>
<td></td>
<td>mayfly larva</td>
</tr>
<tr>
<td></td>
<td>water penny</td>
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<tr>
<td></td>
<td>caddisfly larva</td>
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<tr>
<td></td>
<td>hellgramite</td>
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<tr>
<td>Fair</td>
<td>crayfish</td>
</tr>
<tr>
<td></td>
<td>damselfly larva</td>
</tr>
<tr>
<td></td>
<td>alderfly larva</td>
</tr>
<tr>
<td></td>
<td>crane fly larva</td>
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<tr>
<td></td>
<td>dragonfly larva</td>
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<tr>
<td></td>
<td>riffle beetle larva</td>
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<td></td>
<td>watersnipe fly</td>
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<tr>
<td></td>
<td>scud</td>
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<tr>
<td></td>
<td>beetle larva</td>
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<tr>
<td></td>
<td>fishfly larva</td>
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<tr>
<td></td>
<td>sowbug</td>
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<tr>
<td></td>
<td>whirligig</td>
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<tr>
<td>Poor</td>
<td>aquatic worms</td>
</tr>
<tr>
<td></td>
<td>lunged snail</td>
</tr>
<tr>
<td></td>
<td>blackfly larva</td>
</tr>
<tr>
<td></td>
<td>leech</td>
</tr>
<tr>
<td></td>
<td>clam or mussel</td>
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<tr>
<td></td>
<td>midge fly larva</td>
</tr>
</tbody>
</table>

Based on the results of your sampling, what is the water quality?

Given all the results of this lab’s testing, would you consider this water source to be a healthy ecosystem?
APPENDIX C

SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT – PRE-SERVICE

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = STRONGLY AGREE  
A = AGREE  
UN = UNCERTAIN  
D = DISAGREE  
SD = STRONGLY DISAGREE

<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
<th>SA</th>
<th>A</th>
<th>UN</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When a student does better than usual in science, it is often because the teacher exerted a little extra effort.</td>
<td></td>
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<tr>
<td>2</td>
<td>I will continually find better ways to teach science.</td>
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<td>3</td>
<td>Even if I try very hard, I will not teach science as well as I will most subjects.</td>
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<td>4</td>
<td>When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.</td>
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<td>5</td>
<td>I know the steps necessary to teach science concepts effectively.</td>
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<tr>
<td>6</td>
<td>I will not be very effective in monitoring science experiments.</td>
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<td>7</td>
<td>If students are underachieving in science, it is most likely due to ineffective science teaching.</td>
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<td></td>
<td>Statement</td>
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<tr>
<td>8</td>
<td>I will generally teach science ineffectively.</td>
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<tr>
<td>9</td>
<td>The inadequacy of a student’s science background can be overcome by good teaching.</td>
<td></td>
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<tr>
<td>10</td>
<td>The low achievement of some students cannot generally be blamed on their teachers.</td>
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<tr>
<td>11</td>
<td>When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.</td>
<td></td>
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<td>12</td>
<td>I understand science concepts well enough to be effective in teaching science.</td>
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<tr>
<td>13</td>
<td>Increased effort in science teaching produces little change in some students’ science achievement.</td>
<td></td>
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<tr>
<td>14</td>
<td>The teacher is generally responsible for the achievement of students in science.</td>
<td></td>
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<tr>
<td>15</td>
<td>Students’ achievement in science is directly related to their teacher’s effectiveness in science teaching.</td>
<td></td>
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<tr>
<td>16</td>
<td>If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child’s teacher.</td>
<td></td>
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<tr>
<td>17</td>
<td>I will find it difficult to explain to students why science experiments work.</td>
<td></td>
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<tr>
<td>18</td>
<td>I will typically be able to answer students’ science questions.</td>
<td></td>
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<tr>
<td>19</td>
<td>I wonder if I will have necessary skills to teach science.</td>
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<tr>
<td>20.</td>
<td>Given a choice, I will not invite the principal to evaluate my science teaching.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>21.</td>
<td>When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better.</td>
<td></td>
<td></td>
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<tr>
<td>22.</td>
<td>When teaching science, I will usually welcome student questions.</td>
<td></td>
<td></td>
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<tr>
<td>23.</td>
<td>I do not know what to do to turn students on to science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
December 30, 2009

Betsy Sullivan
1417 Highland Colony Parkway
Madison, MS 39110.

Re: official permission of use letter for the STEBI-B instrument

Please consider this letter as evidence of permission of use of the STEBI-B. I wish you well in your research effort.

Larry G Enochs
Professor
Science and Mathematics Education
237 Weniger Hall
Oregon State University
Corvallis, OR 97331
541-737-1305
APPENDIX E
PRE / POST QUESTIONNAIRE

1. Anonymous Identifier

2. Age Range
   - □ 17 – 19
   - □ 20 – 22
   - □ 23 – 25
   - □ 26+

3. What is your major field of study at USM?

4. Have you ever learned from others? If so, give an example of how you learn from others?

5. What has been said to you or about you regarding your work in a science course?

6. What is your opinion of your ability to successfully complete a science course?

7. Relate a memorable story about an experience you have had in science.

8. What will be your area of expertise when you are a practicing teacher? (i.e., reading, language arts, mathematics, science, social studies, art, music)

9. Complete the following statement. Please elaborate your answer.
   “Science is….”

10. Complete the following statement. Please elaborate your answer.
    “I would / would not (choose your answer) choose to teach science because….”
APPENDIX F
REFLECTION FORM

Reflection

Identifier: _________________________ Date: __________________________

Class topic: _______________________

Complete the following open-ended questions by writing your responses.

Before We Begin….

1. What I knew about this topic before beginning this activity:

2. What I think I will learn with this activity:

3. I (am / am not) comfortable with this topic because…. (Circle your choice and complete the statement.)
Bringing It Home….

4. The method for learning new information was….

5. The new information I learned was ….

6. I feel that I contributed….

7. My greatest challenge was….

8. I think this activity could have been better if….

9. As a teacher, I would make the following changes before I used this activity:
APPENDIX G

INTERVIEW QUESTIONS

1. What lead you to become involved in education?

2. When you were in (elementary school / middle school / high school), which class was your favorite?

3. Tell me why you like that class so much.

4. What would your ideal class be like as a teacher? (include both student composition, focus area, and physical structure)

5. You mentioned teaching ____________. Why that subject?

6. Why did you not select science (if this was not the focus area chosen)?

7. Elementary teachers are expected to be able to teach many different subjects. The administrator assigns the duties. Imagine that you’ve been hired at an elementary school. You been assigned to teach science. Before participating in this lab section, what would have been your response?

8. What science experiences can you recall from elementary or middle school?

9. How did you come to be a participant in this lab section?

10. Before taking this lab, what was your opinion of science?

11. What activity (or activities) stood out to you in our labs? What made that one stand out?

12. What would be your response if, after participating in this lab section, you were asked to teach science?
13. How did this lab affect your idea of science?

14. After participating in this lab section, what have you learned about yourself and science?
APPENDIX H

APPROVAL FORMS

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

118 College Drive #5147
Hattiesburg, MS 39406-0001
Tel: 601.266.6820
Fax: 601.266.5509
www.usm.edu/irb

TO: Betsy Sullivan
2401 A Rive Oaks Blvd.
Jackson, MS 39211

FROM: Lawrence A. Hosman, Ph.D.
HSPRC Chair

PROTOCOL NUMBER: C29111206
PROJECT TITLE: Self-Regulated Learning and Pre-Service Elementary Teachers’ Perceived Self-Efficacy in Science and Teaching Science

Enclosed is The University of Southern Mississippi Human Subjects Protection Review Committee Notice of Committee Action taken on the above referenced project proposal. If I can be of further assistance, contact me at (601) 266-4279, FAX at (601) 266-4275, or you can e-mail me at Lawrence.Hosman@usm.edu. Good luck with your research.
HUMAN SUBJECTS REVIEW FORM
UNIVERSITY OF SOUTHERN MISSISSIPPI
(SUBMIT THIS FORM IN DUPLICATE)

Name: Benjamin Sullivan
Phone: 601-940-8150
E-Mail Address: bsullivan@madison-schools.com

Mailing Address: 2401 A River Oaks Blvd, Jackson, MS 39211

College/Division: COT  Dept: CSNE
Department Box #: PO Box 5087  Phone: 601-266-4148

Proposed Project Dates: From 01/19/16 To 11/29/16
(specific month, day and year of the beginning and ending dates of full project, not just data collection)

Title: Self-Regulated Learning and Pre-Service Elementary Teachers' Perceived Self-Efficacy in Science and Teaching Science

Funding Agencies or Research Sponsors:

Grant Number (when applicable):

- New Project
- Dissertation or Thesis
- Renewal or Continuation: Protocol #
- Change in Previously Approved Project: Protocol # 29111206

Principal Investigator:

Sherry Lassman
Date: 08/28/2010

Advisor:

Sherry Lassman
Date: 09/21/10

Department Chair:


 RECOMMENDATION OF HSPRC MEMBER

- Category I, Exempt under Subpart A, Section 46.101 ( ), 45CFR46.
- Category II, Expedited Review, Subpart A, Section 46.110 and Subparagraph (b).
- Category III, Full Committee Review.

HSPRC College/Division Member

Alex Kaplan
Date: 10/4/10

HSPRC Chair

Laurens A. Hooper
Date: 10-11-10
TO: Betsy Sullivan
2401 A Rive Oaks Blvd.
Jackson, MS 39211

FROM: Lawrence A. Hosman, Ph.D.
HSPRC Chair

PROTOCOL NUMBER: 29111206
PROJECT TITLE: Self-Regulated Learning and Pre-Service Elementary Teachers’ Perceived Self-Efficacy in Science and Teaching Science

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HUMAN SUBJECTS REVIEW FORM
UNIVERSITY OF SOUTHERN MISSISSIPPI
(SUBMIT THIS FORM IN DUPLICATE)

Name: Brian Sullivan
Phone: 601-940-8150

E-Mail Address: B.Sullivan@madison-schools.com

Mailing Address: 2401 A River Oaks Blvd, Jackson, MS 39211
(address to receive information regarding this application)

College/Division: COST
Dept: CSNE

Department Box #: P.O. Box 50X75
Phone: 601-266-6145

Proposed Project Dates: From 1/1/10 To 11/29/11
(specific month, day and year of the beginning and ending dates of full project, not just data collection)

Title: Self-Regulated Learning and Pre-Service Elementary Teachers' Perceived Self-Efficacy in Science and Teaching Science

Funding Agencies or Research Sponsors: 

Grant Number (when applicable): 

______ New Project
______ Dissertation or Thesis
______ Renewal or Continuation: Protocol # 

X Change in Previously Approved Project: Protocol # 2911206

Principal Investigator: 
Signature: 
Date: 09/28/2010

Advisor: 
Signature: 
Date: 9/21/10

Department Chair: 
Signature: 
Date: 9/31/10

RECOMMENDATION OF HSPRC MEMBER

X Category II, Expedited Review, Subpart A, Section 46.110 and Subparagraph (g).

HSPRC College/Division Member: 
Signature: 
Date: 10/4/10

HSPRC Chair: 
Signature: 
Date: 10-11-10
References


