The Attitudinal And Cognitive Effects Of Interdisciplinary Collaboration On Elementary Pre-Service Teachers Development Of Biological Science Related Lesson Plans

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THE ATTITUDINAL AND COGNITIVE EFFECTS OF INTERDISCIPLINARY COLLABORATION ON ELEMENTARY PRE-SERVICE TEACHERS DEVELOPMENT OF BIOLOGICAL SCIENCE RELATED LESSON PLANS

A Dissertation
presented in partial fulfillment of requirements
for the degree of Doctor of Philosophy
in the Department of Teacher Education
The University of Mississippi

By
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ABSTRACT

There is a need for STEM (science, technology, engineering, and mathematics) education to be taught effectively in elementary schools. In order to achieve this, teacher preparation programs should graduate confident, content strong teachers to convey knowledge to elementary students. This study used interdisciplinary collaboration between the School of Education and the College of Liberal Arts through a Learning-by-Teaching method (LdL): Lernen durch Lernen in German. Pre-service teacher (PST) achievement levels of understanding science concepts based on pretest and posttest data, quality of lesson plans developed, and enjoyment of the class based on the collaboration with science students. The PSTs enrolled in two treatment sections of EDEL 404: Science in the Elementary Classroom collaborated with science students enrolled in BISC 327: Introductory Neuroscience to enhance their science skills and create case-based lesson plans on neuroethology topics: echolocation, electrosensory reception, steroid hormones, and vocal learning. The PSTs enrolled in the single control section of EDEL 404 collaborated with fellow elementary education majors to develop lesson plans also based on the same selected topics. Qualitative interviews of education faculty, science faculty, and PSTs provided depth to the quantitative findings. Upon lesson plan completion, in-service teachers also graded the two best and two worst plans for the treatment and control sections and a science reviewer graded the plans for scientific accuracy. Statistical analyses were conducted for hypotheses, and one significant hypothesis found that PSTs who collaborated with science students had more positive science lesson plan writing attitudes than those who did not. Despite overall insignificant statistical analyses, all PSTs responded as more confident after collaboration. Additionally,
interviews provided meaning and understanding to the insignificant statistical results as well as scientific accuracy of the lesson plans.
DEDICATION

This dissertation is dedicated to my wonderful family who has always been there for me throughout this entire process. First, I want to thank my wonderful husband, Chip, for encouraging me all along the way. We both learned more patience and perseverance through this experience, and I look forward to spending more quality time together in the future. I love you more than I can express.

To my children, Luke and Levi, my goal was to finish this degree before you started tee-ball and organized sports. I am so thankful that you will not remember me being gone at nights, and I look forward to spending more time with both of you. You kept me going when times were hard. You are both sweet, beautiful boys and mean the world to me.

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Lastly, I dedicate this dissertation in memory of my dearest Rebel. You will never know how much I loved you and still love and miss you. You were my faithful friend for 11 years, and your companionship will never be replaced.

I thank God for each of you!
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CHAPTER I
INTRODUCTION

With a recent STEM (science, technology, engineering, and mathematics) education initiative set in motion by the United States Department of Education (USDE), science education reform in America is essential to become globally competitive (USDE, 2010). The Organisation for Economic Co-operation and Development (OECD) cited the United States is currently listed as “average” in reading and science, and “below average” in mathematics based on the 2009 and 2012 results from the Programme for International Student Assessment (PISA), (OECD, 2013) which internationally tests 15-year olds on mathematics, science, and reading. Additionally, the United States ranked 20 out of 34 in science literacy among countries that participated in the PISA testing and members of OECD (OECD, 2013). According to the National Center for Education Statistics (NCES), the National Assessment of Educational Progress (NAEP) has indicated that scores from 4th and 8th grade students in 2009 were equivalent to 1996 results, and Mississippi was ranked the lowest on the NAEP science assessment for all grade levels (2009). For 4th graders only, 17% were performing at a proficient level and 54% at a basic level compared to the national average of 31% and 72%, respectively. Results from 4th grade students tested in 2011 showed improvements since 2009, but Mississippi still has the largest below basic level of any state at 53% (2013).

The poor academic achievement described above, could be the result of many factors. But, a few critical topics important to science education reformation aimed at improving the statistics mentioned are content knowledge and pedagogy for science teaching, interdisciplinary
collaboration of pre-service teachers (PSTs), and creation of lesson plans on interesting and unique topics to help spark interest in elementary age children. In this study, I describe many aspects in which educators are not adequately prepared to teach science content. I also describe the important role that interdisciplinary collaboration has in increasing PST confidence and achievement while learning about novel, interesting topics in science. As Watters and Ginns (2000) mentioned, “Pre-service teacher educators will play a major role in the reform agenda by providing meaningful experiences for undergraduate students through which they can develop appropriate dispositions and understandings of the process and role of science” (p. 301).

One feasible solution to improve undergraduate science education and PSTs’ achievement is interdisciplinary collaboration between the School of Education and the College of Liberal Arts. Since additional coursework in undergraduate level elementary education curriculum is not practical, a blend between schools of education, particularly science methods courses, and liberal arts courses is likely to improve PSTs’ science teaching ability without increasing course load. Additionally, the lack of communication skills from the scientific community to convey accurate scientific information to the lay level further complicates the task of education teachers accurately representing scientific information in the classroom. Therefore, utilizing a Learning-by-Teaching method (LdL: Lernen durch Lernen) of interdisciplinary collaboration between elementary education PSTs and science students by integrating science content into already developed classes is a promising solution. In this way pre-science students also learn to convey science at a lay level, a skill that will be valuable for them as mature scientists. An appropriate class to use LDL with increased science interaction at The University of Mississippi is EDEL 404: Science in the Elementary Classroom.
By uniting science students and PSTs, science students should learn to communicate effectively with elementary PSTs making the science easy to understand without over simplification of topics which can lead to misconceptions. Elementary PSTs can then use the information gained by collaboration to create content-accurate lesson plans based on material covered when collaborating with science students. In my study, the content within this collaborative model is focused around interesting and unique neuroethology topics, or brain and behavior relationship in an evolutionary context, such as echolocation in bats, electroreception adaptation in sharks, steroid hormones effects on brain and behavior in children, and vocal learning in birds. The topics were pre-selected; however, the basic lesson plan assignment associated with this collaborative study has long been established within the EDEL 404 course. This novel approach allows PSTs to gain scientifically accurate information as well as generate lesson plans in the underserved area of adaptation and brain-based behavior in a timely manner. It was also hoped that PSTs would gain confidence and self-efficacy in teaching science through interdisciplinary experiences in this study.

Statement of the Problem

Elementary teachers are responsible for conveying accurate academic information to young students without possibly having enough background coursework in each of the subjects (Levine, 2006). By integrating more science content into established elementary teacher education undergraduate coursework, elementary PSTs will have more access to critical subject matter that many are currently lacking. They will also have access to faculty (as experts) in the fields of science and education. Importantly, the use of the LdL model will aid in learning how to gain scientific knowledge on their own when they become practicing teachers. In a recent national survey, only 33% of elementary teachers responding felt comfortable teaching science
(Fulp, 2002), which is almost identical to a previous national survey in which Jarrett (1999) found that only 28% of PSTs felt comfortable teaching science. Thus, while Goodman, Freeburg, Rasmussen, and Di (2006), found that elementary teachers who value and enjoy science are more likely to teach science with students. Such a small percentage of teachers who actually enjoy and feel comfortable enough to teach science content correctly to our future leaders creates a political milieu in which science is little valued and little understood.

According to the Committee on Undergraduate Science Education, one of the most important challenges facing college and university faculties is the improvement of science education of PST (National Research Council, 1999). In 2010, Buss conducted a similar study to determine science and mathematics teacher efficacy compared to other subjects. Significant results indicated Efficacy For Teaching (EFT) science and mathematics were lower than all other elementary content areas. This national data indicates a need for novel approaches in teacher education preparation, specifically involving science content. Teacher education universities and colleges must focus on graduating confident, content strong teachers to move above the “average” ranking in science, especially since STEM education is the focus for America’s global competitiveness (NGSS, 2013).

**Purpose of the Study**

The intent of this two-phase, sequential mixed methods study was to investigate the effects of an educational treatment on elementary PST achievement as measured by pretest and posttest scores in addition to lesson plan scores. The treatment was collaboration with science students, and I specifically measured improvements in scientific content knowledge and ability to create quality lesson plans on unique topics related to neuroethology. The PSTs’ gains in science skills were to be demonstrated by improvement of pretest to posttest scores, and ability
to produce age-appropriate, scientifically accurate, lesson plans as demonstrated by final lesson plan scores. In the first phase, quantitative aims addressed pretest and posttest scores, lesson plan scores, and the relationship or comparison of attitudinal responses based on collaboration with science students and elementary science education PSTs enrolled in EDEL 404 in the Fall 2014 semester. Upon completion of the course, the two highest and two lowest scoring lesson plans for each topic, as graded by myself as the researcher, were disseminated to in-service teachers and an external reviewer, who graded the lesson plans for quality and usability in the elementary classroom and scientific accuracy, respectively. Both additional graders provided comments and critiques that will be used for the final lesson plan collection. A final goal of this study is to disseminate scientifically accurate, age appropriate lesson plans to in-service teachers to implement in their classrooms.

Data from this first phase was explored further in a second qualitative phase. Qualitative interviews were used to investigate explanations for possible significant differences in lesson plan scores by exploring aspects of this LdL interdisciplinary collaborative method with two education faculty members, a science faculty member and six PSTs at the end of the Fall 2014 semester. The reason for following up with qualitative research in the second phase is to better understand and explain the quantitative results. Both faculty and PSTs’ interviews provided insights into the likeability and sustainability of the initiative. Additionally, an external reviewer graded the same highest and lowest graded lesson plans for scientific accuracy and gave very detailed comments on each lesson plan for qualitative data. According to Creswell (2014), mixed methods research is used to first generalize results to a population and then focus on qualitative data through interviews to collect detailed views.

Hypotheses and Research Question
Several null hypotheses and one research question have guided this study to determine if interdisciplinary collaboration between the School of Education and the College of Liberal Arts affects science education PST achievement by gaining understanding of scientific material.

**Null Hypothesis One**: There is no significant difference in mean elementary PST posttest scores by teaching method (treatment or control) when controlling for pretest scores.

**Null Hypothesis Two**: There is no significant difference in mean elementary PST lesson plan scores by teaching method.

**Null Hypothesis Three**: There is no significant relationship between achievement score of lesson plan and attitudes toward the collaborative activity.

**Null Hypothesis Four**: There is no significant difference of attitudes towards science lesson plan writing by teaching method.

**Null Hypothesis Five**: There is no significant difference of confidence, competence, and enthusiasm posttest scores by teaching method when controlling for pretest scores.

**Null Hypothesis Six**: There is no significant difference in quality and usability of lessons by teaching method as graded by in-service teachers.

**Qualitative Research Question**: How do responses and reactions of university education faculty, university science faculty, and elementary education majors’ interviews explain any quantitative differences in lesson plan quality and complexity when comparing those taught in collaborative classrooms to those without collaboration?

**Significance of the Study**

This study employed an interdisciplinary collaborative technique that allowed the schools of education and the colleges of liberal arts to interact while fostering the LdL model. While
interdisciplinary collaboration and LdL methods are not new concepts, the approach of this research is a novel idea. The LdL technique has proven successful in improving students’ ability to collaborate with others, think independently, and effectively present ideas (CITE). Research has shown LdL techniques improve scores on material content when taught by oneself compared to when learned from others (Tessier, 2004). The current study aims to advance LdL methods by fostering teaching across disciplines: science students teach senior elementary education majors and senior elementary education majors teach science students. Additionally, this study focused on the topic of neuroethology, which is the study of evolutionary brain-based behavioral adaptations, because there is a lack of lesson plans in this area and few teachers willing to teach this topic (Barlow, 2012). Furthermore, this study concentrated on creating scientifically accurate lesson plans specifically for fourth and fifth grade elementary students as this is the timeframe most students, especially girls, lose interest in science (Blue & Gann, 2008). Lastly, lesson plans were collected, disseminated, and graded by in-service teachers and a science external reviewer to assess their value for possible future use.

It is hoped that science students conveyed science-based knowledge effectively to the elementary education PSTs who gained scientifically accurate content knowledge through collaborative LdL techniques. It is equally important that PSTs learned methods of obtaining knowledge through research and inquiry. By gaining more content knowledge, they become more confident, content strong leaders of science education. It is also hoped that content accurate lesson plans were generated by PSTs on unique topics that in-service teachers can readily use. This study may be replicated and used for subjects other than science education to determine if collaboration improves understanding of content in any topic domain. Such collaborations would create a dynamic shift in teacher preparation.
Definitions of Terms

Adaptation- The result of “selective pressures influencing the survival and reproduction of organisms over many generations and can change the distribution of traits in the population” (NASa, 2012, p. 164).

Collaboration- “To work together, especially in a joint intellectual effort” (Uchiyama & Radin, 2008, p. 273).

Efficacy- “Beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Buss, 2010, p. 290).

Evolution- “Occurs when natural selection acts on the genetic variation in a population and changes the distribution of traits in the population gradually over multiple generations” (NASa, 2012, p. 161).

Grounded theory- “Grounded Theory emphasizes systematic rigor and thoroughness from initial design, through data collection and analysis, culminating in theory generation” (Patton, 2002, p. 489).

Learning by Teaching (LdL)- A theory that gives students the responsibilities of teaching by engaging in the highest step of activity (Grzega & Schoner, 2008).

Pedagogical Content Knowledge (PCK)- types of knowledge teachers utilize to help students progress for a deeper comprehension of the subject matter (Beyer & Davis, 2012).

Personal Science Teaching Efficacy (PSTE)- a survey used to investigate teacher beliefs and attitudes toward teaching science (Bayraktar, 2011).

Pre-service teacher (PST)- A pre-service teacher is a student within a teacher preparation program (Davis, Petish, & Smithey, 2006).
Scientific inquiry- As the current National Science Teacher Association’s position statement: The *National Science Education Standards* defines scientific inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p. 23).

**Limitations**

First, this study is limited to only one Southeastern university in the fall semester of 2014, which may limit the generalizability. Second, students are allowed to take the course EDEL 404 in the summer term which decreased participation in the Fall 2014 course so subject numbers were fairly low. Third, senior elementary education majors enrolled in science methods courses collaborated with science students enrolled in BISC: 327. This may not accurately represent the enjoyment levels for other subjects, such as reading, math, or language arts. Finally, only 55 PSTs are taking this course, which is recognized as a small sample size for generalizability. Only three classes were taught; therefore, comparisons cannot be made between instructor for both treatment and control sections.

**Summary**

Enhancing undergraduate elementary education coursework can be performed through interdisciplinary collaboration. As elementary PSTs are expected to know a plethora of subjects, increasing their exposure to more content knowledge, and the methods for gaining this content knowledge, is critical in the undergraduate curriculum. Using an LdL design increases exposure to content material as well as fostering independent and critical thinking skills, and possibly increases science achievement and understanding levels, as well as confidence. Lastly, focusing
on interesting and unique topics on adaption and brain-based behavior, PSTs learn new and interesting material that will be useful when becoming an in-service teacher.
CHAPTER II

REVIEW OF THE LITERATURE

This literature review is organized around three major topics. The first topic is about efficacy for teaching science, PSTs’ science content knowledge upon completion of a traditional teacher preparatory program, and pedagogical content knowledge in science. The second topic related to the effects of interdisciplinary collaboration, LdL methods, successful collaborative models, and the challenges and concerns of implementing a collaborative program. The final topic is about pre-service and in-service science teachers’ beliefs and how they affect teaching practice in general in addition to teacher beliefs for teaching adaptation and topics such as evolution.

The goal for examining and researching these three main topics is to conceptualize the importance of undergraduate coursework for elementary education majors, the significance of the science methods course and interdisciplinary approaches, and the importance of teacher beliefs in relation to teaching. It is important to focus on both pedagogy as well as content knowledge and in elementary PSTs. It is equally important to focus on research about teaching beliefs in general and how those play a role in overall achievement, with a specific focus on beliefs towards topics such as evolution or brain-based behavior.

Efficacy for Teaching Science, Science Content Knowledge, and Pedagogical Content Knowledge in Science

This section includes information on efficacy for teaching science and PSTs’ science content knowledge upon completion of a traditional undergraduate elementary teacher
preparation program. It also highlights the impacts of pedagogical content knowledge (PCK) of future teachers.

**Efficacy for Teaching Science.** Efficacy, as first defined by Bandura in 1977, is “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1977, p. 3; Buss, 2010, p. 290). Teacher efficacy is essential to student learning, since teachers teach what they understand and enjoy the most. Davis et al. (2006) stated that teachers must develop self-confidence and see themselves as effective teachers. Additionally, Goodman et al. (2006) revealed that elementary teachers who value and enjoy science are more likely to teach science. In 2010, Buss conducted a study directed toward PSTs to determine science and mathematics teacher efficacy compared to other subjects. Science and math were hypothesized to be the lowest scores. Significant results indicated that efficacy for teaching (EFT) science and mathematics were lower than all other elementary content areas. This study also indicated that future teachers are concerned about their capabilities to teach math and science possibly because they did not perceive themselves as knowledgeable about science compared to other subjects (Buss, 2010). This result is analogous to previous research by Jarrett (1999), that surveyed in-service elementary teachers for capability for teaching various subjects. While 76% of science teachers felt comfortable teaching language arts or reading, only 28% were comfortable teaching science (Jarrett, 1999). Similarly, Fulp (2002) reported that fewer than three in 10 elementary education practicing teachers felt sufficiently prepared to teach science and 72% felt insufficient in their content knowledge. Furthermore, Fulp (2002) described that 77% felt comfortable teaching reading and language arts. More recently, Weld and Funk (2005) restructured a first year general life science course that is required by elementary education majors. By using triangulation, the researchers found important information through
structured interviews. The qualitative data results recognized that none of the participants claimed a command of subject matter in biology prior to enrolling in the course (Weld & Funk, 2005). Responses such as “My understanding (of biology subject matter) is pretty weak---there’s so much to memorize, and I never was interested in it anyway” were documented (Weld & Funk, 2005, p. 196). While PSTs feel confident in teaching other subjects, confidence in teaching science content is lagging behind.

These problems extend beyond the United States. Bayraktar (2011) noted that in-service primary teachers in Turkey must teach all subjects and generally are not able to actually teach science experiments with students. In 2011, Bayraktar administered the Personal Science Teaching Efficacy (PSTE) survey, and found that Turkish PSTs believed that science was important for the growth and success of their country, but that they were not interested in nor enjoyed teaching science (2011). Furthermore, while primary education students’ attitudes were low, experimental and hands-on activity enjoyment levels were extremely high (Bayraktar, 2011).

Berlin and White (2012) conducted a comparable study to examine future teachers’ attitudes and perceptions related to the integration of math, science and technology. It was found that “pre-service teachers need more exposure to specific concepts, processes and skills in STEM” (Berlin and White, 2012, p. 28). In addition, Desimone, Bartlett, Gitomer, Mohsin, Pottinger, and Wallace (2013) interviewed first year math teachers and principals and found that teachers did not feel prepared to teach the math subjects and lacked confidence in teaching skills. Furthermore, Berlin and White (2012) recommended that concepts, skills, and practices for STEM integration must be linked with governing standards related to with state tested subjects and accountability. Watters and Ginns (2005) remarked that attitudes about science ability may
develop during grade school years, but can be influenced by undergraduate pre-service training experiences.

**Science Content Knowledge.** It is essential that PSTs master the content they teach; however, many traditional teacher training programs do not require many subject specific courses. In 2002, Rod Paige, United States Secretary of Education, suggested “teachers be hired on the basis of their subject matter knowledge and verbal ability; education school coursework should be made optional and student teaching should be eliminated as a requirement for new teachers” (Levine, 2006, p. 13). In addition, Levine cited the Dean of the School of Education at the University of Michigan with a similar viewpoint for teacher education, such that students would have a subject specific major, like biology or history in combination with specializations in communicating the subject matter and enabling students to learn the material (2006). For example, Levine (2006) stated, “The content of the curriculum is too often a grab bag of courses, ranging across the various subfields of teacher education from methods to the philosophy and history of education, rather than the focused preparation needed for real classrooms” (p. 107). Furthermore, Levine (2006) acknowledged the “No Child Left Behind” law defined teachers who are “highly qualified” as having specific subject mastery, without teacher education coursework from a traditional university (p. 14).

Likewise, the National Academy of Sciences (2010) concluded that expertise in a subject matter is essential and noted that a strong liberal arts background with undergraduate science courses were important for all teachers. In research for preparing science teachers, attributes such as “grounded in college-level study of the science discipline suitable to the age groups and subject they intend to teach, which develops understanding of the big conceptual ideas in science” (NAS, 2010, p. 143) were suggested to be important. Previous research by Davis et al.
(2006) concluded that PSTs lack understanding of science content, especially teachers in the elementary grades. The focus of this study is on science content knowledge and methods to obtain such knowledge; however, all STEM fields are important to consider. More recently, Desimone et al. (2013) interviewed first year teachers in math and principals about teacher training. The teachers responded that content knowledge was inadequate (Desimone et al., 2013).

There are proponents for teacher education programs that state their importance in higher education. According to Zeichner, schools of education which are responsible for preparing teachers of tomorrow have been antagonized over their purpose and legitimacy of producing qualified teachers (2006). Additionally, Zeichner states that schools of education must shift their focus during this period of uncertainty of their legitimacy (2006). Furthermore, Zeichner suggested that funds should be allocated to support items like in-service teachers gaining more pedagogical and content knowledge by working in conjunction with university faculty in both content and methods courses to produce higher quality teachers (2006).

Much research has found that future teachers in elementary education are lagging behind peers enrolled in other colleges in demanding content knowledge. However, there are exceptional programs that have implemented more rigorous subject matter in teacher preparation programs. One example which will be described further, The University of Virginia, Curry School of Education five year teacher program that requires four years to obtain a liberal arts bachelor’s degree and then a master’s degree for teaching (Levine, 2006). Many other colleges have established this type of program including The University of Mississippi.

Bacolod found that teachers entering teaching today have lower academic qualifications than teachers did many years ago (2007). However, in a report by the Education Testing
Services (ETS), results showed that Praxis test scores have increased in recent groups, and that teachers had higher SAT scores and grade point averages than in past years (Gitomer, 2007). In a report about America’s colleges and teacher education programs at universities, Levine (2006) indicated that Scholastic Aptitude Tests (SAT) scores for elementary education students were much lower than secondary education students. Furthermore, elementary education majors significantly trailed the national SAT average for all students (Levine, 2006). Likewise, elementary education majors were much lower than the national average for Graduate Record Examination (GRE) scores (Levine, 2006). Data compiled by Levine (2006) also revealed that “On most campuses, teacher education is regarded by university professors and administrators inside and outside the education school as one of the poorest-quality campus units owing to low admissions standards, particularly elementary school teachers” (p. 26). In a survey sent out to deans in schools of education, it was concluded that schools of education were not the best place for subject area mastery (Levine, 2006).

Finally, a major goal of an American education is global competitiveness. In this era of reform, there is a need to research high achieving countries for their practices to compare and gain useful strategies. Gal (2011) indicated that Hong Kong has remained a high achiever according to PISA scores in comparison with 41 other countries. Gal stated that the eighth graders in Hong Kong placed first, second, and third for math, problem-solving skills, and scientific literacy, respectively for more than just one test year (2011). Teachers in Hong Kong also have core values described by more than just test scores or technical criteria. Instead, “their passion for the ‘subject knowledge’ they teach” is a significant portion of teacher evaluations (Gal, 2011, p. 248). Subject knowledge is highly important and should become more of a focus in American education.
**Pedagogical Content Knowledge.** Methods classes are essential to building and improving teaching efficacies and pedagogical content knowledge. As teaching efficacies generally develop early and resist change, the focus should be on teacher preparatory programs because PSTs have fewer experiences in life and in the classroom and may adapt easier (Buss, 2010). Buss suggested ways to improve these courses such as, “Specifically, individual students may benefit from learning additional content material or from additional pedagogical material, especially in the areas of science and mathematics” (p. 296). Furthermore, Davis et al. found that elementary and secondary science teachers may be more effective through exposure to more undergraduate science classes or methods classes (2006). Improving PSTs beliefs and attitudes for teaching science is essential (Bayraktar, 2011). As Paul Strode stated “kids understanding how science works and teachers understanding how science works and teaching teachers in a more effective way,” is essential (NASb, 2012, p. 33). And, it is imperative for flexibility and adaptability in teacher education programs (Buss, 2010).

Pedagogical content knowledge is another point of interest for PSTs in adapting materials acquired to teach elementary students. The National Academy of Sciences (2008) highlighted the *Science as a Way of Knowing* project, with a story about teaching practices. A child in third grade came home from school and said to his mother who was a scientist, “Now I understand science. It’s the same as spelling. You just have to memorize it because it does not make any sense” (NAS, 2008, p. 17). The National Academy of Sciences (2010) highlighted a correlation between subject matter mastery and teaching methods for teacher effectiveness. Furthermore, Zeichner identified several viewpoints for the routes that teacher education should use to prepare teachers, such as how many content classes versus education classes should be taken; however, rarely is it debated that content knowledge is all that matters (2006). Likewise, pedagogical
content knowledge was recognized as equally important as subject matter mastery for all teachers (NAS, 2010). Most recently, Desimone et al. (2013) concluded that subject matter mastery and pedagogical content knowledge were both essential components for teachers.

Programs for teacher preparation were examined through research by the National Academy of Sciences (2010). It was concluded that programs varied greatly in how much subject matter was needed (NAS, 2010). Levine (2006) mentioned that the diversity among teacher education programs in universities is the most common feature. In addition, a report by the National Research Council (2007) argued that teacher preparation should be restructured as many science teachers misjudge what science students are capable of doing. Some programs required PSTs to complete a degree in the subject to be taught and many elementary programs required pre-service teachers to take a broad spectrum of content and pedagogy classes (NAS, 2010).

**Interdisciplinary Collaboration, Models, Learning-by-Teaching, and Challenges for Implementation**

**Interdisciplinary Collaboration.** Collaboration is a critical topic of interest in education. Researchers have focused on collaboration among schools and organizations, among coworkers, and among students. “It is made possible when institutional citizens-including graduate students- with different disciplinary and subdisciplinary orientations interact with a shared purpose of designing and/or engaging in new teaching and learning experiences” (Freidow, Blankenship, Green, & Stroup, 2012, p. 405). Collay specified that learning environments that embrace collaboration among teachers with students, colleagues or even families is needed (2013). Specific to science education, Ford, Allen, Dagher, and Donham (2011) stated that interdisciplinary content courses often involve science educators and faculty of
scientists. It is important that educators provide future teachers opportunities to gain science understanding through inquiry-rich experiences and connect content with pedagogy (Ford, et al., 2011).

Hudson, Kloosterman, and Galindo (2012) created a scale to measure teacher’s beliefs about teaching math and science, with a particular focus on “Commitment to Collaboration” (p. 436). Collaboration is an important piece of the education puzzle. Previous research by Heibert, Gallimore, and Stigler (2002) suggested that teachers in the United States hardly ever progress in their practice by working with others from their respective fields of study. However, evidence suggested peer collaboration is helpful in altering instructional practices (Hudson et al., 2012). This critical piece of research is useful in determining how much collaboration can help shape and/or alter a teacher’s practice. Furthermore, literature regarding science education reform recommended students work independently and in collaborative groups to foster learning in a college setting (Goodman et al., 2006). Peer teaching as a form of collaboration has been identified as an effective learning strategy for improving understanding of students in biology (Tessier, 2004). Likewise, the National Academy of Sciences (2010) revisited data collected by Shroeder and colleagues on strategies for teaching science. The research described that “in an environment in which students can actively connect the instruction to their interests and present understandings and … experience collaborative scientific inquiry… achievement will be accelerated” (NAS, 2010, p. 137). Berlin and White (2012) assessed critical components of an integrated STEM curriculum. “It is critical that teachers—both pre-service and in-service—approach the design and implementation of integrated STEM teaching and learning through collaboration and teamwork with their colleagues in other subject areas” (Berlin & White, 2012, p. 28).
Collaboration delivers many benefits such as increasing student motivation and the sense of accomplishment (Miller & Benz, 2008). Different techniques may be applied to foster peer collaboration into the classroom. For example, Miller and Benz (2008) employed two techniques of collaboration: computer mediated conferencing and the fishbowl technique. Computer mediated conferencing is essentially a threaded discussion which allows individuals to work on-line outside of class time. The fishbowl technique allows a large class to be equally subdivided to work on specific topics (Miller & Benz, 2008). This study used different classes and a survey to test the different methods. Important findings from this study stated both methods had a positive effect on collaboration of students and were beneficial for peer assistance (Miller & Benz, 2008).

Davis et al. (2006) confirmed that collegial relationships and collaboration is important for teachers, including new teachers, experienced teachers, and researchers. Furthermore, research by the National Academy of Sciences (NAS) indicated teaching methods that foster collaborative learning have more affirmative influences on student achievement (2010).

It is imperative that teacher education programs be flexible and adapt to build on student capabilities (Buss, 2010). Such programs could include, “individualized, supplemental modules or coursework to ensure the development of competence and confidence for teaching the subject matter areas required of elementary school teachers” (Buss, 2010, p. 296). Likewise, Collay (2013) stated effective teachers must navigate partnerships and embrace expertise. In addition, research by NAS has identified collaborative programs that linked education and departmental faculty to parallel PST experiences as well as programs that have faculty who co-teach pedagogy and content materials (NAS, 2010). Reviewing successful interdisciplinary
collaborative models can be useful to gather approaches and ideas when implementing collaboration across disciplines.

**Interdisciplinary Collaborative Models.** Levine’s *Educating School Teachers* described Boston College’s Lynch School where education faculty and arts and science faculty collaborate and co-teach several subjects. Furthermore, many arts and science professors are actively involved in conducting research in K-12 schools (2006). Goodman et al. (2006) also created a program to provide elementary education majors with access to scientists and hands on activities in laboratories. “The course was designed to use laboratories and activities that either helped students learn major concepts in the life sciences or modeled how to teach these life science concepts to the future students (Goodman et al., 2006, p. 196). From this research it was concluded that elementary PSTs were emerging with confidence, articulating opinions, and addressing pertinent issues after experience in the program (Goodman et al., 2006).

Another analogous program implemented by Guziec and Lawson (2004) at State University of New York College included a three-hour class for interdisciplinary science for students majoring in childhood education. Education majors took a science-based course geared toward learning content and pedagogy. Of the participants surveyed, 71% were more attracted to science upon completion of the course, while 85% surveyed approved the class for others to take. An additional collaborative model is observed at the University of Tennessee at Chattanooga (Watson, Miller, & Patty, 2011). Future biology teachers from the Teacher Preparation Academy collaborated with their Challenger Center, “Chattanooga’s STEM Learning Center” (Watson et al., 2011, p. 801). At the Challenger Center future teachers planned, developed, and evaluated lessons for elementary science students (Watson et al., 2011). From this program,
PSTs gained confidence in teaching, while gaining important feedback from biology instructors and peers (Watson et al., 2011).

With more interdisciplinary collaborative programs, elementary education majors may gain a greater appreciation and interest in science and these could possibly become a long-term solution for improving attitudes towards science (Goodman et al., 2006). From Levine’s report (2006) on exemplary teacher education programs, he stated “There is a close connection between the teacher education program and the schools in which students teach, including ongoing collaboration between academic and clinical faculties” (p. 81). For example at Alverno College, senior English professors served as faculty for methods classes in education and observed students teachers in specific content areas (Levine, 2006). Diez, et al., stated that all professors at Alverno College, agreed that,

“Ours is not a highly selective program at entry; most of candidates are first-generation college students. But our program-founded on a strong set of liberal arts and teacher education learning goals, situated within a larger continuous assessment system, and using extensive and scaffolded field-based training- develops teachers' confidence and competence to an extraordinary degree,” (2010, p.19).

Furthermore, roughly half of the national pool of teachers leave the profession before five years. In contrast, at least 85% of Alverno College education graduates are still in the classroom after five years of teaching (Diez et al., 2010). Likewise, at Emporia State University, arts and sciences professors also observed student teachers and helped create lessons. In addition, these professors taught education methods courses (Levine, 2006). The University of Virginia has faculty advisors for students in liberal arts and the school of education (Levine, 2006).
Other programs have been implemented in the wake of science education reform that have shown improvements in science content knowledge and PST efficacy. These programs have broader reform efforts by involving science methods courses and science classes (Ford et al., 2011). The Integrated Credential Program at California State University San Marcos has been influential in the creation of Teacher Professional Continuum at The University of Delaware (Ford et al., 2011). The Integrated Credential Program included an entire semester centered on science. Future elementary teachers take a content course in each science (life, physical, and earth), a science methods course, and another course on science and society (Ford et al., 2011). From the previously mentioned model, The University of Delaware developed courses in science that includes a science semester with collaboration of content and pedagogy specifically for PSTs majoring in elementary education (Ford et al., 2011).

Additionally, Purdue University created a collaborative partnership of scientists, science educators, master teachers, graduate students, and undergraduate students to improve undergraduate-level introductory classes in science (Krockover, Shepardson, Eichinger, Nakhleh, & Adams, 2002). The goal of the collaboration was to improve PST education, and the education of students in STEM fields, and the goal of the research was focused around case studies centered on three science courses. One specific class addressed was Biology 205/206 (Biology for Elementary Teachers). Krockover et al. (2002, p. 274) cited strengths from collaborative action-based research teams as,

“Involving a diverse group of undergraduates, graduates, scientists, science educators, and teachers in course instruction, course development, action research, and decision making; using multiple perspectives on teaching and strengthening conceptual
understanding; and providing scientists and graduate teaching assistants with a model for undergraduate teaching.”

Krockover et al. stated, “Furthermore, enhancing communication between colleagues, students, teaching assistants, and practitioners is beneficial to improving the science curriculum,” (2002, p. 275). Interdisciplinary collaboration is important no matter the field of study, because it fosters and offers models for faculty communication.

Research by McCoy and Gardner (2012), stated that interdisciplinary collaboration has received much more attention from funding organizations such as the National Science Foundation and the National Institute of Health. The University of Virginia is a classic example, as the Carnegie Corporation awarded $5 million to the Curry School of Education to develop other programs to strengthen teaching by cultivating collaboration between the education faculty and the College of Arts and Sciences (Levine, 2006).

**Challenges and Concerns of Implementing Collaborative Models.** There are several challenges and impediments in not only creating but establishing lasting collaborative models. Krockover et al., stated that many relationships between educators in schools of education and academic specialists in colleges of liberal arts are possible, but are not unified (2002). Ford et al. described obstacles such as willingness of participants/faculty in each education and science department, manipulating class schedules to accommodate collaboration, and access of classrooms for collaboration (2011). Another disadvantage is the time commitment for faculty in addition to normal teaching loads. Time constraints often result in faculty becoming hesitant to joining collaborative efforts (Krockover et al., 2002). While many collaborative models require a large time commitment, the LdL method might make these collaborations less time consuming for instructors.
There are many concerns that regard working in collaborative partnerships and research. McCoy and Gardner (2012) issued five questions that all interested parties should consider before embarking on the collaborative course. Items for consideration include time allocation, the right people, proper resources, the right policies, and departmental support (McCoy & Gardner, 2012). The primary question from the five regarded time and people. Most interdisciplinary collaboration involves more than one field of study, and it takes time to learn other approaches of research. The second question regarded soliciting the right people. McCoy and Gardner further explained that doctoral students and instructors with background coursework in the liberal arts were most content with interdisciplinary collaboration (2012).

**Learning-by-Teaching Method as Collaboration.** “It has long been obvious that children learn from their peers, but a more significant observation is that children learn more from teaching other children” (Gartner, Kohler, & Riessman, 1971, p. 1; Whitman, 1988, p. 17). Learning-by-Teaching, “Lernen durch Lehren”, in German, is a method that is common practice in many global institutions.

“[The methodological core idea is to have a pair or group of students instruct the majority of topics (selected by the teacher or by the students themselves) to their classmates, but in a way that activates their classmates' participation and communication in the best possible way” (Grzega & Schoner, 2008, p. 169).](https://example.com)

It focuses on how to learn by the learner actually teaching the material to be learned often times to peers. This type of learning also has a rich history in American education. In the 1960s, Marcel Goldschmid, McGill University professor, was dissatisfied with traditional lectures and proposed peer teaching, thus the learn by teaching ideology (Whitman, 1988). Many LdL programs have been found at the university level, teacher training, and virtual
learning as well as many different fields of study such as biology, psychology, and education (Grzega & Schoner, 2008). For pre-medicine students in Iran, Jarari (2014) found that students increased scores and satisfaction levels when participating in collaborative LdL group learning as opposed to individual lecture learning. This technique has shown to improve students’ ability to collaborate with others, think independently, and effectively present ideas. Research has also shown LdL techniques provide higher scores on material taught by oneself in science (Tessier, 2004). Likewise, in education (Introduction to Teaching courses), Velez, Cano, Whittington, and Wolf (2011) qualitatively determined that student involvement and contribution to the classroom environment was increased through peer teaching.

Peer teaching and review could be especially beneficial when connected with interdisciplinary collaborations. “One could easily imagine a campus where all students are learners and teachers at different times and in different subjects, thus facilitating social interactions and enhancing learning” (Goldschmid, 1976, p. 441; Whitman, 1988, p. 25). This idea of interdisciplinary collaboration and peer teaching is not a new concept. However, programs must fully investigate existing collaborative models and the challenges of implementation before gaining the possible benefits.

**Teacher Beliefs and Teaching Implications**

If PSTs are to develop lesson plans on adaptation and brain-based behavior on evolution, it is important to examine research on how teacher beliefs in general play a role in lesson development. It is equally important to examine how specific beliefs on teaching evolution or adaptation-based lessons can affect teaching practices. Beliefs are extremely important in the instructional lessons teachers produce. Forbes and Davis (2008) explained that “Teacher’s knowledge and beliefs contribute more generally to their orientations toward teaching practice”
(p. 909). For example, Hudson et al. (2012) created a scale to measure a teacher’s beliefs about teaching math and science. Justification for the research was in the end tied to the conclusion that a belief system can impact instructional decisions that a teacher makes which can ultimately affect student achievement (Hudson et al., 2012). Teachers who enjoy science are typically more inclined to teach science.

Teaching evolution-based topics or adaption can be dependent on one’s belief as well. The National Academy of Sciences (2008) found that “teachers’ acceptance and understanding of evolution can have major impacts on its dissemination into the classroom” (NAS, 2008, p. 9). For example, a teacher, Paul Strode, commented about waiting until the end of the year to discuss evolution and warned students that, because it was in the curriculum, it would be covered (NASb, 2012). Students returned the next day with pamphlets about material Paul could not answer; therefore, he did not cover evolution for another seven years (NASb, 2012). “Many teachers in some parts of the country cannot deal with the conflicts with parents and students who confront them on a daily basis, so they avoid evolution” (NASb, 2012, p. 35).

Cavallo and McCall (2008) conducted a study to explore high school biology students’ beliefs and understanding about the theory of evolution and how that might change from pre to post instruction. Another similar study by Brem, Ranney, and Schindel (2002) led a study that discovered views of college students on the impacts of evolutionary theory. Two groups (i.e., creationists and evolutionists) were created from data gathered. Research from both studies yielded the same results, i.e., beliefs were not changed. Cavallo and McCall’s study found that there was a significant difference in understanding of evolution between pre- and post-instruction; however, students’ beliefs did not change (2008). Brem et al. (2002) discovered that students in their study largely rejected any proposal that disregarded their personal beliefs.
Previous research by Blackwell, Powell, and Dukes (2003) likewise revealed that beliefs which are deeply engrained are unlikely to change over a brief period of time.

However, Cavallo and McCall stated “The goal of teaching evolution should not be to change one’s personal beliefs” (2008, p. 529). Betty Cavellas, member of _Science, Evolution, and Creationism_’s authoring committee, shared that while students she taught did not have to believe in evolution, they did need to acknowledge the scientific evidence indicating evolution as a fact and theory (NASb, 2012). According to the National Academy of Sciences, scientific evolution and religion should both be discussed together (2012). Dotger, Dotger, and Tillotson (2010) researched how future science teachers could direct a conversation with parents that were against teaching evolution. This case study made up of K-12 pre-service biology teachers suggested that evolution should be taught based on scientific evidence and based on curriculum guides; however, understanding evolution as a theory did not mean accepting evolution (Dotger et al., 2010). As stated by Nancy Moran, “Many people have been exposed to very negative ideas about evolution; the worst thing to do is immediately draw a line in the sand and start talking about evolution versus religion” (NASb, 2012, p. 41).

According to the National Academy of Sciences, starting when students are young and broadening the audience for scientific evolution-based material is a key (2008). Additionally, data observed from the National Academy of Sciences (2008) found that 40 percent of the United States population does not believe that evolution exists, which can make targeting an audience difficult. Using an informal survey study conducted by a colleague of Richard Potts with the National Museum of Natural History, reported about students in biology where evolution had been talked about (NASb, 2012). A plethora of people and places were given accordingly: first was friends and family; second was church; third was television shows; and
lastly were classes and school (NASb, 2012). According to the National Academy of Sciences (2012), evolution is learned about from several different settings, and it is imperative that evolution education should reach many audiences. The public should be intrigued with interesting topics such as medicine, forensics, and pest-management topics (NAS, 2008). Once children and the public (in general) get fascinated about science, progress can be made. “Children need to start learning important concepts even before they enter school,” (NASb, 2012, p. 40). Interesting, novel topics to spark interest in children is essential to science education. Research has shown that evolution is critical to the foundation of the life sciences. Therefore aiding students in the learning process of evolution is essential for a quality education (NAS, 2008).

Biological evolution has become a unifying theme in science. Thus, future teachers must gain insight into this subject and how to help prepare their students in future coursework in the sciences. Pre-service and in-service teachers must use governing standards, produced at the state and national levels, to know exactly what content should be taught at certain grade levels. Standard-based documents, such as the Mississippi Science Framework (2010) and the national-level Next Generation Science Standards (NGSS, 2013) both have recognized evolution as an important theme to be taught. The Mississippi Science Framework recognized in content strand 3a, that evolution is an important concept starting in fourth grade: “Analyze the characteristics, structures, life cycles and environments of organisms,” and “describe the cause and effect relationships that explain the diversity and evolution of organisms over time” (MSF, 2010, p. 34).

More recently, the NGSS have identified evolution as the culmination of core ideas. According to Dimension 3 of the Framework the: “fourth core idea, LS4: Biology Evolution:
Unity and Diversity, explores changes in the traits of populations of organisms over time and the factors that account for species’ unity and diversity alike” (NASa, 2012, p. 140). This idea also leads into natural selection and adaptation as important parts to the theory of evolution (NASa, 2012). Students should be able to understand more about the nature of science and adaptation by the end of the second grade using the NGSS and focusing on evolution, natural selection, and adaptation (NASa, 2012). By understanding evolution and natural selection, fifth grade students should leave understanding that there are survival, mating and reproducing advantages due to different characteristics within and across species (NASa, 2012).

The National Association of Biology Teachers (NABT) completed a survey asking members about topics they were most interested in learning more about. Answer choices were given, and 50% answered evolution. However, the second section to the question asked which topics are taught. From the same list, only 30 percent of NABT members answered evolution (NASb, 2012).

Much progress has been made for teaching evolution in K-12 schools yet few resources for teachers are available. Foremost, teachers need to establish evolution as an experimental and observational science (NASb, 2012). Another great way to help change the culture is based on research by the National Academy of Sciences (2008) which stated that “Teaching evolution across the curriculum, as well as modeling effective teaching approaches, is a way to break out of this cycle. Effective teachers can show their colleagues how to teach evolution well and effectiveness will spread” (p. 20). In the report Vision and Change in Undergraduate Biology Education: A Call to Action (Brewer and Smith, 2011) five basic concepts in biology were addressed. This report clearly identifies evolution “is a thread that should extend all the way through the undergraduate curriculum,” (NASb, 2012, p. 48).
The “Understanding Evolution” website was launched by The University of California Museum of Paleontology in 2004, and most recently created a new version in 2011 in partnership with the National Evolutionary Synthesis Center (NESCent) and American Institute of Biological Sciences (AIBS). Through a grant with the National Science Foundation in 2009, the website has been enhanced with K-12 lessons and undergraduate lessons as well (NASb, 2012). The website’s mission is to reach a broader audience, and reaching students early, will result in the majority of the public understanding evolution better and will similarly affect attitudes (NAS, 2008).

Summary

Through extensive review on science teacher efficacy, elementary education majors’ science content knowledge upon completion of a traditional teacher preparatory program and pedagogical content knowledge in science, much work is still needed in teacher preparation degree programs to become globally competitive. As teachers increase content knowledge, teaching efficacies also increase. Being “highly qualified”, or content area strong, is the best starting place for teachers to feel more confident and become more qualified to teach research-based science based on research. With practice, pedagogical content knowledge becomes evident and teachers can build upon the content knowledge for best teaching practices. The effect of collaboration is tremendous for educating PSTs. Interdisciplinary collaboration is observed in the best teacher preparation programs and should become a focus for fostering more content knowledge into established education classes. Individual beliefs play an enormous role in what teachers actually teach in the classroom, and there is a bias against teaching evolution. Topics such as evolution and adaptation have a long history in American education and currently are in governing standards that science teachers should use nationally (NGSS, 2013). Both are
used to explain many scientific concepts and should be taught starting in early elementary school. In closing, by learning the science content through collaborative methods, teachers will hopefully become confident and effective in teaching topics such as evolution and adaptation.
CHAPTER III

METHODOLOGY

Introduction

The succeeding pages discuss details of mixed methods approaches used for this research project. First, quantitative, quasi-experimental design followed by qualitative approaches in grounded theory will be explained. Second, population, sample, and participants are discussed. Next, procedural information and instrumentation are described. Lastly, hypotheses and the research question are identified followed by statistical tests for specific data analyses used.

Design of the Study

This study was designed as a two-phase, sequential mixed methods study. A sequential explanatory strategy was employed as weight was given to quantitative data with the second qualitative phase building on the initial results (Creswell, 2014). The quantitative, quasi-experimental phase was conducted first. Three total sections of EDEL 404: Science in the Elementary Classroom and two total sections of BISC 327: Introductory Neuroscience were used in this study. Two sections of EDEL 404 at different course times served as the treatment method with different instructors and collaborated with BISC 327 science students at the corresponding course time. One other section of EDEL 404 served as the control and did not collaborate with science students. Initially, one more control section was planned, but due to low enrollment, the class was cancelled.

The two elementary education treatment sections and science classes used the LdL method in which science students relayed technical summary and case study information in an
understandable format for PSTs who then created lesson plans on adaptations or evolutionary brain-based behavior. All PSTs enrolled in EDEL 404 took a pretest and posttest to track individual performance on content knowledge, understanding scientific inquiry, attitudes about teaching science in general and evolution in particular. In addition, all PSTs created an individual lesson plan based on one of four neuroethology topics assigned: echolocation; electrosensory reception; steroid hormones; or vocal learning, which were randomly assigned at the beginning of the semester. Lesson plans were collected at the end of the semester in early December and disseminated to in-service teachers to review and grade for quality and usability during a luncheon on January 9, 2015. The same plans were also distributed to an external reviewer to grade for scientific accuracy.

One control section of EDEL 404 was used to compare the results of treatment and control on lesson plan quality and overall science content achievement and understanding based on individual pretest and posttest scores at the end of the Fall 2014 semester. All PSTs in EDEL 404 took an Attitudes and Opinions Survey which was then used to correlate final lesson plan grades earned with the different attitudes of the project. This also allowed any differences in attitudes between treatment and control groups to be identified.

Table 1. Quantitative Design of the Study

<table>
<thead>
<tr>
<th>EDEL 404 Section</th>
<th>N</th>
<th>Condition</th>
<th>Quantitative Data</th>
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<tr>
<td>2</td>
<td>17</td>
<td>Treatment</td>
<td>Pretest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lesson plan</td>
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<td></td>
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<td>Posttest</td>
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<td></td>
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<td>Attitude Survey</td>
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<tr>
<td>3</td>
<td>19</td>
<td>Treatment</td>
<td>Pretest</td>
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<tr>
<td></td>
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<td>Lesson plan</td>
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<td>Posttest</td>
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<td></td>
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<td></td>
<td>Attitude Survey</td>
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<tr>
<td>4</td>
<td>19</td>
<td>Control</td>
<td>Pretest</td>
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<tr>
<td></td>
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<td>Lesson plan</td>
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<td>Posttest</td>
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<tr>
<td></td>
<td></td>
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<td>Attitude Survey</td>
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</table>
A succeeding qualitative, grounded theory phase was then conducted. According to Patton, “The purpose of interviewing, then, is to allow us to enter into the other person’s perspective” (2002, p. 341). A purposeful sample consisting of both university education faculty members, one university science faculty member, and four PSTs in the treatment sections of EDEL 404 were interviewed to discuss the collaborative design. Topics regarding the enjoyment of the project and helpfulness in understanding science concepts were addressed during these interviews. Details of collaboration with science students were highlighted, as well as perceptions of the process. Two additional PSTs in the control section were interviewed as well to check for topic understanding and insights for improvements of lesson plan construction. Grounded theory was used by beginning with basic description, then moving toward conceptual ordering (Patton, 2002). Interview questions were limited in number and open-ended to stimulate responses from participants (Creswell, 2014). The exact questions also changed based on participant responses.

**Population, Sample, and Participants**

The population for this study was senior-level PSTs enrolled in method based education classes, as this study is intended to be generalizable to any subject, such as math, science, or English, at this university or beyond. A sample consisted of 55 PSTs in three sections of EDEL 404: Science in the Elementary School. There were 36 PSTs enrolled in the treatment sections and 19 enrolled in the control section. The total number of 55 pre-service teachers available who participated is significantly lower than anticipated, but this study was greatly limited due to enrollment for the Fall 2014 semester.

Participants that were chosen through purposeful sampling were interviewed independently by the researcher. Two university education faculty members and one university
science faculty member were interviewed to address the impact of collaboration and success of the collaborative program. Six total education PSTs were also interviewed. A purposeful sample of PSTs who displayed high-achieving status, low-achieving status, or tremendous growth during the experience, as measured by first and second lesson plan drafts submitted through Blackboard SafeAssign were selected from each section of EDEL 404 to address opinions of the study and the impact of collaboration.

Procedure

This study was designed for the Fall 2014 semester with collaboration between EDEL 404: Science in the Elementary School senior-level education methods classes and BISC 327: Introductory Neuroscience classes. Institutional Review Board (IRB) approval for this study was obtained and was ruled as exempt during the 2013-2014 school year. An amendment was provided for the IRB Board regarding using student work for possible publication. Therefore, student permission forms were made available and signed by all PSTs in December of the fall semester to obtain approval for using and publishing student work. All assignments in the EDEL 404 classes remained consistent with rubrics for grading all assignments. The only difference in the EDEL 404 sections was the exposure to science students in the two treatment sections.

On the second day of class, PSTs were randomly assigned to groups for one of four neuroscience topics that the lesson plan assignment was based upon. The pretest was also administered which consisted of 28 questions: eight questions based on individual neuroscience topics, four questions on competence and attitudes towards teaching science, four questions on beliefs and knowledge of evolution, eight education questions, and four scientific method questions. The pretest was administered by a graduate assistant in the biology department who knew how to manage the Turning Point clicker software used. Four different pretests were made
as questions 1-8 were based on one of four topics: echolocation; electrosensory reception; steroid hormones; or vocal learning.

EDEL 404 sections continued learning information about the 6-E learning cycle, scientific inquiry, experimental design, etc. As the semester progressed, treatment sections (two and three) of EDEL 404 paired with BISC 327 science students taught at the same time by visiting the biology department classroom. This arrangement was made to accommodate both education and biology classes at the same time. Transportation options were provided to the PSTs to enhance this experience in case of bad weather, disability, or parking issues.

Table 2. Collaborative Meetings

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Treatment</th>
<th>Control</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Case Studies, 6E Model, Standards, Blogging</td>
<td>Research topic, Standards</td>
</tr>
<tr>
<td>2</td>
<td>lesson plan rough draft due, Collaborate,</td>
<td>lesson plan rough draft due,</td>
</tr>
<tr>
<td></td>
<td>Blogging</td>
<td>Standards</td>
</tr>
<tr>
<td>3</td>
<td>lesson plan second drafts due, Collaborate,</td>
<td>lesson plan second drafts due,</td>
</tr>
<tr>
<td></td>
<td>Finalize</td>
<td>Finalize</td>
</tr>
</tbody>
</table>

EDEL 404 sections and BISC 327 sections met three times in the Fall 2014 semester. Collaboration among these sections was enhanced by blogging through Google Drive that allowed PSTs and science students to communicate outside of the collaborative in-person meetings. Prior to the first meeting, science students worked in cooperative groups and received one of four topics on brain-based behavior: echolocation; electrosensory reception; steroid hormones; or vocal learning. The science students created case studies with corresponding technical summaries. There were approximately ten biology students partnering with approximately five PSTs at each of the collaborative meetings. Grouping was based on size of the class and the four selected topics: echolocation; electrosensory reception; steroid hormones;
or vocal learning. The control section (four) of EDEL 404 did not collaborate with science students, but with fellow PSTs, while completing the same lesson plan assignment.

At the first collaborative meeting, the science students explained the technical summary and case study information at a lay-level to their corresponding groups by topic in treatment sections of EDEL 404. The PSTs then presented information about the 6-E learning cycle and how to construct lesson plans using scientific information. Both groups were provided a document with a pool of science teaching standards from the Next Generation Science Standards (NGSS) and Mississippi Science Framework (MSF) to possibly use based on the scientific information (Appendix B). Science students and PSTs determined which teaching standard(s) were appropriate based on the scientific information shared. Science students and PSTs interacted among their collaborative group to interpret knowledge of science students, addressed related misconceptions, identified appropriate standards, and understood the 6-E learning cycle. The PSTs in treatment sections of EDEL 404 then created first drafts of individual lesson plans from the case study and technical summary information gained from the science students. The PSTs in control sections also created individual lesson plans based on the same topics, but did not have the interaction between the science students. At this time, the control sections received their topic, and started researching on their own or with fellow class members during class time. All first drafts were submitted to the SafeAssign tool in Blackboard. Before the second collaborative education/science meeting, PSTs blogged at least two questions to the science students about the science content in their lesson plans. Science students responded accordingly before the next scheduled meeting.

At the second collaborative meeting, PSTs in treatment sections explained their lesson plan rough drafts to science students. At this meeting PSTs and science students collaborated to
check for scientific accuracy and connect brain behavior evolution to the lesson. PSTs continued working on their lesson plans until the third meeting. Prior to the third collaborative education/science meeting, PSTs blogged at least four questions again to the science students about the science content accuracy in lesson plans. Science students again responded accordingly before the next scheduled meeting. Control sections discussed their lesson plans collaboratively with fellow PSTs at this time.

At the third and final collaborative meeting, the second draft of lesson plans were described by the PSTs to the science students. This meeting allowed both disciplines to share information to create scientifically accurate lessons based on the scientific information. PSTs finalized their plans after the collaboration with science students. Control sections discussed their second draft and sought suggestions from peers. All second drafts of the lesson plan were submitted to SafeAssign in Blackboard to check if any information had changed. All EDEL 404 sections then finalized their lesson plans, which were graded.

Treatment and control sections of EDEL 404 submitted final lesson plans in fulfillment of the lesson assignment for EDEL 404 coursework at the end of the semester on December 5, 2014. Lesson plans collected were graded by professors and then disseminated to in-service teachers to grade and check for quality and usability in classrooms. In addition, an external evaluator graded lesson plans for scientific accuracy. Both additional graders provided detailed comments for qualitative data as well.

On the last day of class, a posttest was administered for data analysis. The posttest consisted of the same 28 questions as the pretest. Attached to the posttest was an attitudinal survey. There were separate surveys for the treatment and control sections as the questions were somewhat different based on teaching methodology, but as identical as possible for comparison.
Questions regarding collaboration with science students resulted in more total questions for the treatment sections. The treatment sections completed 18 total questions, and the control sections completed 13 questions for the attitudinal survey.

After quantitative data collection of pretest scores, drafts of lesson plan scores, attitude surveys, and posttest scores, interviews were conducted. Two education faculty members and one science faculty member involved with the collaborative study were interviewed. Faculty were asked about the likability, benefits, and challenges of collaboration. The science faculty member was also the external reviewer and provided comments regarding scientific accuracy for qualitative data. Six education PSTs were also interviewed. A purposeful sample of PSTs with the highest and lowest lesson achievement score from first and second drafts were chosen from EDEL 404 sections to address opinions and perceptions of the study. Elementary PSTs were interviewed to determine the likeability of the collaboration as well as perceived gains in understanding science content, specifically related to adaptation and brain-based evolution. Interviews were then coded for themes by the researcher.

**Instrumentation**

Group-based pretests and posttests were used to assess elementary pre-service teacher achievement in the EDEL 404 classes (Appendix A). The original multiple choice instrument was created by one science faculty member and two graduate assistants in 2012. The Center for Educational Research and Evaluation (CERE) (Wolff, Bryant, & Rutherford, 2014) at the University of Mississippi and the principle investigator for the National Science Foundation grant award # 1140810 recently modified the instrument for better content validity for the pilot study in 2013. Another modification for fall 2014 was made to study learning based upon grouping of individual topics. There were four versions of the performance based pretest on
assigned topics. This 28 question test was administered via clickers to all sections of EDEL 404 during the Fall 2014 semester as a pretest and at the end of the semester as a posttest to gain insight into knowledge gains in science content, scientific method, and general education understanding. The first eight questions were based on one of four neuroethology topics assigned: echolocation; electrosensory reception; steroid hormones; or vocal learning. There were four questions on competence and attitudes towards teaching science, four questions on beliefs and knowledge of evolution, eight questions based on science education, and four on the scientific method.

The Mini-Lesson Rubric was used in EDEL 404 sections to assess the quality of lesson plans that was designed in a joint effort between the current investigator, CERE, and a collaboration of science education faculty members over many years with regard to the lesson plan requirement to address content validity (Appendix C). This rubric utilized a four-point scale with responses not at all, somewhat, moderately well, and extremely well with respectively assigned numerical values 0, 1, 2, and 3. It also assessed PSTs’ objectives, teaching procedures, assessments, and learning cycle application. Some of the elements considered important by science education faculty included Next Generation Science Standards, Diversity issues, and Misconceptions in Science. Both myself as the researcher, and a graduate assistant graded all lesson plans. There was a positive correlation between graders’ rubric scores on final lesson plans, (r(53) =.463, p<0.01). However, only the researcher’s grades were used since the additional grader did not have any K-12 teaching experience and due to the low grader inter-reliability.

The Nature of Science Rubric (Appendix D) was also used to grade another lesson plan assignment (Nature of Science lesson plan) in EDEL 404 to check for student competence and
reliability. There was a positive correlation between the lesson plan rubric scores and the Nature of Science rubric score, \( r(53) = 0.437, p<0.01 \) as scored by the researcher.

An Attitudes and Opinions survey was administered to all sections of EDEL 404. Treatment sections (Appendix E) and control sections (Appendix F) completed a survey on a five point Likert scale, including: *strongly disagree, disagree, no opinion, agree, and strongly agree*. Points assigned include 1, 2, 3, 4, and 5, respectively. Control sections completed 13 questions about the overall enjoyment and complexity of the lesson plan assignment. Treatment sections completed 18 questions about the overall enjoyment and complexity of the lesson plan assignment as well as collaboration with science students. Both instruments were used to assess the enjoyment levels of science and education student collaboration and teaching methods.

CERE, science faculty, and the primary researcher collaborated to create this instrument to address content validity. Minor changes have been made since 2013 by science faculty and researchers due to changes in the structure of the collaborative meetings.

A modified Mini-Lesson Rubric was used for in-service teachers at the end of the semester to assess the quality of lesson plans (Appendix G). This rubric was almost identical to the lesson plan rubric the instructors of EDEL 404 used, so that we could compare differences in grading by internal and external in-service teachers. This rubric also utilized a four-point scale with responses *not at all, somewhat, moderately well, and extremely well* with respectively assigned numerical values 0, 1, 2, and 3. Both rubrics assessed PSTs’ objectives, teaching procedures, assessments, and learning cycle application. Elements considered important by science education faculty included Next Generation Science Standards, Diversity issues, and Misconceptions in Science.
Lastly, an external reviewer graded lesson plans for scientific accuracy (Appendix H). This rubric also utilized a four-point scale with responses *not at all, somewhat, moderately well, and extremely well* with respectively assigned numerical values 0, 1, 2, and 3. It also assessed the scientific accuracy of the PSTs’ objectives, teaching procedures, assessments, and learning cycle application. Qualitative data was also gathered based on extensive comments by the grader.

**Hypotheses and Research Question**

The following null hypotheses and research question directed this study:

**Null Hypothesis One:** There is no significant difference in mean elementary pre-service teacher posttest scores by teaching method (treatment or control) when controlling for pretest scores.

**Null Hypothesis Two:** There is no significant difference in mean elementary pre-service teacher lesson plan scores by teaching method.

**Null Hypothesis Three:** There is no significant relationship between achievement score of lesson plan and attitudes toward the collaborative activity.

**Null Hypothesis Four:** There is no significant difference of attitudes towards science lesson plan writing by teaching method.

**Null Hypothesis Five:** There is no significant difference of confidence, competence, and enthusiasm posttest scores by teaching method when controlling for pretest scores.

**Null Hypothesis Six:** There is no significant difference in quality and usability by teaching method as graded by in-service teachers.

**Qualitative Research Question:** How do responses and perceptions of university education faculty, university science faculty, and elementary education pre-service teachers’ interviews explain any quantitative differences in lesson plan quality and

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complexity when comparing those taught in collaborative classrooms to those without collaboration?

**Statistical Tests and Data Analysis**

Null Hypothesis One: There is no significant difference in mean elementary pre-service teacher posttest scores by teaching method (treatment or control) when controlling for pretest scores. An analysis of covariance (ANCOVA) test was used. The posttest score was the dependent variable. The method of instruction, collaboration with science students or treatment method was the independent variable, and the pretest score was the covariate. According to Hinkle (2003), an ANCOVA is designed to “control and explain variation in the dependent variable” (p. 496). For completeness, gains between pretest and posttest scores were analyzed by dependent t-tests for each teaching method. Additionally, posttest scores for each topic were analyzed using a One-Way ANOVA to detect if there was a significant difference between any of the topics. There were four different pretests and corresponding posttests that represented the four topics selected. Only the portion related to learning was considered in the analysis. Eight questions on the pre and post tests were opinion questions used for other analyses (Appendix A).

Null Hypothesis Two: There is no significant difference in mean elementary pre-service teacher lesson plan scores by teaching method. An independent t-test was used to detect if there was a significant difference in lesson plan scores by teaching method. There were 69 total points possible on the rubric used for grading (Appendix C). The independent variable was the method of instruction, and the dependent variable was lesson plan score.

Null Hypothesis Three: There is no significant relationship between achievement score of lesson plan and attitudes toward the collaborative activity. A correlation was used for to check if a linear relationship existed between lesson plan score and attitudes towards the collaborative
activity. This determined the enjoyment or satisfaction levels of the collaborative effort with science students in treatment sections and with fellow peers in control sections. To aid in comparison, the questions regarding attitudes towards the collaborative activity were as follows:

Control section questions

4. I felt knowledgeable when I discussed my lesson plans to my fellow students.
5. I was able to answer questions from my instructor and fellow students after my discussion.
6. It was helpful to meet in small groups to collaborate on lesson plans.
11. Overall I enjoyed the activities throughout this project.

Treatment section questions

2. I learned a lot from the cases discussed by the science students.
10. I personally made an effort to work with the science students.
17. Overall I enjoyed the activities throughout this project.

Null Hypothesis Four: There is no significant difference of attitudes towards science lesson plan writing by teaching method. An independent t-test was used to determine if there was a significant difference in writing attitudes by teaching method. The mean score from these questions selected was the dependent variable, and teaching method was the independent variable. The specific questions regarding attitudes towards the science writing of lesson plans were as follows:

Control section question:

3. It was easy to write lesson plans using information I located researching the topics for my science mini lesson plan.

Treatment section questions:

3. It was easy to write lesson plans using information from the science students’ collaboration and personal research.
7. I knew how to rewrite my lesson plan based on the conversations with science instructor and students.
Null Hypothesis Five: There is no significant difference of confidence, competence, and enthusiasm posttest scores by teaching method when controlling for pretest scores. An ANCOVA was used. Selected questions that referenced confidence, competence, and enthusiasm on the pretest and posttest were averaged for a composite score, which was the covariate and dependent variable, respectively. The teaching method was the independent variable. Questions 21, 22, and 23 were used and were the same for both control and treatment groups as the pretest and posttest were identical in each section. The independent variables were teaching method and time (pretest and posttest). The following questions regarding competence, confidence and enthusiasm were as follows:

21. My degree of competence to teach this topic is sufficient
22. My degree of confidence to teach this topic is sufficient
23. I feel enthusiastic about teaching science in my future classroom

Null Hypothesis Six: There is no significant difference in quality and usability by teaching method as graded by in-service teachers. An independent t-test was used. A rubric very similar to the Mini-Lesson Rubric used in EDEL 404 was used for in-service teachers grading lesson plans. There was a graded portion worth 63 possible points and an opinion portion. The dependent variable was the grade of the lesson plans by in-service teachers to check for usability and quality. The independent variable was teaching method. Additionally, an external reviewer graded the same lesson plans for usability and scientific accuracy with a similar rubric also worth 63 possible points. A correlation was used to determine if there was a relationship between lesson plan scores and scientific accuracy. An independent t-test was also used to determine if there was a significant difference between accuracy by teaching method.

For the research question, short yet in-depth interviews of two education faculty members, one science faculty member, and six PSTs were conducted at the end of the Fall 2014
semester. Interviews were transcribed and coded for themes. Dependability and integrity by the investigator was upheld exhibited by honesty and without bias throughout the interviews or data collection.
CHAPTER IV

RESULTS

This quasi-experimental, mixed methods study investigated PST achievement measured by pretest and posttest scores in addition to lesson plan scores by different teaching methodologies. Additionally, attitudes towards collaboration and science lesson plan writing were examined. Quantitative and qualitative findings from data collected during the Fall 2014 semester are presented below.

Quantitative Analyses

Hypothesis One: An ANCOVA test was used to determine if there was a significant difference in mean elementary PST posttest scores by teaching method when controlling for pretest scores.

Table 3. Posttest by Teaching Method

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>13.22</td>
<td>2.830</td>
<td>36</td>
</tr>
<tr>
<td>Control</td>
<td>14.32</td>
<td>2.286</td>
<td>19</td>
</tr>
</tbody>
</table>

Results for posttest scores by teaching method indicate that the control section scored higher on average than the treatment sections.

Table 4. ANCOVA Results by Teaching Method Controlling for Pretests

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>101.832</td>
<td>1</td>
<td>101.832</td>
<td>19.224</td>
<td>.000</td>
</tr>
<tr>
<td>Methodology</td>
<td>11.913</td>
<td>1</td>
<td>11.913</td>
<td>2.249</td>
<td>.140</td>
</tr>
<tr>
<td>Error</td>
<td>275.455</td>
<td>52</td>
<td>5.297</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
All assumptions, including Levene’s Test, were met; thus, the ANCOVA results were considered valid. The ANCOVA test results were not significant at the p=0.05 level (F(1,52)=2.249, p=0.140), which indicated that there was no significant difference between posttest scores by teaching method when controlling for pretest scores.

Table 5. Dependent t-Test Results by Teaching Method

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Treatment</td>
<td>-1.667</td>
<td>2.630</td>
<td>.438</td>
<td>-3.803</td>
<td>35</td>
<td>.001</td>
<td>-2.556</td>
</tr>
<tr>
<td>Control</td>
<td>-2.421</td>
<td>2.874</td>
<td>.659</td>
<td>-3.672</td>
<td>18</td>
<td>.002</td>
<td>-3.806</td>
</tr>
</tbody>
</table>

Dependent t-tests were conducted for treatment and control sections to check gains from pretest to posttest. There was a significant gain in pretest and posttest scores in both treatment (t(35)=3.803, p=0.001) and control sections (t(18)=3.672, p=0.002) at the 0.01 alpha level.

Table 6. Posttest by Topic

<table>
<thead>
<tr>
<th>Topics</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Echolocation</td>
<td>14</td>
<td>14.36</td>
<td>2.098</td>
<td>.561</td>
<td>13.15</td>
</tr>
<tr>
<td>Electrosensory Reception</td>
<td>13</td>
<td>14.38</td>
<td>2.599</td>
<td>.721</td>
<td>12.81</td>
</tr>
<tr>
<td>Steroid Hormones</td>
<td>15</td>
<td>12.73</td>
<td>3.305</td>
<td>.853</td>
<td>10.90</td>
</tr>
<tr>
<td>Vocal Learning</td>
<td>13</td>
<td>13.00</td>
<td>2.345</td>
<td>.650</td>
<td>11.58</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>13.60</td>
<td>2.685</td>
<td>.362</td>
<td>12.87</td>
</tr>
</tbody>
</table>

To further investigate Hypothesis One, posttest scores were analyzed by each topic using an ANOVA. The posttest means by topic from highest to lowest were as follows: electrosensory reception, echolocation, vocal learning, and steroid hormones.

Table 7. ANOVA Results of Posttest by Topic
The One-Way ANOVA test results were not significant at the 0.05 alpha level (F(3,51) =1.522, p=0.220), which indicated that there was no significant difference between posttest scores by topic.

**Hypothesis Two:** An Independent t-test was used to determine if teaching method had an impact on lesson plan quality as determined by scores from a grading rubric.

Table 8. Lesson Plan Scores by Teaching Method

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>36</td>
<td>48.08</td>
<td>13.451</td>
<td>2.242</td>
</tr>
<tr>
<td>Control</td>
<td>19</td>
<td>49.95</td>
<td>10.097</td>
<td>2.316</td>
</tr>
</tbody>
</table>

There were 36 PSTs in the treatment sections compared to 19 in the control section. There were 69 possible points for the Mini-Lesson Rubric, and the treatment sections had a lower mean average than the control section.

Table 9. T-Test for Lesson Plan Scores by Teaching Method

<table>
<thead>
<tr>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levene’s F</td>
<td>Sig</td>
</tr>
<tr>
<td>Lesson Plan Score variances assumed</td>
<td>1.991</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-.578</td>
</tr>
</tbody>
</table>

There was no significant difference in lesson plan scores between treatment sections (t(53) =-0.530, p=0.599) at the 0.05 alpha level.
**Hypothesis Three:** A correlation was used to find if there was a relationship between lesson plan scores and attitudes toward collaboration. Both treatment and control sections of EDEL 404 were used.

Table 10. Collaborative Attitude and Lesson Plan Scores

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative Attitude</td>
<td>3.5582</td>
<td>.63346</td>
<td>55</td>
</tr>
<tr>
<td>Lesson Plan Score</td>
<td>48.73</td>
<td>12.331</td>
<td>55</td>
</tr>
</tbody>
</table>

The collaborative attitude mean score was determined by averaging questions on the attitudinal survey for the different teaching methods. Treatment sections averaged questions 2, 10, and 17 and the control section averaged 4, 5, 6, and 11. The Mini-Lesson Rubric was used with 69 possible points.

Table 11. Correlation of Collaborative Attitude and Lesson Plan Scores

<table>
<thead>
<tr>
<th></th>
<th>Collaborative Attitude</th>
<th>Mini-Lesson Plan Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative Attitude</td>
<td>Pearson Correlation</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>55</td>
</tr>
</tbody>
</table>

There was no significant relationship between attitudes toward collaboration and final lesson plan scores regardless of condition (r(53)=−0.173, p=0.205) at the 0.05 alpha level.

**Hypothesis Four:** An Independent t-test was used to test for any possible difference of attitudes towards science lesson plan writing by teaching method.

Table 12. Writing Attitude by Teaching Method

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>36</td>
<td>3.6667</td>
<td>.78376</td>
<td>.13063</td>
</tr>
<tr>
<td>Control</td>
<td>19</td>
<td>2.2632</td>
<td>.99119</td>
<td>.22739</td>
</tr>
</tbody>
</table>
Attitudes towards writing science lesson plans were gathered from questions on the attitudinal survey. The treatment sections had a higher mean average than the control section.

Table 13. T-Test for Writing Attitude by Teaching Method

<table>
<thead>
<tr>
<th>Writing Attitude</th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal variance assumed</td>
<td>F .655 Sig .422 t 5.756 df 53 Sig. 2-tailed .000 (2-Mean Difference 1.40351 Std. Error Difference .24382)</td>
<td>95% Confidence Interval of the Difference Lower .91447 Upper 1.89255</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>F -.578 Sig .30151 t 30.151 df 53 Sig. 2-tailed .000 (2-Mean Difference 1.40351 Std. Error Difference .26224)</td>
<td>95% Confidence Interval of the Difference Lower .86805 Upper 1.93897</td>
</tr>
</tbody>
</table>

There was a significant difference in attitudes towards science lesson plan writing between treatment sections (t(53)=-5.756, p=0.000). The PSTs in treatment sections had significantly higher their attitude scores than the control section at the p=0.01 level.

**Hypothesis Five:** An ANCOVA was used for hypothesis five addressing PST confidence, competence, and enthusiasm which were measured on the pretest administered at the beginning of the semester and again on the posttest administered at the end of the semester for both control and treatment sections.

Table 14. ANCOVA for Competence, Confidence, and Enthusiasm

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1.409</td>
<td>1</td>
<td>1.409</td>
<td>5.633</td>
<td>0.021</td>
</tr>
<tr>
<td>Methodology</td>
<td>0.215</td>
<td>1</td>
<td>0.215</td>
<td>0.858</td>
<td>0.359</td>
</tr>
<tr>
<td>Error</td>
<td>13.006</td>
<td>52</td>
<td>0.250</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There was no significant difference in confidence, competence, and enthusiasm attitudes for PSTs by teaching method \((F(1,53)=0.858, p=0.359)\) at the 0.05 alpha level, but all sections improved confidence levels.

**Hypothesis Six:** An independent t-test was used to determine if there is a significant difference in quality and usability by teaching method as graded by an in-service teacher.

Table 15. In-Service Lesson Plan Scores

<table>
<thead>
<tr>
<th>Method</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>16</td>
<td>30.81</td>
<td>13.536</td>
<td>3.384</td>
</tr>
<tr>
<td>Control</td>
<td>16</td>
<td>38.75</td>
<td>12.434</td>
<td>3.108</td>
</tr>
</tbody>
</table>

One in-service teacher graded the two best and worst lesson plans for each topic, by using a rubric very similar to the EDEL 404 Mini-Lesson Rubric with 63 possible points. The treatment sections \((M=30.81)\) scored lower on average than the control section \((M=38.75)\) as graded by the in-service teacher.

Table 16. T-Test of In-Service Lesson Plan Scores by Teaching Method

<table>
<thead>
<tr>
<th>Lesson Plan scores</th>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equal variance assumed</td>
<td>.101</td>
<td>.753</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-1.73</td>
<td>29.786</td>
</tr>
</tbody>
</table>

There was no significant difference in quality and usability by teaching method \((t(30)=-1.727, p=0.094)\) at the 0.05 alpha level. Additionally, an external reviewer graded the two best and two worst lesson plans from each group for scientific accuracy. A correlation was used to
determine if there was a significant relationship between lesson plan score and scientific accuracy.

Table 17. External Reviewer Scientific Accuracy Correlation

<table>
<thead>
<tr>
<th>Lesson Plan Score</th>
<th>Pearson Correlation</th>
<th>Scientific Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0.922</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>32</td>
<td>32</td>
</tr>
</tbody>
</table>

There was a strong, positive relationship between lesson plan scores and scientific accuracy (r(32)=0.922, p=0.000). This is significant at the 0.01 level. An independent t-test was also used to test for a significant different in scientific accuracy by teaching method.

Table 18. T-Test for Scientific Accuracy by Teaching Method

<table>
<thead>
<tr>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig</td>
</tr>
<tr>
<td>Equal variance assumed</td>
<td>.093</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-2.59</td>
</tr>
</tbody>
</table>

There was no significant difference in scientific accuracy scores by teaching method as graded by the external reviewer (t(30)=-2.59, p=0.797) at the 0.05 alpha level.

Qualitative Data

PST Interviews. PSTs were selectively interviewed to help gain a better perspective of the collaborative model between EDEL 404 and BISC 327 classes. There was no significant difference in posttest scores when controlling for the pretest, and there was no significant
difference in lesson plan scores based on method of teaching; therefore, it was important to examine PSTs in each section to understand their perspective of the collaboration. Six total PSTs were interviewed based on achievement level of lesson plans and gains between drafts of the lesson plan. Four PSTs were interviewed from the treatment sections and two were interviewed from the control section. The research questions for PSTs that guided this study were as follows:

1. What were the benefits of collaborating?
2. What were the disadvantages of collaborating?
3. Did you gain a better understanding of the science in your lesson plan topic through collaboration?
4. How do you think your lesson plan would turn out if you did not collaborate?

Based on careful selection and meaningful analysis, three major themes with three subthemes were determined. These interrelated themes provided more detail to the quantitative findings.

The themes were:

1. Collaboration
   a. Benefits
   b. Disadvantages
2. Science Understanding
3. Lesson plan quality
   a. No collaboration

<table>
<thead>
<tr>
<th></th>
<th>Benefits of Collaboration</th>
<th>Disadvantages of Collaboration</th>
<th>Science Understanding</th>
<th>Lesson Plan Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>Unanimously important</td>
<td>Time commitment</td>
<td>Full understanding</td>
<td>Blander without collaboration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perceived arrogant behavior</td>
<td>Partial understanding</td>
<td>High quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No understanding</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Unanimously important</td>
<td>None expressed</td>
<td>Partial understanding</td>
<td>High quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No understanding</td>
<td></td>
</tr>
</tbody>
</table>

Table 19. PST Interviews by Teaching Method
By analyzing PST interviews, different perceptions of benefits of collaboration, disadvantages of collaboration, science understanding, and lesson plan quality were identified.

**Collaboration.** This study found that collaboration, whether it was with science students or fellow peers, was viewed by PSTs as an important part in constructing their lesson plans on topics in neuroethology. Participants interviewed recognized benefits as well as disadvantages with collaboration, which are described below.

**Benefits of Collaboration.** The benefits of collaboration were unanimous. All six participants documented benefits through a collaborative effort. Treatment sections worked with science students and several gave specific ideas they thought were beneficial. For instance, in this example a PST described working with science students:

“I think for them to be able to take the terms that we don’t hear every day or we don’t know, and kind of break it down for us in a way… and to make it easier for us to understand how we can use it to teach.”

Many treatment PSTs recognized that collaboration with science students helped gain scientific information, especially fine details.

“Growing up I knew what echolocation was, but there were things that I didn’t know. For example, I didn’t know that not all bats echolocate, only certain ones echolocate. Also, there are other animals that echolocate. So there were tiny details that I didn’t know that I learned from working with them.”

The control PSTs also recognized the importance of collaboration. They responded more on pedagogical aspects of the lesson plan instead of the science. When asked if the PSTs in the control groups think collaboration with science students would have made a difference in their lesson plan, PSTs all agreed that collaborating with classmates was sufficient. For example, one
student revealed, “I think we (PSTs) were all going for the same goal. So, I think that in the end it was just as helpful to work with them as anybody else.”

*Disadvantages of Collaboration.* As all PSTs identified benefits of collaboration regardless of teaching method, PSTs in treatment sections described disadvantages of collaboration. Particularly they described the amount of time spent collaborating, such as,

“There were five of us in a group and a lot of them in the science group and so it was a lot of wasted time because we would go and two people would look over our lesson plans, and then that was it.”

Additionally, one PST in a treatment section recalled how the science students talked to their group in a condescending manner. This PST specifically remembered asking a question to the science students of which one replied, “Why don’t you know that?” This student has a lasting impression from the science students about collaborating with them.

*PST Understanding of Science.* One important goal for this collaboration was for PSTs to understand both the science of their topic as well as evolution behind their specific topic. The four topics PSTs were required to write lesson plans on were selected based on gaining more understanding of the science in general, but evolution specifically. PSTs had mixed reviews when asked if they understood the science of their topic. Only one participant thought both the science content as well as the evolution was understood. Half of the participants responded unsure if they understood the science content and evolution. Two participants said they did not understand the evolution of their topic. Additionally, a PST stated, “I don’t know; I really couldn’t tell you.”

*Lesson Plan Quality.* The PSTs in treatment sections were asked about the quality of their final lesson plan if there was no collaboration. Half of the participants agreed that their
lesson plans would probably remain the same, but one specifically mentioned it would have been more difficult to start.

“I think it would turn out the same. It probably would have been a little bit more difficult trying to figure out which different aspects of stress we were going to use.”

The other half of the participants agreed that collaborating with science students enhanced their lesson plan quality. One stated, “I think it would have been more bland.”

Another PST mentioned,

“I think it would be a little bit more surfaced, just the surface things we already knew about stress. Whenever I met with them (science students) I learned more scientific things about it; I wouldn’t have known that if I hadn’t met with them.”

**Faculty Interviews.** Education faculty who taught EDEL 404 and a science faculty member who taught BISC 327 were also interviewed to gain insight to teacher perceptions of collaboration between the classes. Additionally, the science faculty member also was the external reviewer for scientific accuracy. The research questions were very similar for the PSTs, but needed a professor’s perspective. The questions for all faculty were as follows:

1. What were the benefits of this collaboration?
2. What were the disadvantages?
3. Did students like collaborating?
4. What feedback did you provide students?
5. Is interdisciplinary collaboration an important part of higher education?
6. Was this program successful?

Five themes developed with three subthemes:

1. Collaboration
   a. Benefits
   b. Disadvantages
   c. Importance
2. Feedback
3. Student enjoyment
4. Program Success
5. Scientific Accuracy

Table 20. Faculty Interviews by Teaching Profession

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Disadvantages</th>
<th>Importance</th>
<th>Feedback for mini-lesson</th>
<th>Student Enjoyment</th>
<th>Program Success</th>
<th>Scientific Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Exchange of knowledge across disciplines</td>
<td>Time allocation Perceived arrogance</td>
<td>Highly important</td>
<td>None</td>
<td>Not exactly</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Science Exchange of knowledge across disciplines</td>
<td>Motivation Perceived arrogance</td>
<td>Highly important</td>
<td>Constructive feedback</td>
<td>Mostly</td>
<td>Yes &amp; No</td>
<td>Many Inaccuracies</td>
</tr>
</tbody>
</table>

Equal investment

By analyzing the faculty interviews, collaboration, feedback, student enjoyment, and program success were identified with similar and very different viewpoints.

**Collaboration.** Collaboration was unanimously viewed as an important piece for higher education. Specifically, faculty interviews regarding interdisciplinary collaboration found in this study recalled several benefits and disadvantages. It was also regarded as highly important by all faculty. The viewpoints of faculty concerning interdisciplinary collaboration are depicted below.

**Benefits of Collaboration.** All faculty agreed that collaboration, including interdisciplinary collaboration is beneficial for participants. Universally, very similar responses were given. Professors all agreed that PSTs were helped by the science students explaining difficult topics at an understandable level, and it was equally viewed that the science students were helped from the PSTs by describing how science is actually taught in the classroom. Faculty also agreed that both science students and PSTs were sharing knowledge in a productive manner. One faculty stated, “Knowledge was gained back and forth, and they developed really an easy rapport with the biology students, and I think they enjoyed that.”
Disadvantages of Collaboration. There were also a few disadvantages within the collaboration as described by two of the faculty members. Both members who shared disadvantages felt that students from the opposite school could come across as arrogant despite multiple efforts to negate this behavior. Another point made was the collaboration was very time consuming, and it was hard to cover all the necessities of class. This coincides to another point that both parties have to be equally invested. For example, “Unless both sides are equally interested in vesting the same amount of time and effort in making it work, it kind of falls apart.”

Importance of Collaboration. All faculty members quickly responded that interdisciplinary collaboration is very important in higher education. All faculty established that real life includes collaboration between different groups. One response included, “it mirrors life.” Another response included, “You don’t learn things in succinct areas, sometime you have to cross over to the other areas.” All members also agreed that collaborative experiences are learning experiences. Another response was, “I think it’s exceedingly important. Without that exchange of ideas I don’t think we improve as much.”

Feedback. In this study, all faculty members were accessible for PSTs. Faculty responded quite differently when asked about feedback given to EDEL 404 sections. Each faculty member did something different. One response indicated no feedback was given. Another stated only pedagogical feedback was given between drafts of the lesson plans submitted. Alternatively, positive, constructive feedback when asked was given by one faculty member, but the aim was to really push for collaboration among science students and PSTs during the collaborative meetings.

Student Enjoyment. Each faculty member responded differently about overall student enjoyment of this collaborative study. Education faculty felt more strongly that students did not
like the activity as much as the science faculty member did. Students will not be distinguished between science and education. One thought that students did not like the activities associated with this collaboration because of its complex nature. Another mentioned that certain aspects were enjoyable to students, but did not provide clear examples. Additionally, another thought that most students enjoyed the activity. The point was made that students who wanted to learn, did not care about the extra activities, and these students enjoyed the activity more. For other students, it was a complete waste of time, because no extra effort was put forth. These students just wanted a grade.

**Program Success.** Faculty members had differing opinions on the success of this interdisciplinary collaborative study. One viewpoint was that this particular program might not be successful in significantly increasing lesson plan scores based on collaboration with science students based on the nature of the topics selected; however, it might be successful attitudinally. Another viewpoint expressed was this program was not successful, regardless of topic, because everyone is so specialized at the university level. An alternative viewpoint identified that specific aspects were successful. The faculty member stated, “Even opening teachers’ minds to the idea they don’t have to teach about migration and weather patterns, I think was good.” Additionally,

“I think if nothing else, I have planted the seed in the minds of premed and future researchers that outreach is important. This is why- I need to be able to explain my research to my grandma, to my sister, cousin, to teachers.”

**Scientific Accuracy.** An external reviewer graded the two best and worst lesson plans in each topic area and provided detailed comments for qualitative review. Comments were reviewed and broken into three categories: Many inaccuracies, minor inaccuracies, and unclear
PST understanding. There were 16 lesson plans determined with many inaccuracies, seven with minor inaccuracies, and nine that were unable to detect PST understanding. Many inaccuracies indicated that PSTs had lesson plans with several inaccurate materials, including, incorrect books, resources, or teacher directions. Minor inaccuracies indicated that PSTs had one to two inaccuracies in the lesson plan. Several lesson plans did not contain enough information to detect if the PSTs understood the material correctly.
CHAPTER V

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Summary of Research

This research was a continuation of a pilot study conducted the previous year in Fall 2013, 2012, and 2011. The goal to enhance learning through a collaborative LdL model has remained consistent including similarities in the four topics selected; however, many methodologies changed. Initially, PSTs took a pretest and posttest including questions on all four topics, scientific method, and pedagogy. Then, they listened to all presentations made by science students on the same four topics, but created group lessons based only on one specific topic. Elementary education majors then presented their group lesson to all science students for critiques and constructive feedback. They each created individual lesson plans regarding one specific topic for a grade. Upon data collection in Fall 2013, analyses were conducted by Wolff et al., at CERE (2014) within the School of Education, and are presented below.

The pilot study found that there was no significant gains between pretest and posttest scores by teaching method (t=1.588, sig=0.117). However, significant gains between pretest and posttest were significant within the control sections (t=7.156, sig=0.000) and the treatment sections (t=4.617, sig=0.000). There was no significant difference between lesson plan scores by teaching method (t=1.816, sig=0.074), and the control sections had a higher mean score (M=33.22) than the treatment sections (M=31.19). Additionally, an external reviewer graded lesson plans on scientific accuracy. It was determined there was no significant relationship between lesson plan score and scientific accuracy (r(14) =-0.134, p=0.620).
The quantitative results were clear that PSTs in control sections created lesson plans of the same quality, whether accurate or not, to those in treatment sections; however, a qualitative component of research was needed. There was no additional method of gaining access to what the PSTs or faculty were thinking or observing during the process. Additionally, the current research sought ways to improve the study by providing more equality in collaboration and allowing PSTs to bring information, such as the 6E learning cycle, to the table. Also, instructors allowed more collaboration among both sets of students both in class and online through blogging. This current study investigated the effects of elementary PST achievement measured by pretest and posttest scores in addition to lesson plan scores through collaboration with science students, specifically measuring improvements in scientific content knowledge and ability to create quality lesson plans on unique topics related to neuroethology. This year, there was a total of three sections of EDEL 404: Science in the Elementary Classroom and two total sections of BISC 327: Introductory Neuroscience used.

The two treatment sections of elementary education science methods classes and science students enrolled in neuroscience classes utilized an LdL method in which science students relayed technical summary and case study information in an understandable format for PSTs who then created lesson plans on four neuroethology topics randomly assigned: echolocation; electrosensory reception; steroid hormones; or vocal learning. All PSTs took a pretest and posttest to track individual performance on content knowledge, understanding scientific inquiry, attitudes about teaching science in general and evolution in particular. In addition, all PSTs created an individual lesson plan based on their specific topic. Lesson plans were collected at the end of the semester in early December 2014 and disseminated to in-service teachers and an external reviewer, to grade for quality and scientific accuracy, respectively.
One control section was used to compare the results of lesson plan quality and overall science content achievement and understanding based on individual pretest and posttest scores of PSTs. In addition, all PSTs took an Attitudes and Opinions Survey which was then used to correlate achievement with different attitudes related to the project.

Summary of Results

Quantitative Results. Overall, several null hypotheses were supported. There were no significant differences found in posttest scores when controlling for the pretest by teaching method at the 0.05 level. There was also no significant difference in mean elementary PST lesson plan scores between the control and treatment sections. Likewise, there was no correlation between attitudes toward collaborative activities regardless of teaching method and lesson plan scores. There was no significant difference of PST confidence attitudes on pretest and posttest by teaching method.

At the end of the Fall 2014 semester, data was gathered and the best and worst lesson plans were selected for in-service teachers to grade, for a total of 32 lesson plans. There was no significant difference in quality and usability by teaching method as graded by in-service teachers. There was a strong, positive relationship between lesson plan scores and scientific accuracy as graded by the external reviewer. However, there was no treatment effect.

Only one null hypothesis was rejected: There was a significant difference of attitudes towards science lesson plan writing between the treatment versus control sections at the 0.01 level. The results will be discussed in the next section.

Qualitative Results. In the second phase, qualitative interviews were conducted with two education faculty members, a science faculty member and six PSTs enrolled in EDEL 404. The reason for following up with qualitative research in the second phase is to better understand
and explain the quantitative results. Themes and subthemes emerged from interviews with PSTs and faculty members. Both sets of interviews produced stimulating qualitative data that the quantitative data just could not gather alone.

The PSTs felt that collaboration was beneficial while also recognizing the benefits and disadvantages from this particular interdisciplinary study. They also felt very differently about their level of understanding the biological concepts; some felt very confident, while others did not. The PSTs also had differing views of lesson plan quality. Many were proud of their lesson plans, and stated their final product would have turned out the same way. Some gave credit to science students and agreed that the first meeting was very beneficial in starting the writing process.

Themes and subthemes also materialized from faculty interviews. All faculty agreed that interdisciplinary collaboration was very important in higher education. They all agreed there were benefits to this particular collaboration between science students and PSTs. Many recognized disadvantages, and offered differing levels of feedback to the future elementary teachers. The success of this program was the most varied response. Faculty members had different levels and ideas of what success actually meant, and scientific accuracy was explored.

**Discussion of Results**

**Quantitative Discussion.** The pretest and posttest have changed since the pilot study to more accurately understand the levels of PST understanding based on specific topics selected. Elementary education majors selected their own classes and times based on personal preference. The control sections, both years of the study, have had really bright students, that seem very motivated to learn. I was intrigued that the control section had a higher mean pretest and posttest score for the pilot study as well as this current study. There was no significant difference in
posttest scores while controlling for pretest scores, and I think this is a result of motivated students in the control section using research, from the Internet or fellow students in order to gain knowledge about their selected topics.

There was no significant difference in mean elementary PST lesson plan scores by teaching method. The pilot study nor the current study showed significant differences, yet in both studies the control section had a higher mean score. This demonstrates that control PSTs were able and are capable of researching topics as adequately as the treatment sections. Also, elementary majors are a close group of students. They talk; they share information. Even though there were treatment and control sections, there was no definitive solution to keep the PSTs from talking with each other.

No significant relationship between achievement score of lesson plan and attitudes toward the collaborative activity were found in the pilot study or this current study. Many collaborative programs require more work from students other than lecture or what the students actually expect. Some students do the required work and want to learn, while others feel extra activities are a complete waste of time. For example, the blogging was determined not successful, because it was extra work from PSTs as well as science students. This extra work probably caused dissatisfaction and lower ratings in the collaborative attitudes. I think that PSTs have been challenged differently by collaborating on topics that normally would never be chosen. It is possible that the topics themselves lent to more negative attitudes rather than working with peers or science students. I also think it is possible that elementary PSTs are so consumed with all of their methods classes for every subject that additional collaborative work was extraneous for them. If this collaboration occurred in a different semester, results might have been different.
There was a significant difference of attitudes towards science lesson plan writing by teaching method. Bayraktar mentioned that improving beliefs and attitudes for teaching science is essential for future teachers (2011). This study has shown that collaboration with science students improved attitudes towards writing science lesson plans. I believe the PSTs enjoyed knowing how to start writing their lesson plans, and this made a huge impact on how they felt about writing. An important aspect of teaching in the elementary or secondary schools is writing lesson plans. This is an important finding, because any improvement in attitude is likely to reflect in teaching practices. By increasing this specific attitude, PSTs may have a better outlook for teaching science in the future.

While there was no significant difference of confidence, competence, and enthusiasm before and after collaboration by teaching method, it is very important to remark that confidence significantly increased for both treatment and control sections. This study was designed using the fishbowl technique, in that a large class was equally divided and worked on specific topics (Miller & Benz, 2008). Likewise, Ford et al., stated that it is very important to provide PSTs science learning opportunities to connect both content and pedagogy (2011). By providing this collaborative LdL technique, PSTs felt more confident after collaborating with science students or fellow elementary majors. Similarly, a collaborative model, “Chattanooga’s STEM Learning Center” also showed that future teachers had increased confidence in teaching while gaining important constructive critiques from biology teachers and peers (Watson et al., 2011).

At the end of the semester, after data was collected, the two best and worst lesson plans were selected from the treatment sections and control section to be disseminated to in-service teachers in early January. An initial email list was gathered by the researcher from The University of Mississippi Center for Math and Science Education (CMSE) for fourth and fifth
grade science teachers. An email was sent in November, with an inadequate response rate. Another email was sent in December with another inadequate response rate. The luncheon was initially planned for ten in-service science teachers to learn more about this research and grade the lesson plans selected. Due to differing circumstances, only one in-service teacher attended the luncheon. No significant difference in quality and usability by teaching method as graded by this in-service teacher was found. However, there is a need for more in-service teachers to grade these lesson plans.

An external reviewer graded for scientific accuracy. There was a strong, positive correlation between lesson plan scores and scientific accuracy as graded by the external reviewer. However, there was no treatment effect because the control group scored slightly higher on the lesson plans reviewed by the external grader. This is somewhat surprising, because the treatment sections had access to the science students to help address these inaccuracies. Based on qualitative data, the second and third collaborative meetings were not considered useful, and the collaboration might have not focused on this particular aspect of the lesson plan assignment.

**Qualitative Discussion.** The pilot study did not have a qualitative component, which I have found very beneficial in this current study for understanding more about the quantitative data. While there was no significant difference in lesson plan scores based on method of teaching, it is important to note that PSTs in the treatment sections described that collaborating with science students was very beneficial as they started writing their lesson plans. The PSTs seemed to enjoy receiving information on what to specifically write their lessons on. The control sections also admitted that it was hard to start writing their lesson plans. It is of particular note that all treatment PSTs interviewed agreed that the first collaborative meeting was very helpful.
During this collaboration, education PSTs shared their knowledge of the 6-E learning cycle as well as the science students teaching the scientific topic-specific content. Possibly PSTs enjoyed the collaborations more in this study compared to the pilot study because both sectors were able to bring knowledge for a common goal.

I think it is also very important that most PSTs believed that the collaborative meetings after the first one were unnecessary because they did not learn anything new. This helps to explain why there was no significant relationship between lesson plan scores and attitudes towards collaboration. In addition, so many measures were taken for this current study to alleviate feeling of inferiority of the PSTs; however, one incident still happened where education majors felt that the science students or instructor came across as arrogant. Both education and science instructors talked to their respective students about what to expect during the collaborative meetings, which is an improvement from the pilot study but still insignificant since an incident occurred.

What is particularly concerning from the PSTs interviews is the lack of knowledge of their topic specifically related to evolution of the behavior, which was a major goal of this study. According to the NGSS (2013), evolution is a core idea throughout the elementary grade levels. When asked if the collaborative meetings increased their understanding of the evolutionary science behind the topics, the answers varied. The standards are very hard to understand, and it takes practice understanding the differences in similar standards that cover adaptation and evolution. Students may not understand the standards, thus not understanding evolution.

It is very stimulating to note regardless of the drawbacks mentioned, the PSTs interviews revealed that the PSTs thought their lesson plans would be less descriptive, blander, or more difficult to understand and start if they did not meet with the science students. This is very
encouraging and aligns with the quantitative findings of increased attitudes in writing science
lesson plans.

While it is important to gain a better understanding of the collaborative process from the
PSTs, it was equally important to gain insights from the professors in the School of Education
and the Biology Department that taught the classes involved. The benefits of collaboration were
evident by sharing ideas with each other. The type of learning environment created in this study
is aligned with research by Collay (2013), which indicated the importance of teacher
collaboration with several entities, such as students and colleagues, as being essential for
learning.

Different opinions were expressed with regards to the drawbacks of the collaboration.
One thought that this year was much better than the pilot year, and no real disadvantages were
observed. Another mentioned that time was a factor. Likewise, in other studies, time was also a
factor. Krockover et al., described that faculty are reluctant to joining collaborative efforts due
to time commitments (2002). Additionally, Ford et al., described similar obstacles, such as time
in class schedules and access of classrooms (2011). This collaboration took so much time out of
the classroom for pedagogical content knowledge and PSTs were required to travel for
collaborative meetings. Factors such as time probably played a role in enthusiasm for the project
by faculty, which could potentially affected the students’ attitudes.

There were also somewhat different opinions regarding faculty perceptions of student
enjoyment of the activity. From experiences in education and science classes as a student
myself, I think that PSTs, particularly elementary majors talk or even vent their thoughts to
professors more so than science students. I think education faculty heard more negative aspects
of collaboration than science faculty leading to reasons why they thought students did not enjoy it or only certain aspects.

Education faculty responded differently regarding feedback given on the lesson plan in the treatment sections. One education professor provided pedagogical feedback on the lesson plan drafts. For example, feedback was given on the 6-E model being addressed appropriately. The second professor did not provide any feedback. In either case, there were no significant differences determined in lesson plan grades by teaching method, so I do not think one instructor influenced PSTs more than the other.

The major question that had the most variance in responses among faculty regarded the success of this particular interdisciplinary collaborative study. Faculty members were not in agreement that this program was a success. All members recognized that there were aspects that simply just did not work at this university. Motivation, time, and enthusiasm were all thought to be rather scarce for this study. Based on research of five essential questions to ask before working on interdisciplinary collaboration on campus, doctoral students and faculty with a background in liberal arts were most comfortable with working with others in different disciplines (McCoy, 2012). I believe, from this study, that more enthusiasm came from the science students and faculty, because this idea stemmed from that department. If the topics had originally stemmed from the education side, and included topics other than the four selected, then the attitudes towards collaboration might have changed significantly. Additionally, I really think time played a role in the enjoyment and motivation of the activities for faculty. Time limitations are definitive reasons faculty choose not to work in collaborative efforts (Krockover, et al., 2002). I think some science students as well as PSTs enjoyed the activities and started
thinking “outside the box” and realized there is an important link between scientists and education, and that is enough reason to feel a hint of success.

A major goal of this study was to produce scientifically accurate lesson plans that can be shared with elementary in-service teachers to help address topics on brain-based behavior. The external reviewer discovered that some resources, like PBS media have incorrect facts. Scientific inaccuracies could be from the lack of research or inaccurate sources that should be trustworthy. Overall, the goal of increasing scientific accuracy improved, as there was a strong correlation between lesson plan scores and scientific accuracy; however, the treatment section did not produce more scientifically accurate lesson plans than the control section.

**Summary.** The interdisciplinary collaborative efforts made for this study hold many significant achievement. This was a major interdisciplinary collaboration involving two different schools at The University of Mississippi. This study required PSTs to work along science students, and both sides learned from each other. Even though lesson plan quality and scientific accuracy did not improve via science student collaboration, I still feel like this study was a success in improving attitudes and confidence levels for all PSTs enrolled in the science methods course. With few improvements over time, big changes may happen in the future of elementary science education.

**Recommendations for Future Research**

Based on this study, there are several recommendations to further this research. First, many more in-service elementary science teachers need to grade the best and worst lesson plans to check for usability and quality at the most appropriate time. Even though a request email was sent multiple times, teachers find it hard to attend meetings during the school year. Possibly attending a teacher’s work day at a school would be most appropriate. The goal is to select the
best lesson plans as graded by in-service teachers, and disseminate into schools for implementation.

Next, it would be interesting to collaborate with partners that had specific and similar goals of improving STEM education. By taking a science methods course that includes topics from all science disciplines, such as life science, physical science, and ecology, and then specifically focusing on just one area, like neuroethology, might have made the collaboration hard to implement. There is too much science content to cover to just focus on one unique aspect. The science methods course has a much broader scope and goal than to focus on one single element.

Third, if the collaboration was sustained between education and science majors, the topics should be different to include a broader range of interesting scientific ideas that also incorporated math and/or reading. As teacher beliefs play a role in what and how they teach, PSTs might have been apprehensive to write a lesson plan on the selected topics, even knowing these topics are in the governing standards that should be taught. Additionally, I think the collaboration could be improved if the topics originated from the education side, and then gain more scientific information from the science students.

**Conclusion**

This research used novel approaches to address interesting, unique, and underserved topics, such as echolocation, electrosensory reception, steroid hormones, and vocal learning in elementary science education. Despite the many insignificant findings, this study broke barriers between the School of Education and the College of Liberal Arts, and improved attitudes towards science lesson plan writing in PSTs who collaborated with science students. This study also significantly increased science content knowledge and pedagogical knowledge and
increased confidence levels in PSTs in the science curriculum without a treatment effect.

Although the specific teaching methodologies only yielded one significant result, this study has demonstrated that collaborative experiences can improve elementary science PST achievement and attitudes.
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doi:10.1002/sce.20466


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LIST OF APPENDICES
APPENDIX A: PRETEST/POSTTEST
Use your clicker to answer the questions AND Circle the answer on your paper. Papers will be used in case of technical failure only. Your clicker answers are your final answers.

1. What other animals besides bats use echolocation on a regular basis?
   a) Dolphins
   b) Cats
   c) Bears
   d) Humans

2) Echolocation is the use of sound waves bouncing off of objects to determine the identity and location of the object. Where do you think the sound waves would be processed in most echolocating animals?
   a) The visual system
   b) The auditory system
   c) The olfactory system
   d) A specialized sensory system that other non-echolocating animals do not have

3) In most echolocating animals, like the bat, the ability to echolocate makes up for an impaired visual system
   a) True
   b) False

4) Animals that use echolocation, should be able to detect
   a) How far away an object is
   b) If an object is moving
   c) Where an object is
   d) All of the above

5) Brains of animals that use echolocation must be
   a) Completely different from closely-related, non-echolocating species to accommodate echolocation
   b) No difference from closely-related, non-echolocating species
   c) Possess the ability to discern differences in the sound produced versus the echo received
   d) Contain brain regions unique for echolocation

6) Any human can learn how to echolocate as long as
   a) They can make sound but are blind – so they have heightened hearing
   b) They can make sound and detect differences in their vocal output and the echoes received
   c) They are wearing special technology for echolocation
   d) Humans can’t echolocate because our brains are specialized for it

7) For echolocation to work, animals must
   a) Fly (because this only works in the air)
   b) Have a large vocal repertoire (be able to produced lots of different sounds)
c) Produce sounds of a duration short enough to prevent sound interference
d) Have large and specialized ear lobes (pinna) to hear

8) The frequency of an emitted echolocation sound from the animal is important. Why?
   a) it should be out of the hearing range of predators
   b) it should be within the hearing range of prey
   c) Because one frequency travels best in all environments
   d) Echoes return to the sender best when sent at one particular frequency

Education Pretest: VERSION 2
Name _______________________________        ID# ______________________

Use your clicker to answer the questions AND Circle the answer on your paper. Papers will be
used in case of technical failure only. Your clicker answers are your final answers.

1) Most of the organisms that communicate with electroreception do so in water
   a) True
   b) False

2) Animals that use electrosensory reception, should be able to detect electric fields emitted by
   a) Rocks
   b) Trees
   c) Water
   d) Other Animals

3) Where do you think electrical stimuli would be processed in most electoreceptive animals?
   a) The visual system because electricity is a lot like light and therefore uses the eyes as
      receptors
   b) The auditory system as electrical stimuli make crackling noises and thus uses the ears as
      receptors
   c) The somatic (touch) system because we feel electricity on our skin
   d) A specialized sensory system because detecting electric fields requires specialized
      receptors

4) What types of animals are best known for having electrosensory reception ability?
   a) Only fish (e.g. sharks, fresh and salt water fish, eels)
   b) Fish and some marine invertebrates (e.g. lobsters, crabs, shrimp)
   c) Fish, sharks and rays, and a few odd mammals
   d) Fish and some reptiles

5) Which of the following is included in the sensory system for electroreception?
   a) Sensory organs/receptors for magnetic fields
   b) Sensory nerves the transmit electrical signals from the receptor to the appropriate brain
      region
   c) Specialized areas of the brain to interpret the magnetic input information
   d) Specialized body appendages for receptor placement
6) 6. What is one of the most likely reasons why electrosensory reception evolved?
   a) Systems originally used for touch were modified to detect electrical fields
   b) It is hard for sharks and fish to see underwater
   c) There was a great deal of competition for capturing prey in murky water
   d) It is a really cool sensory power

7) 7. Where do most of the electrical stimuli that electrosensory receptive animals detect originate?
   a) From electrical impulses given off intentionally by other organisms (like the electric eel)
   b) From the movement of ions in the water created by another organism moving
   c) From the brain activity of other organisms
   d) From muscle contractions of other organisms

8) 8. What might be the benefits of using electrosensory reception?
   a) It allows animals for migrate long-distances by providing them with electrical map of the Earth
   b) Allows animals a diverse variety of abilities like communication, hunting, navigation, and predator avoidance
   c) It allows all electrosensory animals to stun prey through electrocution for capture because otherwise the prey would be unattainable
   d) It allows animals to detect the magnetic fields of the Earth

Education Pretest: VERSION 3
Name ___________________________        ID# ___________________________
Use your clicker to answer the questions AND Circle the answer on your paper. Papers will be used in case of technical failure only. Your clicker answers are your final answers.

1) Which of the following is the characteristic hormone produced as part of the stress response?
   a) Cortisol
   b) Testosterone
   c) Prolactin
   d) Oxytocin

2) What is stress and how does stress affect the brain?
   a) A biological response to a stimulus that disrupts homeostasis and its effects on the brain are always negative
   b) When a person or animal feels threatened or not in control of the situation/overwhelmed and its effects on the brain are always negative
   c) A biological response to a stimulus that disrupts homeostasis and its effects on the brain are highly variable
   d) When a person or animal feels anxious or worried and its effects on the brain are always positive

3) The stress response is mainly due to increased activity of the __________ system
   a) Peripheral nervous
   b) Parasympathetic nervous
c) Sympathetic nervous
d) Reproductive system

4) How does chronic stress affect learning?
a) It enhances learning – this is why cramming for exams is so successful
b) It alters memory, but not learning
c) It impairs learning significantly
d) It alters learning but not memory

5) The stress response system is highly conserved across vertebrate taxa (meaning all vertebrates have a similar response to stressful situations) from this we can most likely conclude
   a) There is only one way this system could operate
   b) A common ancestor possessed a response system similar to our own
   c) It appeared in thousands of species independently and just happened to use a similar system
   d) Stress is harmful to organism

6) Compared to chronic stress, acute stress ________________?
a) Is of shorter duration
b) Does not enhance memory
c) Is regulated by the parasympathetic nervous system
d) Does not disrupt homeostasis

7) The effects of chronic stress, like high blood pressure and brain damage, are only seen in the elderly
   a) Yes
   b) No

8) Stress is caused by
   a) Just intrinsic factors, such as worrying and thinking about a problem or situation too much
   b) Just extrinsic factors, such as an abusive home or being pushed by a bully
   c) Both extrinsic factors and intrinsic factors may contribute to stress equally
   d) Both extrinsic factors and intrinsic factors can create stress, but extrinsic factors always create more

Education Pretest: VERSION 4
Name ___________________________        ID# _____________________

Use your clicker to answer the questions AND Circle the answer on your paper. Papers will be used in case of technical failure only. Your clicker answers are your final answers.

1) The cat's meow is
   a) a learned vocalization
   b) learned from the cat's mom
   c) a call that requires no specialized neural system
d) requires that the animal be able to hear to be produce the meow

2) Which of the following is NOT capable of learning their vocalizations?
   a) Killer whales
   b) Songbirds
   c) Dogs
   d) Humans

3) Vocal learning is the ability to
   a) produce sounds
   b) produce a particular sound in response to a particular stimuli (such as an alarm call)
   c) imitate sounds you hear and/or create novel sounds
   d) use language

4) One difference in the brains of vocal and non-vocal learners is that all vocal learners have
   a) expanded primary motor corticies
   b) forebrain regions dedicated to vocalization
   c) larger brains than closely-related, non-learning species
   d) specialized auditory pathways for sound detection

5) Which is an example of vocal learning?
   a) A dog sitting in response to “sit” in three languages
   b) A parrot mimicking an alarm clock
   c) A vervet monkey using different alarm calls depending on the predator species sighted
   d) The waggle dance used by bees to relay information about where to find flowers

6) A period during which a particular skill is believed to be most readily acquired is referred to
   as a
   a) Critical period
   b) Vital period
   c) Maximizing period
   d) Imprinting period

7) What is the one likely reason that vocal learning evolved?
   a) An individual with vocal learning produced more offspring than a non-vocal learning in
      the next generation of the population
   b) Vocal learners are smarter than non-vocal learners
   c) Learned vocalizations allow for communication between members of a species whereas
      un-learned calls do not
   d) Vocal learning did not evolve, only humans learned how to use speech to communicate

8) The follow gene is thought to play a role in vocal learning
   a) FOXP2
   b) Wnt
   c) Hox
   d) VOC
9) What is a hypothesis?
   a) A fact
   b) A belief
   c) An observation
   d) A theory
   e) A tentative explanation

10) Which of these statements is correct?
    a) Science does not require verifiable observations
    b) In science, there are absolute truths
    c) In science, hypotheses do not need to be testable
    d) Like science, religious ideas are verifiable
    e) Scientific ideas are subjected to rigorous and repeated testing

11) A scientist hypothesizes that the temperature at which an alligator's egg is incubated will determine whether the alligator will be male or female. The independent variable is the
    a) The gender of the alligator
    b) The temperature
    c) The incubator
    d) The male alligator

12) What skill is a scientist using when she listens to the sounds that whales makes?
    a) Making observations
    b) Interpreting data
    c) Drawing conclusions
    d) Making a hypothesis

13) Which of the following is not part of the 6-E model?
    a) Explain
    b) Engage
    c) Elaborate
    d) Educate
    e) Elaborate

14) How can one find science standards for lesson plans?
    a) Mississippi Framework
    b) Next Generation Science Standards
    c) National Framework
    d) Both A & B

15) Which of the following is not a science in the Mississippi Framework?
    a) Life science
    b) Physical science
    c) Earth & Space science
    d) Industrial science
16) What is STEM an acronym for?
   a) Science Teaching and Elaboration Mechanism
   b) Social Teaching and Experimental Methods
   c) Science Technology Engineering and Mathematics
   d) Science and Technology Educational Methods

17) What variable(s) is/are manipulated (changed) in an experimental design?
   a) Dependent
   b) Independent
   c) Control
   d) Both A & B.
   e) None of the above.

18) What is the first step in designing an experiment?
   a) Observation
   b) Experiment
   c) Hypothesis
   d) Conclusion

19) NSES describes which teaching method as “students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.”?
   a) Cooperative learning
   b) Direct Instruction
   c) Scientific Inquiry
   d) Demonstration

20) Why is it important to have an engaging SET?
   a) To conduct an experiment that students will remember.
   b) To gain interest in the lesson.
   c) To help students remember the lesson before leaving.
   d) To elaborate upon the lesson.

21) My degree of competence to teach this topic is sufficient.
   a) strongly disagree
   b) disagree
   c) agree
   d) strongly agree

22) My degree of confidence to teach this topic is sufficient.
   a) strongly disagree
   b) disagree
   c) agree
   d) strongly agree

23) I feel enthusiastic about teaching science in my future classroom.
   a) strongly disagree
b) disagree
c) agree
d) strongly agree

24) My favorite subject to teach is
   a) science
   b) math
   c) language arts
   d) reading

25) I believe evolution is a scientific theory?
   a) strongly disagree
   b) disagree
   c) agree
   d) strongly agree

26) I believe that organisms are currently evolving?
   a) strongly disagree
   b) disagree
   c) agree
   d) strongly agree

27) Microorganisms like bacteria evolve, but macroorganisms like tigers and humans are done evolving.
   a) strongly disagree
   b) disagree
   c) agree
   d) strongly agree

28) I learned about evolution and adaptation prior to this course.
   a) strongly disagree
   b) disagree
   c) agree
   d) strongly agree
APPENDIX B: SCIENCE STANDARDS
MS Science Framework

4th Grade

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

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. Classify the organs and functions of the nervous, circulatory, and respiratory systems of the body. (DOK 1)
c. 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

5th Grade

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, and muscular) and the ways they support one another
      - Examples of organisms as single-celled or multi-celled
   c. Research and cite evidence of the work of scientists (e.g., Pasteur, Fleming, Salk) as it contributed to the discovery and prevention of disease. (DOK 3)
   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)

d. 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)

e. 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)

Next Generation Science Standards

3-LS3 Heredity: Inheritance and Variation of Traits
3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.

3-LS4 Biological Evolution: Unity and Diversity
3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.
3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.
3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

4-LS1 From Molecules to Organisms: Structures and Processes
4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction
4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
# Mini-Lesson Rubric for EDEL 404

Topic of Presentation ________________________________ Date __________________

Name: ___________________________________________________________ Section: ____________

Assign each component a rating according to the following scale. Circle the appropriate number of the rating you wish to assign.

<table>
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<th>1 – Somewhat</th>
<th>2 – Moderately Well</th>
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## Objectives

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<tr>
<td>Objectives are integrated with other subjects</td>
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<tr>
<td>Defines vocabulary and concepts pertinent to lesson accurately</td>
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## Teaching Procedures

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## Assessments

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## Learning Cycle and Written Work

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<td>-your question/prompt used to gather students’ understanding</td>
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<td>-students written work (sample)</td>
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<td>-a brief interpretation and identification of their responses</td>
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<td>-a brief discussion of correct science concepts</td>
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<td>-explanation of how you would and did consider students’ prior knowledge in planning your lesson</td>
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Comments/Constructive Critique:
APPENDIX D: NATURE OF SCIENCE RUBRIC
Nature of Science Rubric for EDEL 404

Topic of Presentation _________________________________________________________ Date _____________

Name: ____________________________________________________________________ Section: ____________

Assign each component a rating according to the following scale. Circle the appropriate number of the rating you wish to assign.

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<tr>
<td>Teaching procedures include innovative and interesting introduction</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Teaching procedures include innovative and interesting closure</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Teaching procedures use a variety of materials effectively</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Assessments**

<table>
<thead>
<tr>
<th>Not At All</th>
<th>Somewhat</th>
<th>Moderately Well</th>
<th>Extremely Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessments/evaluations are correlated with objectives</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A variety of informal and formal assessments is included</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Nature of Science and Written Work**

<table>
<thead>
<tr>
<th>Not At All</th>
<th>Somewhat</th>
<th>Moderately Well</th>
<th>Extremely Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Mississippi Science Frameworks was appropriately addressed</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>One Common Core Standard appropriately addressed topic</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Strategies to address a diverse classroom (both multicultural and special needs students)</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Teachers background information/ student interests- paragraph form; suggests topic understanding through the science content and references</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>How is Nature of Science relevant to your topic?</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>How can the Nature of Science be taught within each science content area?</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
APPENDIX E: TREATMENT PST ATTITUDES
Pre-service Teachers Attitudes and Opinions Treatment Sections

Please rate these statements according to the following scale:

SD = Strongly Disagree (1), D = Disagree (2), NO = No Opinion (3), A = Agree (4), SA = Strongly Agree (5)

<table>
<thead>
<tr>
<th>Attitudes and Opinions</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>No Opinion (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a result of this experience, my knowledge of this topic area became sufficient.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I learned a lot from the cases discussed by the science students.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>It was easy to write lesson plans using information from the science students’ collaboration and personal research.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I felt knowledgeable when I discussed my lesson plans to the science students.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I had successful dialogue with the science instructor and the science students during collaboration.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I understood the inquiries of the science instructor and the science students about my lesson plan.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I knew how to rewrite my lesson plan based on the conversations with science instructor and students.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>After my second rough draft, I was better able to discuss my lesson plan with the science instructor and students.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>It was helpful to meet in small groups with the science students for discussion and feedback.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I personally made an effort to work with the science students.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>The science instructor who rotated among small groups offered helpful advice.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I thought the questions on the pretest and posttest adequately assessed my content knowledge.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I believe this activity helped me to understand the new science content area better.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>Statement</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----</td>
<td>-----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>The science students were respectful when offering critiques about my lesson plans.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>This activity made me feel more confident about my ability to integrate science content into my lesson plans.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>This activity made me more enthusiastic about teaching science-related material.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>Overall I enjoyed the activities throughout this project.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I feel competent and confident teaching the lesson plan I wrote.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>Prior to this experience, I thought my knowledge of this topic area was sufficient.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>

**Comments/Constructive Critique:**
APPENDIX F: CONTROL PST ATTITUDES
Pre-service Teachers Attitudes and Opinions Control Sections

Please rate these statements according to the following scale:

SD = Strongly Disagree (1), D = Disagree (2), NO = No Opinion (3), A = Agree (4),
SA = Strongly Agree (5)

<table>
<thead>
<tr>
<th>Attitudes and Opinions</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>No Opinion (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a result of this experience, my knowledge of this topic area became sufficient.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I learned a lot from researching the topics for my science mini lesson plan.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>It was easy to write lesson plans using information I located researching the topics for my science mini lesson plan.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I felt knowledgeable when I discussed my lesson plans to my fellow students.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I was able to answer questions from my instructor and fellow students after my discussion.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>It was helpful to meet in small groups to collaborate on lesson plans.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I thought the questions on the pretest and posttest adequately assessed content knowledge.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I believe this activity helped me to understand the new science content area better.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>This activity made me feel more confident about my ability to integrate science content into my lesson plans.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>This activity made me more enthusiastic about teaching science-related material.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>Overall I enjoyed the activities throughout this project.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>I feel competent and confident teaching the lesson plan I wrote.</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
<tr>
<td>Prior to this experience, I thought my knowledge of this topic area was sufficient</td>
<td>SD</td>
<td>D</td>
<td>NO</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>

Comments/Constructive Critique:
APPENDIX G: IN-SERVICE TEACHER MINI-LESSON RUBRIC
Mini-Lesson Rubric for In-Service Teachers

Topic of Presentation _________________________________________________________ Date _____________

Name: __________________________ ____________________________________________Section: ____________

Assign each component a rating according to the following scale. Circle the appropriate number of the rating you wish to assign.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Not At All</th>
<th>Somewhat</th>
<th>Moderately Well</th>
<th>Extremely Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives are developmentally appropriate</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Objectives are stated as performance (measurable) objectives</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Objectives are clearly aligned with assessments</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Objectives are integrated with other subjects</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Defines vocabulary and concepts pertinent to lesson accurately</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teaching Procedures</th>
<th>Not At All</th>
<th>Somewhat</th>
<th>Moderately Well</th>
<th>Extremely Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching procedures correlate with objectives</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Teaching procedures are sequential</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Teaching procedures include innovative and interesting introduction</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Teaching procedures include innovative and interesting closure</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Teaching procedures use a variety of materials effectively</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessments</th>
<th>Not At All</th>
<th>Somewhat</th>
<th>Moderately Well</th>
<th>Extremely Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessments/evaluations are correlated with objectives</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Pre and post-test/evaluations are included</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A variety of informal and formal assessments is included</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning Cycle and Written Work</th>
<th>Not At All</th>
<th>Somewhat</th>
<th>Moderately Well</th>
<th>Extremely Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>6E learning cycle was presented accurately to enhance understanding (Engage, Explore, Explain, Expand, Evaluate, and E-search)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>One Mississippi Science Frameworks was appropriately addressed</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>One Next Generation Science Standards appropriately addressed topic</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Children’s literature- APA citation</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Strategies to address a diverse classroom (both multicultural and special needs students)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Teachers background information- paragraph form; suggests topic understanding through the science content and references</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Short bio of a scientist or inventor relevant to your topic - one paragraph; do your scientists work in a field of your topic?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Myth/Misconception - common myths or misconceptions are identified - explanations of why the myth is not true</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Opinion Questions</td>
<td>Not At All</td>
<td>Somewhat</td>
<td>Moderately Well</td>
<td>Extremely Well</td>
</tr>
<tr>
<td>Does the lesson interest to you? (Do you want research this more?)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Is the lesson interesting for the grade level (4th or 5th)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Does the lesson teach a framework you need help with?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Is it appropriate for the grade level (4th or 5th)?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Is the student assessment appropriate for the grade level?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Does the student assessment accurately measure student understanding?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>If this lesson plan was not written for you, would you have time to write and research the plan yourself?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Comments/Constructive Critique:
APPENDIX H: BRAIN BEHAVIOR RUBRIC
Brain Behavior Lesson Plan

Topic of Lesson Plan _____________________ Reviewer ______________ Lesson Plan Number: ___________

Assign each component a rating according to the following scale. Circle the appropriate number of the rating you wish to assign. If item is missing assign a zero.

<table>
<thead>
<tr>
<th></th>
<th>Not At All</th>
<th>Somewhat</th>
<th>Moderately Well</th>
<th>Extremely Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defines vocabulary and concepts pertinent to lesson.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Describes behavior</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Describes behavior accurately</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Behavior related to Nervous System function</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Behavior related to Nervous System function accurately</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Connects behavior to survival of organism</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Connects behavior to survival of organism accurately</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Connects behavior or brain to evolution or adaptation</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Connects behavior or brain to evolution or adaptation accurately</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Corrects typical misconceptions about topic.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Uses experimental methods to teach concept.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Explains experiments in field noting hypotheses and methods.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Book choice appropriate</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Scientist biography relevant</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Activities enhance accurate understanding of topic</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Objectives taught effectively by lesson</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Standards stated were taught in lesson</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Assessments appropriate for testing learning</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>E-search conducive to learning</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Lesson plan suggests topic was researched thoroughly.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>References appropriate.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Comments/Constructive Critique:
VITA

Jada Jamerson Mills

EDUCATION

2008  University of Mississippi
      M. Ed. Biology Education, 3.90 GPA

2007  University of Mississippi
      B.A.E. Biology Education, 3.82 GPA Magna cum Laude

PROFESSIONAL EXPERIENCE

Itawamba Community College, Biology Instructor, August 2010-present
   Principles of Biology I and II, General Biology lab, Nutrition

University of Mississippi, Adjunct Instructor, NSF grant, Fall 2013

Lafayette County High School, August 2009 – July 2010
   Biology I, Biology II, Advanced Placement Biology

University of Mississippi, Temporary Instructor, Spring 2009
   Science in the Classroom, EDEL 404

HONORS, AWARDS, AND MEMBERSHIPS

Present
   Fulton Community Volunteer Member
   Women in Higher Education Mississippi Network Member
   Phi Kappa Phi
   Itawamba Community College Wesley Foundation Board Member
   Itawamba Community College continuing education awardee $1000
   National Science Teachers Association

2013
   Graduate Instructorship, UM ($18,000)

2009
   Advanced Placement Institute graduate for AP Biology