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The Importance of Practice: Learning to Teach Student-Centered Labs with Confidence

Linda Nix

THE IMPORTANCE OF PRACTICE: LEARNING TO TEACH STUDENT-CENTERED LABS WITH CONFIDENCE

by

Linda Maria Nix

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Approved by:

Dr. Sherry S. Herron, Committee Chair
Dr. Jennifer Walker
Dr. Sheila Hendry
Dr. Richard Mohn
Dr. Kyna Shelley

Dr. Sherry S. Herron Committee Chair	Dr. Sherry S. Herron Director of School	Dr. Karen S. Coats Dean of the Graduate School

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ABSTRACT

This quantitative research study examined the relationship between science teachers' science education experiences (high school, undergraduate science courses, teacher education program science methods courses, in-service teaching, and professional development) regarding exposure to student-centered labs and science teacher self-efficacy in teaching student-centered labs. This research study also examined the relationship between science teachers' opportunity to practice teaching student-centered labs during their science teacher experiences (teacher education program science methods course, in-service teaching, and professional development) and science teaching self-efficacy in teaching student-centered labs as they relate to the social constructivist and experiential learning theories.

A modified version of the Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1989) was completed by 104 Mississippi public school science teachers teaching grades 6-12 of which all were members of the Mississippi Science Teachers Association. The research hypothesis stated that if science teachers are provided with the opportunity to practice teaching student-centered labs outside of their classrooms, then science teachers will have higher self-efficacy when implementing student-centered labs within their classrooms. The hypothesis was answered by running a one-way ANOVA.

Results suggest that practicing teaching student-centered labs during their teacher education program and professional development did not have a significant effect on science teachers' self-efficacy when implementing student-centered labs. However, practice teaching student-centered labs during in-service teaching did have a significant effect on science teachers' self-efficacy when implementing student-centered labs. Future

research studies examining the frequency and quality of practice that science teachers receive in teaching student-centered labs may be useful in developing science lab curriculum for teacher education programs and professional development opportunities.

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DEDICATION

I have always strived to be the best, to take it to the next level, to push myself a little further and with finishing this dissertation I have advanced my education and career to a level that has satisfied that need. I want to thank you, Mama and Daddy, for always believing in me and for allowing me to push myself so hard while I was growing up. Thank you for giving me the freedom to fight my own battles and for instilling the strength and values needed to conquer my dreams.

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God, I should have thanked you first but I'm still working on that. Thank you for creating a world in which dreams are possible.

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LIST OF ABBREVIATIONS

PISA	The Program for International Student Assessment
MSTA	Mississippi Science Teachers Association
MS CCRS	Mississippi College-and-Career Readiness Standards for Science
OECD	Organization for Economic Co-operation and Development
NRC	National Research Council
NSF	National Science Foundation
IRB	Institutional Review Board
USM	The University of Southern Mississippi
MSU	Mississippi State University
Ole Miss	University of Mississippi
STEBI	Science Teaching Efficacy Belief Instrument
ANOVA	Analysis of Variance
PSTEB	Personal Science Teaching Efficacy Belief
STOE	Science Teaching Outcome Expectancy

CHAPTER I - INTRODUCTION

Background

Scientific literacy holds a different meaning for various interest groups such as educators, agencies, and scientists. Murcia (2009) defined scientific literacy as "a literacy that crosses disciplinary boundaries and puts human values at the center of educational practices"(p. 40). The Program for International Student Assessment (PISA) defined scientific literacy as "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions to understand and help make decisions about the natural world and changes made to it through human activity" (Kjærnsli & Lie, 2004, p. 272). Regardless of who or what organization has defined scientific literacy, two key components have emerged in most definitions. 1. Scientific literacy incorporates some form of science knowledge. 2. Literacy in science can be achieved by all people through proper instruction (Mc Eneaney, 2003).

Beginning in 2000 and administered to countries across the world, the PISA was designed to assess the literacy abilities of fifteen-year old students in the areas of mathematics, science, and reading. According to the authors at PISA (Kjærnsli & Lie, 2004), students must be able to recognize research questions that can be investigated using science, identify scientific evidence, make and communicate conclusions or evaluate the conclusions of others, and exhibit understanding of scientific concepts in order to perform successfully on the assessment. The PISA assessment has been administered every three years with most recent results recorded in 2015. According to PISA (2015), in scientific literacy, the United States ranked twenty-fifth out of all PISA tested countries which placed the United States in the position of being just average. The

United States has continued to be outperformed in scientific literacy by many European and Asian nations, which has created a demand for more emphasis on science literacy in U.S. schools. Science teachers have now been challenged with the responsibility of creating a nation literate in science. In order for science teachers to fulfill those duties, they must themselves be masterfully literate in science as well as be able to create a learning environment that promotes scientific thinking without destroying the individuality and creativity of their students (Koenig, Schen, & Bao, 2012).

Student-centered labs have been implemented in undergraduate courses in recent years as a method of incorporating scientific literacy into the curriculum. Student-centered laboratory work has also been shown to be effective in retaining science majors through the promotion of critical thinking skills, inquiry, teamwork, and nature of science skills versus traditional labs that have been shown to require very little original thought by the students or the teachers (Brownell, Kloser, Fukami, & Shavelson, 2012; Cervato et al., 2008; Kloser, Brownell, Shavelson, & Fukami, 2013; Kudish, Schlag, & Kaplinsky, 2015; Wong, Firestone, Luft, & Weeks, 2013). When planned and implemented using a student-centered approach, labs have also been shown to foster creativity in students (Cervato et al., 2008). Student-centered labs may be categorized into two types and include inquiry-based and authentic research-based labs (Colosi & Zales, 1998; Janssen, Westbroek, & Doyle, 2014; Kloser et al., 2013).

Inquiry-based labs challenge students to think critically and independently and can be implemented in varying degrees (Lord & Orkwiszewski, 2006). An open inquiry-based lab can be described as a lab in which students create a project on their own, including forming their own problem statement, hypothesis, and experiment. An open-ended inquiry-based lab can be described as a lab in which the teacher provides the students with some of the methodology and protocols needed; however, the students must still formulate their own hypotheses and experiment. Finally, a guided inquiry-based lab can be described as a lab in which the teacher provides the problem statement and procedures but allows the students to form their own hypotheses and carry out the experimental, analysis, and conclusion stages on their own (Basey, Mendelow, & Ramos, 2000).

Authentic research-based labs incorporate inquiry and cooperative learning while providing the students with a research experience comparable to real scientists. An authentic research-based lab can be described as a lab in which students work on novel research topics that do not have prescribed conclusions. The teacher works as a facilitator and mentor but does not significantly influence the direction of the research, allowing the students to create their own knowledge based on their actual lab experience (Gray et al., 2015; Kloser et al., 2013).

As compared to more traditional labs, student-centered labs typically require more planning by the teacher, which in turn requires more of the teacher's time and energy. Therefore, some teachers rely on traditional labs, also known as "cookbook" labs, as their primary method of teaching labs. A traditional lab can be described as a lab in which the teacher is the center of learning and the students follow a predesigned lab activity usually from a lab manual (Brownell et al., 2012). The creativity of the students is often limited or constrained by the boundaries of the lab experiment (Basey et al., 2000). There has been increasing pressure on teachers in the U.S. to move away from teaching traditional teacher-centered labs and move more towards implementing student-centered labs in an effort to produce scientifically literate citizens (Basey et al., 2000).

Labs have been shown to be an important component of teaching and learning science when designed with a purpose in mind (Ottander & Grelsson, 2006). Managing labs in the science classroom usually involves three steps: planning, implementation, and evaluation. In the planning phase, generally the teacher maps out what he or she wants the students to learn and why the information is important for the students to learn as well as how the information connects to the lecture materials or concepts covered in class. In the implementation phase, the teacher labors to make sure the lab runs smoothly while the students complete the lab (Janssen et al., 2014). In the evaluation phase, the teacher assesses the students learning through grading lab reports or lab quizzes as well as performing formative assessments during the implementation phase (Janssen et al., 2014; Ottander & Grelsson, 2006). Student motivation and enjoyment may be factors a teacher considers when evaluating the success of a certain lab (Shumow, Schmidt, & Zaleski, 2013). The teacher may also choose to complete a self-evaluation including reflection on the fulfillment of objectives and goals set for the lab, what could be done differently next time, and what worked well this time (Janssen et al., 2014).

Science teachers may acquire their lab teaching skills through many different avenues and at different points in their educational careers. Future teachers begin the accumulation of lab teaching knowledge and techniques as students themselves, which may eventually influence them to teach labs in the format of their previous high school teachers or college professors (Kusch, 2016). The students then enter a teacher education program at a university or four-year college where they are typically introduced to the pedagogy behind teaching labs as well as the content knowledge required to teach labs effectively. The teacher-candidates may or may not be provided with the chance to practice implementing labs in a practical setting among a group of their peers while enrolled in the program (Binns & Popp, 2013; Pilitsis & Duncan, 2012).

Teacher education, in the form of on-the-job training and mentoring, continues when the students enter the classroom as new science teachers. Science teachers learn how to teach labs through trial and error as well as by watching their mentor teachers implement labs (Kusch, 2016). Science teachers also participate in professional development opportunities to increase content knowledge as well as learn new lab teaching strategies or to improve the lab strategies that they have already implemented in their classrooms. Science teacher professional development may come in the form of one day seminars, weekend workshops, or summer programs (Elster, Barendziak, Haskamp, & Kastenholz, 2014; McConnell, Parker, & Eberhardt, 2013; McLaughlin & MacFadden, 2014). When learning to teach labs during their teacher education program, professional development opportunities, or on-the-job training, science teachers can take on one of two roles. They can take on the perspective of the student and participate in performing the labs themselves (Hanegan, Friden, & Nelson, 2009; McLaughlin & MacFadden, 2014) or they can take on the perspective of the teacher and have their peers perform the labs and provide constructive feedback (Elster et al., 2014).

Problem Statement

The need for highly qualified science teachers who can meet the demands of teaching science as an engaging, creative, and relevant course has been identified in the literature (Cervato et al., 2008; Koenig et al., 2012). Several studies have pointed out the failure of teacher education programs, professional development programs, and on-the job training in adequately preparing science teachers to teach science labs in an engaging and student-centered format (Hanegan et al., 2009; Janssen et al., 2014; Koenig et al., 2012; Kusch, 2016; Sharma & Muzaffar, 2012). Some science teachers engage their students in inquiry-based labs and authentic research-based labs to various degrees in high school courses while others rely on traditional labs as their primary method of teaching (Colosi & Zales, 1998; Janssen et al., 2014; Kloser et al., 2013). The literature does not identify the stage of educational experience in which science teachers are introduced to student-centered labs such as inquiry-based labs and authentic research-based labs as well as when they are given the chance to practice teaching labs. Relevant studies have also not identified if there is a relationship between the self-efficacy of science teachers when implementing student-centered labs and their teacher education experience. For the purposes of this study, science teaching self-efficacy is defined as the belief a science teacher holds about his or her ability to affect learning in science. Science teaching self-efficacy is often associated with science teaching outcome expectancy which can be defined as the belief that a certain science teaching behavior will produce a desirable outcome regarding student learning (Riggs & Enochs, 1989).

Purpose Statement

The purpose of this study is to identify the stage of educational experience in which science teachers are introduced to student-centered labs as well as being given the opportunity to practice teaching student-centered labs, specifically inquiry-based and authentic research-based labs. A second purpose of this study is to identify if there is a relationship between science teachers' self-efficacy when implementing student-centered labs and their teacher education experience.

Assumptions

It is assumed that the science teachers who participated in this study took their participation seriously and were honest when filling out their questionnaires. The science teachers who attend the Mississippi Science Teachers Association (MSTA) annual meeting and are members of the MSTA organization are highly motivated and more likely to perform student-centered labs in their classrooms. The sample of secondary science teachers who are MSTA members or who attended the MSTA annual conference are assumed to be representative of a larger population within secondary science teachers in Mississippi.

Delimitations

The secondary science teachers who participated in this study were members of the Mississippi Science Teachers Association (MSTA) or attended the annual MSTA convention held on the Mississippi Gulf Coast in October of 2018.

Justification

Influence on a future science teacher's teaching philosophy may be taking place in a high school or college laboratory at this very moment. Research has shown that new science teachers emulate their past laboratory experiences when implementing labs (Kusch, 2016). The research in this study may have benefited the participants, who were in-service secondary school science teachers, by potentially compelling them to reflect on their choice of lab teaching style and how that choice may affect the way their students teach labs in the future (Pilitsis & Duncan, 2012).

Teacher education programs have the power to shape the teaching philosophies of new science teachers who may choose to teach traditional labs or student-centered labs based on their experiences during their teacher education program (Pilitsis & Duncan, 2012). The conclusions of this study may be used to inform the practices of teacher education programs at universities by highlighting the need for greater emphasis on student-centered labs. The results of this research study may show a need for teacher-candidates to be given the opportunity to practice teaching student-centered labs within their teacher education program. New science teachers also learn different lab teaching styles by discussing lab strategies with colleagues and by watching their mentor teachers execute labs (Kusch, 2016). The research in this study could be useful to educational institutions that have teacher-mentoring programs in place by informing them of potential weaknesses of new science teachers concerning knowing how to teach student-centered labs with confidence. If educational institutions were aware of a potential gap in new science teachers' ability to implement student-centered labs confidently, the institutions could amplify their focus on student-centered lab strategies within their mentoring programs. Finally, novice and experienced science teachers learn new lab teaching strategies or how to improve their lab teaching strategies by taking part in professional development workshops (Elster et al., 2014; Hanegan et al., 2009; McLaughlin & MacFadden, 2014; Zhao, Witzig, Weaver, Adams, & Schmidt, 2012). The research in this study may be used to inform the designers of professional development workshops on the need for more training opportunities for science teachers in student-centered labs.

Specifically, the opportunity for science teachers to practice teaching student-centered labs to potentially boost self-efficacy.

Student-centered labs have been shown to be more effective than traditional labs in producing scientifically literate students (Cervato et al., 2008). If science teachers are exposed to student-centered lab techniques early on in their educational journey as well as have the opportunity to practice teaching those strategies, they may end up with more confidence in the form of self-efficacy in their lab teaching abilities as in-service science teachers. Higher self-efficacy in teaching student-centered labs could lead to better performing teachers regarding the Mississippi College-and-Career-Readiness Standards for Science (MS CCRS); the new standards for Mississippi which were adapted and modified from A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas and will go into effect for the 2018-2019 school year. A major component of the MS CCRS focuses on the nature of science. The Nature of Science core element within the MS CCRS challenges students to think and practice like a scientist, engage in critical thinking, and become a more scientifically literate member of society. The Nature of Science core element performance objectives highlight the significance of a student-centered science classroom and lab environment (Wright, Benton, Massey, & Oakley, 2018).

Definition of Terms

For the purposes of this study the following terms and definitions are used:

1. *Inservice teacher:* a teacher who has finished his or her student-teaching and is actively teaching in his or her own classroom.

2. *Preservice teacher:* a teacher who is still in his or her student-teaching phase and is not actively teaching in his or her own classroom.
3. *Science teaching outcome expectancy*: is defined as the belief that a certain science teaching behavior will produce a desirable outcome regarding student learning (Riggs & Enochs, 1989).
4. *Science teaching self-efficacy:* is defined as the belief a science teacher holds about his or her ability to affect learning in science (Riggs & Enochs, 1989).
5. *Student-centered lab*: A laboratory experience in which the student is the center of learning and engagement and the teacher acts as a facilitator.
6. *Teacher-centered lab:* A laboratory experience in which the teacher is the center of learning and the students are passive participants.

Theoretical Framework

The theoretical foundation for the research completed in this study is based on two key learning theories in education: Social Constructivism and Experiential Learning. Constructivism is founded on the idea that learners construct their own knowledge based on what they experience in the world. Knowledge is not something that should be passively disseminated from generation to generation, learners should have a leading role in their own education (Irby, Brown, & Lara-Alecio, 2013). John Dewey, Jean Piaget, and Lev Vygotsky were all foundational in the formation of the constructivist theory (Irby et al., 2013; Powell & Kalina, 2009; Splitter, 2009). Dewey believed the "real world" should be a main focus in all learning environments and reflection could be a powerful tool to be used in the learning process (Splitter, 2009). Piaget is known for his work in cognitive constructivism in which he postulated individual learners were responsible for their own construction of knowledge whereas Vygotsky believed that an individual's knowledge was constructed based on the social interactions the individual had with other people in his or her environment (Powell & Kalina, 2009; Vygotsky, 1978).

Dewey and Piaget are also widely recognized for their contributions to developing the Experiential Learning Theory. Learning takes place through the evaluation of current ideas and the reconstruction of those ideas repeatedly based on specific experiences. Experiential learning focuses on learning as an ongoing process instead of focusing on learning as an outcome (Dewey, 1938; Merriam, Caffarella, & Baumgartner, 2007). Kurt Lewin contributed to the experiential learning theory through his work in training and organization development. Lewin's research, using training groups, determined that learning takes place most effectively when both learner and teacher engage in an open discussion involving conflict and opposition. As the two sides work together to dispel misconceptions and differences in perception, they can come to a resolution that benefits both parties (Kolb, 1984).

Research Questions

1. At what stage in a science teacher's educational experience is he or she first introduced to student-centered labs?
2. During a science teacher's educational experience, when is the science teacher provided the opportunity to practice teaching student-centered labs?

3. Is there a relationship between the stage of educational experience in which a science teacher is first introduced to teaching student-centered labs and his or her self-efficacy in teaching those labs?

Hypothesis

If science teachers are provided with the opportunity to practice teaching student-centered labs outside of their classrooms, then science teachers will have higher self-efficacy when implementing student-centered labs within their classrooms.

CHAPTER II -LITERATURE REVIEW

Scientific Literacy

The 1950's brought about many headlines in science news including the launching of Sputnik, the introduction of the double helix, and the implementation of the polio virus in mice. Along with these marvels of science, the 1950's also provided a name for a key concept in science education, "scientific literacy" (Hurd, 1958). The idea of scientific literacy has been around for hundreds of years yet the concept itself did not have a widely accepted label until Hurd's 1958 article entitled, "Science Literacy: Its Meaning for American Schools". Hurd (1958) claimed, "More than a casual acquaintance with scientific forces and phenomena is essential for effective citizenship today". (p. 13) Although the phrase "scientific literacy" has been widely accepted, the exact definition is a bit obscure. Hurd (1998) provided twenty-five very specific descriptions of what a scientifically literate individual should be able to do including the ability to make judgments and solve problems using scientific research, be able to differentiate between propaganda and evidence-based data, be aware of the limits of science, and acknowledge science as ever changing in a world that is not completely known (p. 413).

Shen subdivided scientific literacy in 1975 into three main categories including practical, cultural, and civic scientific literacy. Practical scientific literacy involves an individual's ability to directly enhance his or her living standards through scientific or technological knowledge and application. Cultural scientific literacy is based on the aspiration of an individual to obtain knowledge in science as purely a personal goal.

Finally, civic scientific literacy allows an individual to make informed decisions relating to democratic proceedings within his or her community or society (Shen, 1975).

In 1995, Norris claimed scientific literacy within the scope of science education should include science content knowledge, the history of science, and the ability to use science in everyday life (Norris, 1995). By 2000, there was still not a consensus on the definition of scientific literacy. DeBoer (2000) claimed, "to speak of scientific literacy is simply to speak of science education" (p. 582). According to DeBoer, the goal of science education should be to promote scientific literacy through nine well defined objectives, some of which are reminiscent of Hurd and Shen's previously stated descriptions of what a scientifically literate person should be able to do. However, DeBoer does include a somewhat different approach to scientific literacy within his nine objectives. He claims science plays an integral position within the culture of a nation and therefore the accumulated scientific knowledge of that nation should be passed on from generation to generation. The passing on of scientific knowledge requires citizens who are literate in science to possess the foresight required to collect and pass on that knowledge (DeBoer, 2000). Within the many definitions of scientific literacy, some commonalities emerge. Scientific literacy requires some level of understanding of the major concepts of science. Scientific literacy should be and can be a goal for all citizens who wish to be well-informed contributing members of society. The achievement of scientific literacy may be a personal, cultural, or economic goal, whichever the case may be, research has strongly suggested that scientific literacy is important to the overall success of a nation (DeBoer, 2000; Hurd, 1998; National Academies of Sciences, Engineering, 2016).

The Organization for Economic Co-operation and Development (OECD) was established in 1960 to encourage progress and trade amongst the thirty-five countries who participate. Amongst these associate countries are the United States, Japan, the United Kingdom, France, Germany, Spain, Mexico, Australia, Canada and many other European countries. The OECD has measured scientific literacy within seventy-two countries in 2015 using the Programme for International Student Assessment (PISA). The 2015 PISA assessment measured the scientific literacy of fifteen-year-old boys and girls, who have completed at least six years of school. Students are assessed not just in content knowledge, but also in their ability to apply that scientific knowledge to complex problems (OECD, 2015).

The United States has maintained a steady, slightly above average performance on the PISA science assessment from 2006 through 2015. The mean score for participants from the United States on the 2015 science assessment was 496 out of a possible 1,000 points, earning the twenty-fifth position in the PISA rankings, which was significantly lower than the top-ranking countries of Singapore (556), Japan (538), and Estonia (534).. The PISA assessment places students in levels based on their ability to identify science concepts, solve complex science problems, and apply science knowledge to real world situations. The PISA assessment levels range from one to seven, with seven being the most advanced in scientific literacy. Level two is an important hurdle for testers because these students are classified as proficient in scientific literacy. In 2015, twenty percent of American testers scored below the proficiency level while only nine percent of testers scored at the advanced level of six to seven. These statistics only reflect scores from the states of Massachusetts and North Carolina, no other states are tested in the U.S. (OECD, 2015). If the United States wishes to remain competitive in science and technology; U. S. PISA scores could use improvement (Serino, 2017). Secondary science education teachers could be a key component in improving science scores if they were to place more focus on scientific literacy in the classroom through the implementation of laboratory experiences (Basey et al., 2000).

Science Laboratory Experiences

Laboratory experiences have been a part of high school science classrooms for more than three-hundred years. Labs were traditionally implemented with the purpose of teaching rigid procedures and reinforcing science facts but there was an obvious disconnect between classroom instruction and laboratory experience. During the Progressive Era, John Dewey championed a more student-centered lab in which students were encouraged to become more than just participants in their own learning (Wong et al., 2013).

In America's Lab Report in 2006, the National Research Council (NRC) was tasked by the National Science Foundation (NSF) to assess the status of America's high school labs and determine how to ensure scientific literacy was promoted in all science laboratory experiences. The committee defined laboratory experiences as opportunities for students to use the tools of science to collect and analyze data while interacting directly with the physical world. The committee also coalesced a list of learning objectives that have been associated with science laboratory experiences. These learning objectives state that laboratory experiences should enhance the understanding of content knowledge and the nature of science while encouraging students to work as a team. Laboratory experiences should also help nurture an authentic interest in science as well as help develop the skills required to think like a scientist. The NRC found high school science labs in general to be lacking mainly in the areas of authentic interest in science and developing skills to critically think like a scientist. The committee also found most high school science labs to be disengaged from the stream of science instruction taking place in the classroom (National Research Council, 2006).

A possible solution to the disconnect between the science classroom and the science laboratory may be found in the 2012 publication of A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (National Research Council, 2012). The framework was designed by the Committee on a Conceptual Framework for New K-12 Science Education Standards with the intent of incorporating the practices of science with the comprehension of science content knowledge. According to the committee, graduates should be competent in scientific knowledge and practice as well as have a positive outlook regarding science by the end of their high school careers. High school graduates should also be able to apply the critical thinking skills acquired in their science courses to real life situations such as being able to intelligently contribute to public debates and participate in their community as responsible consumers. The main outcome of the Committee is for all students to meet the previously mentioned expectations and therefore be successful in pursuing a degree and career in a science field or any career field chosen. Student-centered laboratory experiences are an integral component of the framework and could serve as the missing link between connecting science classroom instruction with experiences in the laboratory in relation to creating scientifically literate high school students (National Research Council, 2006, 2012).

Student-centered labs are labs in which the student plays an active role in his or her own learning while the teacher acts as the facilitator. This is a direct contradiction to the more traditional “cook book” labs used in many high schools across America (Lord & Orkwiszewski, 2006). In traditional labs, the teacher acts as the center of learning and the students passively participate with little need for creative thought or critical thinking skills. The teacher provides the research question, hypothesis, and lab procedure while the students conduct the prescribed experiment and answer post lab questions designed by the teacher. Traditional labs require little original thought and often lead to students zoning out and missing opportunities to build new understanding in science (Basey et al., 2000; Lord & Orkwiszewski, 2006).

Student-centered labs include, but are not limited to, inquiry-based and authentic research-based labs. Inquiry in the laboratory setting refers to activities in which students can investigate natural phenomena and cultivate a deeper understanding and knowledge base in science. Inquiry in the laboratory should also pursue a similar path scientists may follow. Scientists in the field demonstrate a natural curiosity about the world around them which usually leads to them asking questions for which they can generate testable hypotheses based on their prior knowledge and experience. Scientists generate a research plan and devise an investigation which may include an experiment or a series of observations. Then data are gathered from the investigation and analyzed. The findings of the investigation may lead to the support of their original hypothesis in which case they may report their findings to the scientific community. If the findings of the investigation do not support their original hypothesis, the scientists may choose to revise their hypothesis or consider other possible explanations. Inquiry in the laboratory allows students to tap into their natural curiosity and to understand that science can be a little messy. The students may have to repeat experiments, revise their hypotheses, or start the investigation over completely. Students are shown through inquiry in the laboratory how to critically think as a scientist and problem solve through sometimes difficult issues (National Research Council, 2000, 2006).

Inquiry-based labs allow students to be independent and actively engaged in the learning process and can be subdivided based on the level of teacher involvement (National Research Council, 2000). Bell, Smetana, and Binns (2005) categorized labs into four levels of inquiry: confirmation, structured inquiry, guided inquiry, and open inquiry. Confirmation labs involve very little inquiry and align with a more traditional lab layout where students perform a prescribed experiment to confirm a previously discussed result. The students then answer post lab questions assigned by the teacher. Structured inquiry labs involve some inquiry but still follow a similar path as traditional labs where students research a question and perform an experiment designed and provided by the teacher. Students do not know the results of the experiment before they work through the lab procedures; however, they still must answer post-lab questions provided by the teacher. Both types of labs mentioned thus far are teacher-centered labs and provide very few opportunities for students to develop the skills they may need to work in the field of science (Bell, Smetana, & Binns, 2005).

Guided inquiry labs allow for more student participation and individuality than confirmation and structured inquiry-based labs. In this model, the teacher provides students with a research question and then acts as a facilitator throughout the lab. Students are expected to use critical thinking skills to manipulate through the problem and create their own procedures. Once the students have completed the experiment they created, they are able to analyze the results and formulate a logical and scientifically based conclusion. The student-directed lab that allows students the most freedom and room for creative and critical thought is the open inquiry lab. In open inquiry labs, the teacher provides a general topic in lecture and the students formulate their own research questions based on that topic. The students are free to explore any facet of the general topic that they choose which provides for a rich diversity of experimentation. The teacher acts as the facilitator to ensure students stay focused and work through their problem as would be done by scientists in the field (Basey et al., 2000; Bell et al., 2005; Wong et al., 2013). The varying levels of inquiry-based labs each have their purpose and place in the science laboratory. Students should first be introduced to the simpler confirmation style lab and then work their way up through the structured, guided, and open inquiry labs. Students are not expected to know how to work as a scientist on their first day of lab, however, by the end of the science course they should be proficient in skills needed to perform like a scientist (Bell et al., 2005).

Authentic research-based labs were traditionally implemented in upper level science courses and graduate assistantship programs in universities and four-year colleges across the United States; however, research in the last ten years has seen that trend shift to also including authentic research-based labs in introductory undergraduate science courses in the hopes of inspiring students to consider science as a career pathway (Brownell et al., 2012; Gray et al., 2015; Kloser et al., 2013). Authentic research-based labs are very similar to open-ended inquiry labs regarding student expectations. Students must formulate original research questions and hypotheses as well as design authentic experiments. The students also collect data, analyze the results, and then form conclusions. The students then share their results with the peers in their class usually in written or oral form. Authentic research-based labs require a more long-term commitment than open-ended inquiry labs. Students who participate in authentic research-based labs are expected to perform one longitudinal study which usually lasts for the duration of the lab-based course. The general goals of authentic research-based labs include building critical thinking skills and encouraging students to seek out further research prospects. Students are also exposed to the triumphs and defeats of lab research as well as the trials and rewards of working collaboratively with other students who share common research interests. As authentic research-based labs become more integrated in undergraduate studies, high school students who have participated in inquiry-based labs especially open-ended inquiry labs, may have an advantage over students who do not have those experiences (Brownell et al., 2012; Kloser et al., 2013).

Planning, Implementing, and Evaluating Student-Centered Labs

For science teachers to carry out successful student-centered laboratory experiences a clear purpose with precise teaching objectives and learning goals should be outlined prior to the start of the lab activity. The lab activity should be designed to connect previous and future content knowledge from the science classroom to activities in the laboratory as well as to real world situations. The science teacher should also consider the type and amount of support each student may need during the implementation phase of the lab. Safety precautions required for each specific lab activity as well as the science teacher’s role in the lab should be determined prior to implementing the lab activity (National Research Council, 2006, 2012).

The implementation phase of student-centered labs requires the science teacher to have a strong understanding of how scientific research and experimentation works. The science teacher should have experience performing student-directed labs giving him or her the insight needed to anticipate the types of questions or problems the students may encounter and should act as the facilitator directing student discussion and keeping students on task. During a student-centered lab, the science teacher should listen closely to the students as they reason their way through problems. This will allow the science teacher to formally assess the students throughout the lab activity and provide opportunities to redirect the students when needed or encourage the students to continue their current path. The main goal of the science teacher during the lab activity should be to help students grow in their scientific knowledge and reasoning skills while also helping them to cultivate an appreciation of how science works (National Research Council, 2006).

Once the lab has been completed, the science teacher should evaluate the successes and failures of the student-centered lab activity. The science teacher may evaluate student conversations, previous graded lab activities, and other observations during the lab to help guide them on making improvements. The science teacher may also reflect on his or her own performance during the lab activity. He or she may need to study more on a certain science concept or lab procedure and then make any needed adjustments to the lab activity for the next time (National Research Council, 2006).

Science Teachers' Educational Experiences

Beisenherz and Dantonio (1991) claimed, "teachers cannot be lectured at, demonstrated to, and asked to regurgitate facts in course after course, semester after semester, and then be expected to teach the processes of science without having experienced them" (p.44). All science teachers start out as students themselves. In high school and undergraduate studies, future science teachers are exposed to different approaches of teaching science labs. Many in-service science teachers have reported only having been exposed to traditional labs during their high school and undergraduate careers with very few reporting participations in inquiry-based or authentic research-based student-centered labs. Many in-service science teachers teach labs using the same approach they learned when they were students themselves; which ends up in most cases being traditional "cookbook" labs (Clavert, Bjorklund, & Nevgi, 2014; Kusch, 2016; Ozgelen, Yilmaz-Tuzun, & Hanuscin, 2013; Tatar, 2012).

In recent years, teacher education programs have placed more emphasis on inquiry and student-centered labs than on traditional style labs; however, most of those experiences have focused on participation in labs rather than practicing teaching inquiry-based or authentic research-based student-centered labs. (Janssen et al., 2014; Ozgelen et al., 2013). Many science teachers have reported completing their teacher education program coursework with a positive attitude towards inquiry-based learning; however, as student teachers they were rarely provided with the opportunity to observe or practice teaching inquiry based labs (Binns & Popp, 2013). Many science teachers have reported not using inquiry-based or authentic research-based student-centered labs in their classrooms once leaving their teacher education program due to the lack of confidence in their science content knowledge, understanding of the nature of science, or their ability to facilitate student-centered labs. (Tatar, 2012).

Many science teachers who want to incorporate student-centered labs into their curriculum must do so through trial and error in their own classrooms. These same science teachers spend the first year or more practicing to teach inquiry-based or authentic research-based student-centered labs on their students; therefore, the students may experience an unfair representation of what a student-centered lab should look like. Some science teachers may even become frustrated with the complexities of teaching a student-centered lab and revert back to teaching “cookbook” labs or not teaching labs at all (Windschitl, Thompson, Braaten, & Stroupe, 2012).

Science teachers may participate in professional development opportunities to advance their abilities to teach student-centered labs such as inquiry-based and authentic research-based labs. Professional development for science teachers may range from a one or two-day workshop to a summer long professional development course. The goal of many professional development programs has been to engage the science teacher in the act of doing science by teaming the science teacher with real scientists working on real research (Elster et al., 2014; McLaughlin & MacFadden, 2014). Some professional development programs focus on introducing science teachers to performing inquiry-based labs in a classroom setting. The science teacher plays the role of the student while the professional development presenter takes on the role of the facilitator (Zhao et al., 2012). In both cases, most science teachers do not practice the inquiry-based skills learned in their professional development programs in their own classrooms. Some science teachers reported being excited about teaching inquiry-based or authentic research-based labs initially after completing a professional development program but then regressed back to teaching “cook book” labs after unsuccessful attempts at teaching student-centered labs (Hanegan et al., 2009; Park, Kim, Park, Park, & Jeong, 2015).

Social Constructivism and Experiential Learning Theory

When theory is applied to science education, constructivism has been recognized as one of the most influential theories to date. Constructivism is based on the idea that learners must construct or build their own knowledge based on their prior understanding of how the world works and the addition and acceptance of new information (Hrynchak & Batty, 2012; Todd Hartle, Baviskar, & Smith, 2012). John Dewey claimed the classroom must be sincere and consequential in order for students to gain practical experience needed to manipulate through real world problems (Splitter, 2009). The application of the constructivist theory to science education can be summarized into four key components (1) The science teacher guides student learning as a facilitator, (2) The science teacher assesses students’ prior knowledge seeking out misconceptions and then purposely creating opportunities for students to identify inconsistencies creating a chance to construct new knowledge, (3) Relevant problems and cooperative groups should be used to create active learning environments, (4) Students and teachers should be provided with adequate time to reflect on new experiences. Student-centered labs, especially inquiry-based and authentic research-based labs, are built on the guiding principles of the constructivist theory (Hrynchak & Batty, 2012).

Vygotsky is credited with founding social constructivism which argues knowledge is not built exclusively by one individual but is a product of societal influences including culture and language (Beverly J. Irby, Genevieve Brown, Rafael Lara-Alecio, 2013; Merriam et al., 2007). Science teachers build upon their concept of what a laboratory experience should look like long before they become teachers themselves. As high school and college students they are exposed to various teachers and professors who teach labs using various methods and approaches. How science teachers internalize those lab experiences and construct their knowledge of what a laboratory experience should entail is impacted by those teachers and professors as well as classmates and even the environment of the school. The individual laboratory experiences of science teachers throughout their educational journey may also play a major role in how science teachers teach labs in their classrooms (Clavert et al., 2014; Kolb, 1984).

Experiential Learning Theory claims people can actively learn through experience. Dewey (1938) reasoned learning can happen through experience, however, the experience should prompt the person involved to reflect on past related events as well as have an impact on future experiences, which he referred to as continuity. Dewey also claimed the interaction between a person and their current environment will always define the experience the person has (Dewey, 1938; Merriam et al., 2007). Dewey (1938) believed continuity and experience were a prevailing reality of human existence and a fundamental part of the theory of learning:

> As an individual passes from one situation to another, his world, his environment, expands or contracts….What he has learned in the way of knowledge and skill in one situation becomes an instrument of understanding and dealing effectively with the situations which follow. (p. 44)

Piaget agreed interaction between people and their environment shaped their experiences, but he also claimed that experience could influence and mold a person's intelligence (Kolb, 1984). Science teachers should experience teaching student-centered labs before they attempt to practice them in their own classrooms to reach a level of continuity allowing them to reflect on past taught lab experiences as well as be able to make improvements on future labs. Science teachers should also interact with different groups of students within the student-centered lab environment allowing them to adapt to diverse situations and experiences. Science teachers' intelligence in regards to science and teaching student-centered labs could also be shaped by the peer teaching experiences (Janssen et al., 2014).

Kurt Lewin is best known for his research on group dynamics in which he "discovered" the T-group. The training group project involved new employees and a two-week training program in which trainees and trainers were involved in open discussion on how both parties felt training was progressing (Kolb, 1984). Lewin discovered during his T-group project that active learning takes place when all members of a group are provided the opportunity to voice their individual perspectives allowing them to challenge and stimulate each other. Lewin believed theory and practice should both be present in equal parts especially when combining scientific inquiry and solving social problems (Kolb, 1984). Preservice science teachers could benefit from practicing teaching student-centered labs on their peers. Following the completion of the lab all parties involved could benefit from openly discussing the highlights and problems encountered during the lab, a form of group reflection (Janssen et al., 2014).

Building upon the work of Dewey, Piaget, and Lewin in experiential learning, David Kolb (1984) theorized effective learning through experience requires the learner to possess four distinct abilities. Learners must be willing to fully and openly immerse themselves in new experiences, which Kolb referred to as concrete experience abilities. Learners must also be open to reflection from not only their perspective but also the perspectives of others, which he termed reflective observation abilities. Kolb referred to abstract conceptualization as the ability of learners to construct their own rational and reliable theories based on the incorporation of their observations. Finally, Kolb claimed learners must use their active experimentation abilities to apply the theories they have constructed and put them to use through problem solving and decision making. In order for science teachers to be effective learners during their educational experiences and effective teachers while implementing student-centered labs in their classrooms, science teacher should possess all four abilities (Kolb, 1984; Merriam et al., 2007).

CHAPTER III -METHODOLOGY

The research in this study was conducted using a quantitative approach. Quantitative data collection and analysis was conducted to identify the stage of educational experience (high school, undergraduate, teacher education program, in-service, and professional development) in which science teachers were first introduced to inquiry-based or authentic research-based labs and if they were provided with the opportunity to practice teaching those labs. Quantitative methods were also used to help determine if there is a relationship between science teachers' science educational experiences and their self-efficacy when implementing student-centered labs (Hanegan et al., 2009).

Research Questions

The following quantitative questions guided this study:

1. At what stage in a science teacher's educational experience is he or she first introduced to student-centered labs?
2. During a science teacher's educational experience, when is the science teacher provided the opportunity to practice teaching student-centered labs?
3. Is there a relationship between the stage of educational experience in which a science teacher is first introduced to teaching student-centered labs and his or her self-efficacy in teaching those labs?

Research Hypothesis

The hypothesis developed for this research study is as follows:

If science teachers are provided with the opportunity to practice teaching student-centered labs outside of their classrooms, then science teachers will have higher self-efficacy when implementing student-centered labs within their classrooms.

Setting and Participants

The population studied in this research project included in-service secondary science teachers from Mississippi public schools. The teachers who participated in this study were given the opportunity to participate based on attendance to the Mississippi Science Teachers Association (MSTA) annual conference held in October of 2018 or through the MSTA email list for those science teachers who were not able to attend the conference. The researcher had a table set up among vendors and college representatives on October twenty-ninth of 2018. Participants were asked on a volunteer basis to complete the questionnaire provided by the researcher. The participants were informed of their freedom to withdraw from the research study at any time without penalty or consequence. Attendees at the MSTA conference on October twenty-ninth of 2018 were offered a sweet treat by the researcher regardless of their participation in the study as well as the chance to win a prize through a raffle drawing held at the end of the conference that day. The researcher informed email participants that all questionnaires had to be completed and returned by December thirty-first of 2018.

Institutional Review Board

Prior to distributing the questionnaire, the researcher obtained permission from the University of Southern Mississippi's Institutional Review Board (IRB) to collect data (Appendix A). Participants at the MSTA conference were provided a printed copy of the

IRB approval letter. The researcher emailed a copy of the IRB approval letter upon request to participants who responded to the questionnaire through email. By submitting the questionnaire electronically, participants signified their consent to participate in the research study. Participation in the study was anonymous and all data collected using Qualtrics, an online questionnaire building tool provided through the University of Southern Mississippi, will be kept confidential and housed on a password protected computer. All paper questionnaires collected during the MSTA convention were kept in a lock box during the convention and then transferred to a locked file cabinet at the conclusion of the convention.

Instruments

The Science Teaching Efficacy Belief Instrument (STEBI) (Riggs & Enochs, 1989) was used as the data-gathering instrument for this research project (Appendix B). The STEBI assesses elementary science teacher self-efficacy and outcome expectancy beliefs for teaching behaviors in science. The STEBI, with permission (Appendix C), was modified for this research study to measure the self-efficacy and outcome expectancy of high school science teachers regarding teaching student-centered labs. The STEBI uses a Likert-scale from SA= strongly agree to SD = strongly disagree for twenty-five questions to measure two constructs: science teaching self-efficacy and outcome expectancy. The Likert-scale was used in this study to best reflect participants' extent of agreement or disagreement to questions regarding science teaching self-efficacy and science teaching outcome expectancy. Survey questions two, three, five, six, eight, twelve, seventeen, eighteen, nineteen, twenty-one, twenty-two, twenty-three and twenty-four specifically assessed science teaching self-efficacy while all other questions on the STEBI assessed outcome expectancies (Riggs & Enochs, 1989).

The STEBI instrument is intended for use in an educational setting. A 1989 study conducted by the STEBI instrument's authors confirmed that the STEBI is a decidedly reliable instrument. The overall calculated reliability coefficient for the Personal Science Teaching Efficacy Belief scale (alpha) is 0.92. The overall calculated reliability coefficient for the Science Teaching Outcome Expectancy scale (alpha) is 0.77. Both coefficients are above (alpha) 0.70, which is considered acceptable in educational research (Riggs & Enochs, 1989). In 2017, James Deehan published a book comprising twenty-five years of academic research using the STEBI as a statistically reliable instrument, including one-hundred and seven academic articles and dissertations spanning fifteen different national contexts (Deehan, 2017).

The STEBI was scored by designating a score of five for a "strongly agree" response, a score of four for a "agree" response, a score of three for a "uncertain" response, a score of two for a "disagree" response and a score of one for a "strongly disagree" response for positively phrased items. Higher ratings indicate higher self-efficacy and outcome expectancies while lower ratings indicate lower self-efficacy and outcome expectancies. Survey questions one, two, four, five, seven, nine, eleven, twelve, fourteen, fifteen, sixteen, eighteen, and twenty-three were reverse scored to help produce reliable values amongst positively and negatively phrased items. Item scores for science teacher self-efficacy and outcome expectancies were summed separately for each participant (Riggs & Enochs, 1989). Eight demographic questions were added to the modified version of the STEBI used in this research. The participants were asked their age and how many years of teaching experience they have in lab-based sciences to help determine if the year they completed their undergraduate degree in science teaching correlates with their experiences in teaching student-centered labs. Participants were asked which subjects and which grade level they teach in science to determine if one subject or grade level in science lends itself to teaching student-centered labs over other subjects or grade levels. Participants were also asked what college degrees they completed to determine if there is a correlation between science teacher self-efficacy in teaching student-centered labs and level of education completed. The participants were asked which college they attended to provide some insight into the science education programs available in the state of Mississippi and outside the state regarding learning to teach and practicing teaching student-centered labs.

Fourteen questions were also added to the modified STEBI regarding science teacher lab experiences. These additional questions inquired about participant's high school lab experiences and which type of labs they were exposed to, teacher-centered or student-centered. Participants were also asked about their general science and science education courses from their undergraduate studies regarding participating in and learning to teach student-centered labs. The participants were asked about their current lab teaching practices, what type of lab they teach, student-centered or teacher-centered labs. The professional development experiences regarding participating in and practicing teaching student-centered labs was also addressed. Finally, the participants were asked to estimate the amount of time they spend or have spent practicing teaching student-centered labs.

Data Analysis

Quantitative data were analyzed using a One-Way ANOVA to test the hypothesis: If science teachers are provided with the opportunity to practice teaching student-centered labs outside of their classrooms, then science teachers will have higher self-efficacy when implementing student-centered labs within their classrooms. The independent variables are the stage of educational experience (high school, undergraduate, teacher education program, in-service, professional development) in which science teachers are first introduced to student-centered labs, as well as the stage of educational experience in which science teachers are provided with the opportunity to practice teaching student-centered labs. The dependent variable is science teaching self-efficacy regarding teaching student-centered labs.

Quantitative data were also analyzed using a One-Way ANOVA to determine if there is a relationship between the stage of educational experience in which a science teacher is first introduced to teaching student-centered labs and his or her self-efficacy in teaching those labs. All data collected during the MSTA convention and from Qualtrics were uploaded into the statistical analysis software program SPSS version twenty-five. SPSS allowed for condensation and organization of the data while also allowing the researcher to delve into the demographic aspects of the questionnaire. Data analyses and results from this research study are presented in Chapter IV.

CHAPTER IV – REPORT AND ANALYSIS OF DATA

This chapter includes an analysis of the quantitative data collected over a twelve-week period from October -December 2018. Prior to quantitative data collection, the Qualtrics program was used to distribute the self-created portion of the questionnaire regarding science teacher lab experiences to forty-one Mississippi science teachers to determine the reliability of the instrument (Riggs & Enochs, 1989). The modified version of the Science Teaching Efficacy Belief Instrument (STEBI) used in this research was distributed in person at the Mississippi Science Teachers Association (MSTA) annual meeting and via an e-mail using Qualtrics that was sent to members of MSTA as an accessible link. The research instrument was comprised of forty-four items, twenty-five of the items were on a five-point Likert scale and six of which were designed to collect demographic information in regards to age, highest level of education achieved, Alumni, years of teaching experience, current grade level and science elective being taught. The thirteen questions regarding science teacher lab experiences was on a five-point Likert scale with an additional answer response marked as not applicable (NA). Once the twelve-week data collection period ended, raw data from both Qualtrics and the paper questionnaires distributed at MSTA were uploaded into SPSS version 25. Responses were obtained from 104 Mississippi public school science teachers. Ninety-four responses were recorded on paper questionnaires and ten were recorded online through Qualtrics.

Description of Sample

Science teachers from public school districts from all over the state of Mississippi coalesced at the MSTA annual meeting held in Biloxi, Mississippi on October 29, 2018.

Ninety-four science teachers who taught between sixth and twelfth grades completed the questionnaire on site. After the conference, the questionnaire was emailed to all members of MSTA to allow science teachers who did not attend the conference a chance to participate in the research study. Only ten science teachers completed the questionnaire through Qualtrics.

Table 1 depicts the highest level of education achieved by the science teachers who participated in this study, 61 had a master's degree (58.7 %), while 31 had a bachelor's degree (29.8 %). A combined total of 11.5 % (*n*=12) of science teachers completed either a specialists or a doctorate's degree. The National Center for Education Statistics reports as of 2015-2016, 47.3% of all public school teachers hold a Master's degree ("Digest of Education Statitics," 2017). The participants in this research study surpass the U.S. national average for obtaining a master's degree.

Table 1

Highest Level of Education Obtained

Obtained Degree	*N*	Percent
Bachelor's degree	31	29.8
Master's degree	61	58.7
Specialist's degree	9	8.7
Doctorate's degree	3	2.8

Table 1 (continued).

Total	104	100

Of the 104 science teachers who participated in the research study, ninety-nine reported their degree field. Almost half of the participants were education majors (44.5%), 28.3% (*n*=28)were life science majors, 19.2% (*n*=19) were alternate route teachers, 5.1% (*n*=5) were physical science majors, and 3% (*n*=3) were recorded as other. All 104 participants reported the science electives that they were currently teaching. The highest percentage of science teachers were teaching Life Sciences (53.9%) while 39.4% (*n*=56) of science teachers were teaching General Science. The lowest percentage of teachers (6.7%) were teaching Physical Science. The participants also reported the grade level that they were currently teaching with 53.9% (*n*=56) of science teachers teaching at a 9^{th}-12^{th} grade level and 45.2% (*n*=47) were teaching at a 6^{th}-8^{th} grade level.

The participants' total number of years of teaching experience was gathered as part of the questionnaire (Table 2). The highest percentage of participants had 6-10 years (31.7%) of teaching experience with 1-5 years (23.1%) being the second highest percentage, encompassing 54.8% (*n*=57) of the participants having taught between 1-10 years. The National Center for Education Statics reports as of 2011-2012, 32.3% of U.S. teachers had between 3-9 years of teaching experience ("Digest of Education Statitics," 2017). The participants in this research study are comparable to the U.S. national average as of 2011-2012 for years of teaching experience.

Table 2

Years of Teaching Experience

Total Years	*N*	Percent
1st year	6	5.8
1-5 years	24	23.1
6-10 years	33	31.7
11-15 years	16	15.4
16-20 years	11	10.6
21 years and over	12	11.5
Total	102	98.1

As part of the questionnaire response, participants were asked to provide the institution where they earned their Bachelor's degree (Table 3). Alumni were placed into six separate categories including: The University of Southern Mississippi (USM), Mississippi State University (MSU), The University of Mississippi (Ole Miss), other Mississippi Colleges, other US State Colleges, and other Colleges outside of the U.S. The highest percentage of participants received their bachelor's degree from other Mississippi Colleges (33.7%) while 86% (*n*=74) of the eight-six participant's that provided a response for their alumni, graduated with their bachelor's degree from a university or four-year college in the state of Mississippi.

Table 3

Alumni for Bachelor's Degree

Alumni	*N*	Percent
USM	22	25.6
MSU	13	15.1
Ole Miss	10	11.6
Other MS Colleges	29	33.7
Other US State Colleges	9	10.5
Colleges Outside US	3	3.5
Total	86	100

Instrument

The Science Teaching Efficacy Belief Instrument (STEBI) measures elementary teacher's beliefs towards teaching science and their beliefs about the abilities of students to learn science using two constructs, the Personal Science Teaching Efficacy Belief scale (PSTEB) and the Science Teaching Outcome Expectancy scale (STOE). These constructs are measured using two subscales, self-efficacy and outcome expectancy, both of which are measured using a five-point Likert-scale. The Personal Science Teaching Efficacy Belief construct measures for self-efficacy in science teaching, the belief a teacher has about his or her ability to successfully teach science. The PSTEB is scored by calculating the mean for questions two, three, five, six, eight, twelve, seventeen, eighteen, nineteen, twenty-one, twenty-two, twenty-three, and twenty-four. The Science Teaching Outcome Expectancy construct measures for outcome expectancy of teachers, the belief that certain behaviors such as good teaching in science will lead to desirable outcomes such as positive student performance on science related tasks. The STOE construct can be scored by calculating the mean for questions one, four, seven, nine, ten, eleven, thirteen, fourteen, fifteen, sixteen, twenty, and twenty-five (Riggs & Enochs, 1989).

Before scoring the instrument, questions with a negative connotation must be reverse scored to ensure consistency between positive and negative responses allowing for participants with high self-efficacy or outcome expectancy to receive a high score and those with low self-efficacy or outcome expectancy to receive a low score. Questions on the STEBI that must be reverse scored are as follows: three, six, eight, ten, thirteen, seventeen, nineteen, twenty, twenty-one, twenty-two, twenty-four, and twenty-five (Riggs & Enochs, 1989).

The existing twenty-five question STEBI (Appendix D) was modified, with permission, by rewording the questions to specifically address student-centered labs in the secondary sciences classroom versus the elementary science classroom. Six demographic questions as well as thirteen questions regarding laboratory experiences were also added. Reliability analysis of the thirteen questions regarding science teacher lab experience produced an (alpha) of 0.81 which is consistent with the alpha scores of 0.92 for the Personal Science Teaching Efficacy Belief scale and 0.77 for the Science

Teaching Outcome Expectancy scale established in the original research which produced the STEBI instrument (Riggs & Enochs, 1989).

The five-point Likert scale format that was used on the STEBI portion of the questionnaire ranged from 5 (Strongly Agree) to 1 (Strongly Disagree) or for reverse scored items 1 (Strongly Agree) to 5 (Strongly Disagree), therefore self-efficacy and outcome expectancy mean scores could vary between 1 which would indicate low self-efficacy or outcome expectancy to the highest score of 5 which would indicate high self-efficacy or outcome expectancy. A six-point Likert scale was used for the thirteen lab experience questions in order to add the choice of "Not Applicable" for those students who may have been home schooled or received their teaching license through an alternate route program. The National Center for Education Statistics reports as of 2011-2012, 3% of school aged children were home schooled ("Digest of Education Statitics," 2017) which is slightly higher than the 2% (n = 2) of participants who answered NA to all questions regarding high school experience . As of 2015-2016, 18% of U.S. teachers received their certification through an alternate route program ("Digest of Education Statitics," 2017) which is slightly lower than the 19% (n = 17) of participants that declared an Alternate route degree in this study. The six-point Likert scale ranged from 5 (Strongly Agree) to 1 (Strongly Disagree) with the addition of Not Applicable which received a score of zero. For questions one, three, five, and nine, which were negatively worded, a reverse score was applied therefore the scale ranged from 5 (Strongly Disagree) to 1 (Strongly Agree) with Not Applicable remaining at a score of zero. Lab experience mean scores could range from 0-3.4 which would indicate little to no student-centered lab experience to 3.5-5 which would indicate an average to high amount of student-centered lab experience at one or more level (high school, undergraduate, teacher education program, in-service, and professional development). Questions seven, eight, ten, eleven, twelve, and thirteen applied specifically to the practice of teaching student-centered labs therefore a mean score of 0-3.4 would indicate little to no practice while a mean score of 3.5-5 would indicate average to high practice.

Based on the research questions directing this study, one research hypothesis was developed. The research hypothesis stated that if science teachers were provided with the opportunity to practice teaching student-centered labs outside of their classrooms, then science teachers would have a higher self-efficacy when implementing student-centered labs within their classrooms. Table 4 provides the means and standard deviations for the dependent variable self-efficacy.

Table 4

Self-efficacy – Means and Standard Deviations

Questions	Mean	Std. Deviation
Q 2. I am continually finding better ways to teach science labs.	4.48	.557
Q 3. Even when I try very hard, I don't teach student-centered labs as well as I do traditional teacher-centered labs.	2.98	1.08
Q 5. I know the steps necessary to teach science concepts effectively using student-centered labs.	3.69	.966
Q 6. I am not very effective in monitoring/facilitating science experiments.	3.47	1.02

Table 4 (continued).

Q 8. I generally teach student-centered science labs ineffectively.	3.55	.902
Q 12. I understand science concepts well enough to be effective in teaching student-centered labs.	4.23	.657
Q 17. I find it difficult to explain to students why science experiments work.	3.80	.928
Q 18. I am typically able to answer students' science questions during labs.	3.55	.902
Q 19. I wonder if I have the necessary skills to teach student-centered labs.	3.38	1.13
Q 21. Given a choice, I would not invite the principal to evaluate my science teaching during a student-centered lab.	4.00	1.05
Q 22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	3.92	.889
Q 23. When teaching science labs, I usually welcome student questions.	4.38	.685
Q 24. I don't know what to do to turn students on to science.	3.78	.892

The mean for self-efficacy ranged from 3.38 to 4.48. The highest mean coincided with Question 2 (I am continually finding better ways to teach science labs), while the lowest mean coincided with Question 19 (I wonder if I have the necessary skills to teach student-centered labs). The lower mean for Question 19 suggests that the participants are motivated to improve their science lab teaching skills, but they are not confident they have the skills necessary to teach student-centered labs.

Research Questions

Research questions 1 and 3 are related and were both answered by using a one-way ANOVA.

R1: At what stage in a science teacher's educational experience is he or she first introduced to implementing student-centered labs?

R3: Is there a relationship between the stage of educational experience in which a science teacher is first introduced to teaching student-centered labs and his or her self-efficacy in teaching those labs?

A one-way ANOVA was conducted to compare the self-efficacy of science teachers in relation to teaching student-centered labs and when they were first introduced to student-centered labs during their educational experiences. The lowest percentage of participants had experienced student-centered labs for the first time during professional development (n = 13, 14.5%) while the highest percentage of participants had their first experience as an in-service science teacher (n = 19, 21.1%). The percentage of participants who had never experienced student-centered labs and those who had their first experience during their teacher education program were the same (n = 14, 15.6%). Participants who first experienced student-centered labs in high school was equivalent to the number of participants who first had their experience in their undergraduate science courses (*n* = 15, 16.7%). There were no statistically significant differences in the means for participants who had never experienced student-centered labs (*M* = 3.56, *SD* = .647), those who had experienced them for the first time in high school (*M* = 4.08, *SD* = .436), undergraduate science courses (*M* = 3.84, *SD* = .486), teacher education program (*M* = 4.04, *SD* = .448), in-service (*M* = 3.89, *SD* = .599), or during professional development (*M* = 3.63, *SD* = .488). These results suggest that being first exposed to student-centered labs at a certain stage of educational experience does not have an effect on self-efficacy.

A one-way ANOVA did show that the effect of exposure to student-centered labs was significant, $F(5,98) = 3.442$, $p = .007$. A Tukey post hoc test revealed that the mean score of self-efficacy was significantly higher in the science teachers who were exposed to student-centered labs during three different stages of their educational experiences (*M* = 4.14, *SD* = .460) than those science teachers who had no exposure (*M* = 3.57, *SD* = .597), $F(5,98) = 3.442$, $p = .028$. These results suggest that higher frequency of exposure to student-centered labs does have a positive effect on science teachers' self-efficacy.

A one-way ANOVA was conducted to compare the self-efficacy of science teachers who were exposed to student-centered labs in high school (*n* = 14, 13.7%) and science teachers who were not exposed in high school (*n* = 88, 86.3%) as well as science teachers who were exposed in undergraduate science courses (*n* = 23, 22.5%) and those who were not exposed in undergraduate science courses (*n* = 79, 77.5%). There was no statistically significant difference between science teachers who were exposed to student-centered labs during high school (*M* = 4.08, *SD* = .452) and those who were not exposed (*M* = 3.79, *SD* = .547), $F(1,100) = 3.590$, $p = .061$. There also was no statistically significant difference between science teachers who were exposed to student-centered labs during undergraduate science courses (*M* = 3.99, *SD* = .409) and those who were not exposed (*M* = 3.79, *SD* = .554), *F*(1,100) = 2.610, *p* = .109.

A one-way ANOVA was conducted to compare the self-efficacy of science teachers who were exposed to student-centered labs during their teacher education program (*n* = 23, 26.4%) and science teachers who were not exposed in their teacher education program (*n* = 64, 73.6%) as well as science teachers who were exposed during in-service teaching (*n* = 45, 43.7%) and those who were not exposed during in-service teaching (*n* = 58, 56.3%). There was a statistically significant difference between science teachers who were exposed to student-centered labs during their teacher education program (*M* = 4.12, *SD* = .459) and those who were not exposed (*M* = 3.72, *SD* = .544), *F*(1,85) = 9.583, *p* = .003. There was also a statistically significant difference between science teachers who were exposed to student-centered labs during in-service teaching (*M* = 4.02, *SD* = .487) and those who were not exposed (*M* = 3.67 , *SD* = .538), *F*(1,101) = 11.428, *p* = .001. A one-way ANOVA was conducted to compare the self-efficacy of science teachers who were exposed to student-centered labs during professional development (*n* = 56, 54.9%) and science teachers who were not exposed during professional development (*n* = 46, 45.1%). There also was no statistically significant difference between science teachers who were exposed to student-centered labs during professional development (*M* = 3.87, *SD* = .537) and those who were not exposed (*M* = 3.78, *SD* = .528), *F*(1,100) = .764, *p* = .384. These results suggest that exposure to student-centered labs within a teacher education program and during in-service teaching does have a positive effect on science teacher self-efficacy while exposure to student-centered labs during high school, undergraduate science courses, and professional development does not have an effect on the self-efficacy of science teachers.

Hypothesis

Based on research question 2, one research hypothesis was developed and tested using a one-way ANOVA.

R2: During a science teacher's educational experience, when is the science teacher provided the opportunity to practice teaching student-centered labs?

H: If science teachers are provided with the opportunity to practice teaching student-centered labs outside of their classrooms, then science teachers will have higher self-efficacy when implementing student-centered labs.

A one-way ANOVA was conducted to compare the self-efficacy of science teachers who were provided the opportunity to practice teaching student-centered labs during their teacher education program (n = 37, 42.5%) and science teachers who were not provided the opportunity to practice (n = 50, 57.5%). There was no statistically significant difference between science teachers who practiced teaching student-centered labs during their teacher education program (M = 3.89, SD = .570) and those who did not practice (M = 3.78, SD = .531), $F(1,85) = 1.066$, p = .305. These results suggest that the self-efficacy of science teachers is not affected by the opportunity to practice teaching student-centered labs during their teacher education program.

A one-way ANOVA was conducted to compare the self-efficacy of science teachers who reported that they practiced teaching student-centered labs in their classrooms as in-service teachers (n = 67, 65%) and those who reported that they did not practice teaching student-centered labs in their classrooms (*n* = 36, 35%). There was a statistically significant difference in self-efficacy between groups as determined by one-way ANOVA (F (1,101) = 5.344, p = .023). The self-efficacy of science teachers who taught student-centered labs in their classrooms was statistically significantly higher (M = 3.91, SD = .542) than those who did not practice teaching student-centered labs in their classrooms (M = 3.66, SD = .509). These results suggest that self-efficacy is higher in science teachers who practice teaching student-centered labs in their classrooms as compared to those who do not practice teaching student-centered labs.

A one-way ANOVA was conducted to compare the self-efficacy of science teachers who were provided the opportunity to practice teaching student-centered labs during their professional development (*n* = 56, 54.9%) and science teachers who were not provided the opportunity to practice (*n* = 46, 45.1%). There was no statistically significant difference between science teachers who practiced teaching student-centered labs during their professional development (M = 3.87, SD = .537) and those who did not practice (M = 3.78, SD = .528), $F(1,100)$ = .764, p = .384. These results suggest that the self-efficacy of science teachers is not affected by the opportunity to practice teaching student-centered labs during their professional development.

Finally, a one-way ANOVA did show that the effect of practicing teaching student-centered labs was significant, $F(3,100)$ = 4.580, p = .005. A Tukey post hoc test revealed that the mean score of self-efficacy was significantly higher in the science teachers who were provided with the opportunity to practice teaching student-centered labs during one stage of their educational experiences (M = 3.95, SD = .461) than those science teachers who had no practice teaching student-centered labs (*M* = 3.51, *SD* = .507), $F(1,100) = 4.580$, $p = .024$. The Tukey post hoc test also revealed that the mean score of self-efficacy was statistically significantly higher in the science teachers who were provided with the opportunity to practice teaching student-centered labs during two stages of their educational experiences (*M* = 3.98, *SD* = .442) than those science teachers who had no practice teaching student-centered labs (*M* = 3.51, *SD* = .507), $F(1,100) = 4.580$, $p = .004$.

CHAPTER V – CONCLUSIONS AND DISCUSSIONS

Summary

Science literacy can be defined as the ability to process scientific information and make conclusions based on the evidence available through research(Kjærnsli & Lie, 2004). High school science teachers have been tasked with the mission of preparing scientifically literate high school students to enter the workforce as contributing members of society or to continue their education as college students with the knowledge and skills needed to critically think(National Research Council, 2012). Labs, specifically student-centered labs, have been shown to be successful in promoting scientific literacy in students(Basey et al., 2000; National Research Council, 2012). Science teachers may be exposed to student-centered labs throughout their educational experiences as science students themselves in high school, undergraduate science courses, and science methods courses in their teacher education programs(Clavert et al., 2014; Janssen et al., 2014; Kusch, 2016; Ozgelen et al., 2013; Tatar, 2012). Science teachers may also be exposed to student-centered labs when they enter the workforce as in-service science teachers as well as through their continuing education during professional development opportunities(Elster et al., 2014; McLaughlin & MacFadden, 2014; Windschitl et al., 2012; Zhao et al., 2012).

The purpose of this research study was to identify when science teachers were first introduced to student-centered labs as well as when they were provided with the opportunity to practice teaching student-centered labs during their educational experiences. The researcher explored a possible relationship between science teaching self-efficacy and if the opportunity to practice teaching student-centered labs outside of their own classrooms had a significant effect on how high school science teachers perceived their abilities to effectively teach student-centered labs.

Conclusions and Discussions

The results of the quantitative analyses were presented in Chapter IV and will be discussed here. Science teachers from the state of Mississippi who attended the Mississippi Science Teachers Association (MSTA) annual meeting or who were on the MSTA email listserv were invited to participate in the research study and 104 science teachers agreed to participate. The majority of the science teachers who participated in this study held at least a master's degree (58.7%) and had taught science between 6-10 years (31.7%). Over half of the participants were education majors (44.5%) with the highest percentage currently teaching Life Sciences (53.9%). Out of the 104 participants, 86% of the science teachers received their bachelor's degree from a college or university in Mississippi.

The research study was guided by the following research questions and hypothesis. The first research question asked at what stage in a science teacher's educational experience is he or she first introduced to implementing student-centered labs and the third research question asked if there was a relationship between the stage of educational experience in which a science teacher is first introduced to teaching student-centered labs and his or her self-efficacy in teaching those labs. Questions two, four, six through eight, and ten through thirteen on the laboratory experiences section of the questionnaire asked science teachers if they had experienced student-centered labs during their science educational experiences. There were ninety responses to these questions; fourteen science teachers answered that they had never been exposed to student-centered labs during their science educational experiences (15.6%), fifteen science teachers answered that their first experience with student-centered labs was during high school (16.7%), fifteen science teachers had their first experience during their undergraduate science courses (16.7%), fourteen science teachers had their first experience during their teacher education science methods course (15.6%), nineteen science teachers reported their first experience occurred during in-service teaching (21.1%), and thirteen science teachers stated that their first experience with student-centered labs was during professional development (14.5%). The one-way ANOVA showed that there was not a statistically significant relationship between science teachers' self-efficacy and being first exposed to student-centered labs during a specific stage of their educational experiences.

Science teachers who reported having experienced student-centered labs during three different stages of their educational experiences scored statistically significantly higher on their science teacher self-efficacy score than science teachers who reported having no experience with student-centered labs, suggesting that having repeated experiences with student-centered labs may result in science teachers' having more confidence in their abilities to teach student-centered labs successfully. While actual practice has been shown to produce the most influence on efficacy beliefs, people can also learn by watching other people fail or succeed (Bandura, 1977). These results are in alignment with the literature regarding the experiential learning theory in which Kolb (1984) suggests that individual learners create specific ways of processing and managing information received from the world as a result of recurrent person-environment interactions in unique kinds of learning environments.

The second research question and the research hypothesis addressed when science teachers are provided the opportunity to practice teaching student-centered labs during their educational experiences and if there is a relationship between science teacher self-efficacy and the opportunity to practice. Questions seven, eight, and ten through thirteen on the laboratory experiences section of the questionnaire asked science teachers if they had been given the chance to practice teaching student-centered labs during their science educational experiences which includes their teacher education program, in-service teaching, and professional development opportunities. During their teacher education program 42.5% of science teachers reported having been provided the opportunity to practice teaching student-centered labs, 65% reported practicing during their in-service teaching experiences, while 54.9% reported practicing during their professional development opportunities. The one-way ANOVA showed that there was not a statistically significant difference between science self-efficacy in teachers who had no practice and those who did have practice in teaching student-centered labs during their teacher education program or professional development opportunities.

These results are not in support of the literature regarding the experiential learning theory in which individuals construct knowledge from experience instead of just from conventional lecture and instruction. Kolb (1984) suggests that the experiences of learners, when received and transformed, can result in true knowledge (Beverly J. Irby, Genevieve Brown, Rafael Lara-Alecio, 2013). However, some circumstances may have played a part in this result. Science teachers were asked if they were provided with the opportunity to practice teaching student-centered labs within their teacher education program or professional development; however, what the researcher meant as “practice” was not defined for the participants within the research questionnaire. This lack of clarification may have led to some science teachers claiming that they had practiced teaching student-centered labs when according to the researcher's definition; they had not. For example, question seven on the laboratory experiences portion of the research questionnaire stated: "My instructors in my undergraduate science methods courses provided me with the opportunity to practice teaching student-centered inquiry-based or authentic research-based labs". If question seven regarding practice had been phrased more clearly, then the participants may have been able to answer the question more accurately. For example, "My instructors in my undergraduate science methods courses provided me with the opportunity to practice teaching student-centered inquiry-based or authentic research-based labs, including planning, implementation, and reflection, to a classroom of my peers or high school students".

Teacher self-efficacy is a complex construct and can sometimes be difficult to measure accurately and consistently (Beverly J. Irby, Genevieve Brown, Rafael Lara-Alecio, 2013). Teachers may experience different variables such as science knowledge background, pressure from administration, motivation, and student achievement in various ways which contributes to the complexity of measuring teacher self-efficacy. Subsequently, science teachers may reply to two questions that deserve similar answers with answers on two opposite ends of the scale, resulting in inconsistent answer responses(Riggs & Enochs, 1989). The participants of this study were all science teachers from public schools across Mississippi; however, public schools in Mississippi are ranked on a scale of A-F, based upon various factors associated with student performance, by the Mississippi Department of Education(Mississippi Department of

Education, 2017). Science teachers from various school districts may face different challenges such as low or high pressure from administration or low or high student achievement which could impact their science teaching self-efficacy in different ways (Riggs & Enochs, 1989). Bandura (2006) claimed that self-efficacy does not only affect action absolutely but also affects the goal setting of the individual based on his or her efficacy beliefs. People choose "which challenges to undertake, how much effort to invest in the pursuits and how long to persevere in the face of difficulties"(Albert Bandura, 2006).

Science teachers who reported having practiced teaching student-centered labs during their in-service teaching experience scored statistically significantly higher on their science teacher self-efficacy score than science teachers who reported having not practiced teaching student-centered labs during their in-service teaching, suggesting that having practice in teaching student-centered labs within their own classrooms may result in science teachers' having more confidence in their abilities to teach student-centered labs successfully. Science teachers who reported having practiced teaching student-centered labs during one or two categories of their science teacher educational experiences scored statistically significantly higher on their science teacher self-efficacy score than science teachers who reported having not practiced teaching student-centered labs, suggesting that having practice in teaching student-centered labs within one or two of the following categories of science teacher educational experiences (teacher education program, in-service teaching, or professional development) may result in science teachers having higher self-efficacy when teaching student-centered labs within their own classrooms. "Deliberate practice (DP) occurs when an individual intentionally repeats an activity in order to improve performance. The claim of the DP framework is that such behavior is necessary to achieve high levels of expert performance." (Campitelli & Gobet, 2011). These results are in alignment with the literature regarding the experiential learning and constructivist learning theories in which individuals construct knowledge from experience instead of just from conventional lecture and instruction. The experiences of learners, when received and transformed, can result in true knowledge, which in turn can lead to higher self-efficacy(Albert Bandura, 2006; Beverly J. Irby, Genevieve Brown, Rafael Lara-Alecio, 2013).

Directions for Future Research

While some of the results of this research study are not conclusive, several assumptions can be made from this study. Science teacher self-efficacy is a multifaceted construct especially when regarding self-efficacy in teaching student-centered labs and may not be successfully measured using the researcher modified version of the STEBI. The STEBI was originally created to address elementary teachers and their beliefs about teaching science (Riggs & Enochs, 1989). The researcher should have modified more of the questions to specifically address science teaching self-efficacy in teaching student-centered labs versus labs in general. Several of the questions on the STEBI addressed science labs in general for example, “I am not very effective in monitoring/facilitating science experiments”. A science teacher may feel confident in monitoring a teacher-centered lab because he or she knows the outcome and all the steps of the lab, however the same teacher may not be confident in monitoring a student-centered lab because the outcome is not always known ahead of time(Bell et al., 2005). The science teacher must be very knowledgeable in science concepts as well as the nature of science in order to effectively answer whatever questions students may come up with during a student-centered lab (Basey et al., 2000). The question should have been phrased to specifically address student-centered labs, "I am not very effective in monitoring/facilitating science experiments during student-centered labs", which may have produced a more accurate self-efficacy rating.

The researcher created thirteen questions to measure science teacher lab experience regarding exposure to student-centered labs and the opportunity to practice teaching student-centered labs. The thirteen questions were separated into five categories: high school lab experience, undergraduate general science lab experience, teacher education program science methods course lab experience, in-service teaching lab experience, and professional development lab experience; each category consisted of only two to four questions. Although the lab experience questions passed the reliability analysis using Cronbach's alpha, the low number of questions for each category was a weakness in the questionnaire design. Typically, longer questionnaires yield higher reliabilities because the percentage of measurement error typically decreases as questionnaire length increases(Riggs & Enochs, 1989). Another weakness in the design of the lab experience portion of the questionnaire was the lack of clarification of "practice" regarding practicing teaching student-centered labs. The researcher should have included a definition of "practice" in the instruction section of the questionnaire: Practice in reference to practicing teaching student-centered labs refers to the planning, implementation, and reflection of a student-centered lab that is taught to a classroom of science teacher peers or grades 6-12 students. This clear definition of "practice" may have resulted in more accurate answers by the participants in reference to practicing teaching student-centered labs during their science education experiences.

Future studies examining the frequency and quality of "practice" that science teachers receive in teaching student-centered labs would be useful in developing science methods curriculum for preservice science teachers as well as in developing professional development opportunities that focus on allowing science teachers to practice teaching student-centered labs (planning, implementation, and reflection) with their peers as the students. The current study's *n* of 104 is a comparatively small sample size with all participants being members of MSTA; future studies investigating a more varied population would be useful in establishing how practicing teaching student-centered labs may affect the science teaching self-efficacy of science teachers across the state of Mississippi.

The authors of the STEBI state that in order for students to be prepared for a technologically advancing world, science teachers must have high science teaching self-efficacy(Riggs & Enochs, 1989). The researcher modified the STEBI to make the instrument more applicable to high school science teachers teaching student-centered labs, however additional research is needed to investigate valuable approaches to using the instrument in order to measure science teaching self-efficacy regarding teaching student-centered labs in 6-12 teachers.

APPENDIX A- The University of Southern Mississippi IRB Approval Form

Date: 6-2-2019

IRB #: IRB-18-30
Title: The importance of practice: Learning to teach student-centered science labs with confidence
Creation Date: 9-30-2018
End Date: 10-28-2019
Status: Approved
Principal Investigator: Linda Nix
Review Board: Jo Ann
Sponsor:

Study History

Submission Type Initial	Review Type Exempt	Decision Exempt

Key Study Contacts

Member Linda Nix	Role Primary Contact	Contact linda.landry@usm.edu
Member Sherry Herron	Role Co-Principal Investigator	Contact sherry.herron@usm.edu
Member Linda Nix	Role Principal Investigator	Contact linda.landry@usm.edu

APPENDIX B- Science Teaching Efficacy Belief Instrument (STEBI)

TABLE 7
Final Scales

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = STRONGLY AGREE
A = AGREE
UN = UNCERTAIN
D = DISAGREE
SD = STRONGLY DISAGREE

1.	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2.	I am continually finding better ways to teach science.	SA A UN D SD
3.	Even when I try very hard, I do not teach science as well as I do most subjects.	SA A UN D SD
4.	When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5.	I know the steps necessary to teach sc e concepts effectively.	SA A UN D SD
6.	I am not very effective in monitoring science experiments.	SA A UN D SD
7.	If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8.	I generally teach science ineffectively.	SA A UN D SD
9.	The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD
10.	The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11.	When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12.	I understand science concepts well enough to be effective in teaching elementary science.	SA A UN D SD
13.	Increased effort in science teaching produces little change in some students' science achievement.	SA A UN D SD

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14. The teacher is generally responsible for the achievement of students in science. SA A UN D SD

15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching. SA A UN D SD

16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher. SA A UN D SD

17. I find it difficult to explain to students why science experiments work. SA A UN D SD

18. I am typically able to answer students' science questions. SA A UN D SD

19. I wonder if I have the necessary skills to teach science. SA A UN S SD

20. Effectiveness in science teaching has little influence on the achievement of students with low motivation. SA A UN D SD

21. Given a choice, I would not invite the principal to evaluate my science teaching. SA A UN D SD

22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better. SA A UN D SD

23. When teaching science, I usually welcome student questions. SA A UN D SD

24. I do not know what to do to turn students on to science. SA A UN D SD

25. Even teachers with good science teaching abilities cannot help some kids to learn science. SA A UN D SD

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APPENDIX C– Permission to Use and Modify STEBI

Hi Linda,

The STELAR Center is the resource center for the National Science Foundation (NSF) Innovative Technology Experiences for Teachers and Students (ITEST) Program. The instruments in the database are those that ITEST projects have used in their projects. As STELAR is only the host of the instrument, not the copyright holder, we cannot grant permissions to use it. We recommend contacting the authors if you require permission, though the resource does appear to be rather old and freely available.

Best,
Becca on behalf of

The STELAR Team | STELAR
Education Development Center, Inc. | Learning Transforms Lives

43 Foundry Avenue

Waltham, MA 02453
Tel. 617.618.2772 | STELAR@edc.org | LinkedIn
Twitter: STELAR_CTR| Facebook: stelarctr| web: stelar.edc.org

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-----Original Message-----
From: STELAR@edc.org <STELAR@edc.org> On Behalf Of linda.nix@mgccc.edu
Sent: Monday, August 27, 2018 2:54 PM
To: STELAR <STELAR@edc.org>
Subject: [General Question] STEBI

Linda Nix (linda.nix@mgccc.edu) sent a message using the contact form at http://stelar.edc.org/contact.

I would like to obtain permission to use the STEBI in my dissertation research. I would like to modify it slightly to focus on high school instead of elementary and to focus on science labs instead of science in general.
Can you authorize permission to use this instrument or do you know who I can contact to obtain permission?
Thank you,
Linda Nix

APPENDIX D– Modified STEBI

The importance of practice: Learning to teach student-centered science labs with confidence

Linda Nix, Ph.D. candidate in Science Education, biology
University of Southern Mississippi

Demographic Data

1. What is your age?
   ____24 years or under
   ____25-34 years old
   ____35-44 years old
   ____45-54 years old
   ____55-64 years old
   ____65 years or older

2. Check each level of school you have completed and indicate the field for each degree. (Examples: Elementary Ed., General Ed., Alternate Route, Biology, Chemistry, etc.)
   _____ Bachelor's degree (e.g. BA, BS): _______________________________________
   _____ Master's degree (e.g. MA, MS, MEd, MAT):______________________________
   _____Specialist's degree (e.g. EdS): ____
   _____Doctorate (e.g. PhD, EdD): ____

3. Please list the college/university from which you graduated for each of your degrees.
   Bachelor's:____
   Master's:____
   Specialist's:____
   Doctorate:____

4. How many years have you been teaching science?
   ____ First Year Teacher
   ____1-5 years
   ____6-10 years
   ____11-15 years
   ____16-20 years
   ____21-25 years
   ____26 years and over

5. What grade level do you currently teach? Check all that apply.
   ____ 6th grade
   ____ 7th grade
   ____ 8th grade
   ____ 9th grade
   ____10th grade
   ____11th grade
   ____12th grade

6. Which science electives do you currently teach?
   _____Life Sciences (Examples: Biology, Marine Science, Anatomy & Physiology, etc.)
   _____Chemistry
   _____Physics
   Other: ____

Laboratory Experiences

- For the purposes of this research project, teacher-centered traditional "cookbook labs" are defined as a lab in which the teacher provides the students with a step by step procedure and lab questions (pre-lab/post-lab) for the students to complete. The teacher is the center of learning.
- For the purposes of this research project, student-centered labs include: guided inquiry, open inquiry, and authentic research-based labs. Guided inquiry labs are defined as labs in which the students create one or more of the following on their own: purpose statement, hypothesis, experiment, analysis, and conclusions. Open inquiry labs and authentic research-based labs are defined as labs in which the students are given a general topic and then can create their own research questions, hypothesis, experiment, analysis, and conclusion. The students may complete the lab in one class session or the lab may extend throughout the entire semester. The teacher acts as the facilitator and the students are the center of learning.

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = Strongly Agree A = Agree UN = Uncertain D = Disagree SD = Strongly Disagree NA = Not Applicable

High School Lab Experience	
1. My science teachers in high school used teacher-centered traditional labs.	SA A UN D SD NA
2. My science teachers in high school used student-centered inquiry-based or authentic research-based labs.	SA A UN D SD NA
Undergraduate College: General Science Lab Experience	
3. My science instructors at my undergraduate college taught using teacher-centered traditional labs.	SA A UN D SD NA
4. My science instructors at my undergraduate college taught using student-centered inquiry-based or authentic research-based labs.	SA A UN D SD NA
Teacher Education Program: Science Methods Course Lab Experience	
5. My instructors in my undergraduate science methods courses taught me how to teach teacher-centered traditional labs.	SA A UN D SD NA
6. My instructors in my undergraduate science methods courses taught me how to teach student-centered inquiry-based or authentic research-based labs.	SA A UN D SD NA
7. My instructors in my undergraduate science methods courses provided me with the opportunity to practice teaching student-centered inquiry-based or authentic research-based labs.	SA A UN D SD NA
8. I spent a lot of time practicing teaching student-centered inquiry-based or authentic research-based labs during my science methods coursework.	SA A UN D SD NA
In-service Teaching Lab Experience	
9. I use teacher-centered traditional labs in my classroom.	SA A UN D SD NA
10. I use student-centered inquiry-based or authentic research-based labs in my classroom.	SA A UN D SD NA
11. The majority of the labs I teach during a semester are student-centered inquiry-based or authentic research-based labs .	SA A UN D SD NA
Professional Development Lab Experience	
12. I have had the opportunity to practice teaching student-centered inquiry-based or authentic research-based labs during a professional development workshop or program.	SA A UN D SD NA
13. I spend or have spent a lot of time practicing teaching student-centered inquiry-based or authentic research-based labs during professional development opportunities.	SA A UN D SD NA

Science Teaching Efficacy Belief Instrument (STEBI) (Modified September 2018)

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = Strongly Agree A = Agree UN = Uncertain D = Disagree SD = Strongly Disagree

1. When a student does better than usual in science labs, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2. I am continually finding better ways to teach science labs.	SA A UN D SD
3. Even when I try very hard, I don't teach student-centered labs as well as I do traditional teacher-centered labs.	SA A UN D SD
4. When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach to labs.	SA A UN D SD
5. I know the steps necessary to teach science concepts effectively using student-centered labs.	SA A UN D SD
6. I am not very effective in monitoring/facilitating science experiments.	SA A UN D SD
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8. I generally teach student-centered science labs ineffectively.	SA A UN D SD
9. The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD
10. The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11. When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12. I understand science concepts well enough to be effective in teaching student-centered labs.	SA A UN D SD
13. Increased effort in science teaching produces little change in some student's science achievement.	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in student-centered science labs.	SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in teaching science labs.	SA A UN D SD
16. If parents comment that their child is showing more interest in science in school, it is probably due to the performance of the child's teacher.	SA A UN D SD
17. I find it difficult to explain to students why science experiments work.	SA A UN D SD
18. I am typically able to answer students' science questions during labs.	SA A UN D SD
19. I wonder if I have the necessary skills to teach student-centered labs.	SA A UN D SD
20. Effectiveness in teaching science labs has little influence on the achievement of students with low motivation.	SA A UN D SD
21. Given a choice, I would not invite the principal to evaluate my science teaching during a student-centered lab.	SA A UN D SD
22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	SA A UN D SD
23. When teaching science labs, I usually welcome student questions.	SA A UN D SD
24. I don't know what to do to turn students on to science.	SA A UN D SD
25. Even teachers with good science teaching abilities cannot help some kids learn science.	SA A UN D SD

REFERENCES

Bandura, A. (1977). Self-efficacy: Toward a Unifying Theory of Behaviorl Change. *Psychological Review*, *84*, 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, Albert. (2006). Toward a Psychology of Human Agency. *Perspectives on Pschological Science*, *1*(2), 164–180. https://doi.org/https://doi.org/10.1111%2Fj.1745-6916.2006.00011.x

Basey, J. M., Mendelow, T. N., & Ramos, C. N. (2000). Current trends of community college lab curricula in biology: An analysis of inquiry, technology, and content. *Journal of Biological Education*, *34*(2), 80–85.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying Inquiry Instruction. *The Science Teacher*, 30–33.

Beverly J. Irby, Genevieve Brown, Rafael Lara-Alecio, S. J. (Ed.). (2013). The Handbook of Educational Theories. Charlotte, NC, NC: Information Age Publishing, Inc.

Binns, I. C., & Popp, S. (2013). Learning to teach science through inquiry: Experiences of preservice teachers. *Electronic Journal of Science Education*, *17*(1), 1–24. Retrieved from http://ejse.southwestern.edu/article/view/11346

Brownell, S. E., Kloser, M. J., Fukami, T., & Shavelson, R. (2012). Undergraduate Biology Lab Courses: Comparing the Impact of Traditionally Based “Cookbook” and Authentic Research-Based Courses on Student Lab Experiences. *Journal of College Science Teaching*, *41*(4), 36–45.

Campitelli, G., & Gobet, F. (2011). Deliberate Practice: Necessary But Not Sufficient. *Current Directions in Psychological Science*, *20*(5), 280–285. Retrieved from https://doi.org/10.1177/0963721411421922

Cervato, B. C., Gallus, W., Slade, M., Kawaler, S., Marengo, M., Woo, K., … Acerbo, M. (2008). It Takes a Village to Make a Scientist: Reflections of a Faculty Learning Community. *Journal of College Science Teaching*, 22–30.

Clavert, M., Bjorklund, T., & Nevgi, A. (2014). Developing as a teacher in the fields of science and technology. *Teaching in Higher Education*, *19*(6), 685–696. https://doi.org/10.1080/13562517.2014.901957

Colosi, J. C., & Zales, C. R. (1998). Jigsaw Cooperative Learning Improves Biology Lab Courses. *BioScience*, *48*(2), 118–124. https://doi.org/10.2307/1313137

DeBoer, G. E. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, *37*(6), 582–601.

Deehan, J. (2017). *The Science Teaching Efficacy Beloief Instruments (STEBI A and B)*. Springer International Publishing. https://doi.org/10.1007/978-3-319-42465-1

Dewey, J. (1938). *Experience & Education*. New York: Macmillan.

Digest of Education Statitics. (2017). Retrieved November 5, 2019, from https://nces.ed.gov/programs/digest/d17/tables/dt17_209.10.asp?current=yes

Elster, D., Barendziak, T., Haskamp, F., & Kastenholz, L. (2014). Raising Standards through INQUIRE in Pre-service Teacher Education. *Science Education International*, *25*(1), 29–39.

Gray, C., Price, C. W., Lee, C. T., Dewald, A. H., Cline, M. A., Mcanany, C. E., … Mura, C. (2015). Known structure, unknown function: An inquiry-based undergraduate biochemistry laboratory course. *Biochemistry and Molecular Biology*

Education, *43*(4), 245–262. https://doi.org/10.1002/bmb.20873

Hanegan, N., Friden, K., & Nelson, R. C. (2009). Authentic and Simulated Professional Development: Teachers Reflect What Is Modeled. *School Science and Mathematics, 109*(2), 79–94. https://doi.org/Article

Hrynchak, P., & Batty, H. (2012). The educational theory basis of team-based learning. *Medical Teacher*, *34*(10), 796–801. https://doi.org/10.3109/0142159X.2012.687120

Hurd, P. D. (1958). Science Literacy: Its Meaning for American Schools. *Educational Leadership, 16*, 13–16, 52.

Hurd, P. D. (1998). Scientific Literacy: New Minds for a Changing World. *Science Education*, *82*(3), 407–416. https://doi.org/10.1002/(SICI)1098-237X(199806)82:3<407::AID-SCE6>3.0.CO;2-G

Janssen, F., Westbroek, H., & Doyle, W. (2014). The practical turn in teacher education: desiging a preparations sequence for core practice frame. *Journal of Teacher Education*, *65*(3), 195–206. https://doi.org/10.1177/0022487113518584

Kjærnsli, M., & Lie, S. (2004). PISA and scientific literacy: similarities and differences between the nordic countries. *Scandinavian Journal of Educational Research*, *48*(3), 271–286. https://doi.org/10.1080/00313830410001695736

Kloser, B. M. J., Brownell, S. E., Shavelson, R. J., & Fukami, T. (2013). Effects of a Research-Based Ecology Lab Course: A Study of Nonvolunteer Achievement, Self-Confidence, and Perception of Lab Course Purpose. *Journal of College Science Teaching*, *42*(3), 72–81.

Koenig, K., Schen, M., & Bao, L. (2012). Explicitly Targeting Pre-Service Teacher Scientific Reasoning Abilities and Understanding of Nature of Science through an

Introductory Science Course. *Science Educator*, *21*(2), 1–9. Retrieved from http://www.nsela.org/index.php?option=com_content&view=category&id=51&Itemid=85

Kolb, D. A. (1984). *Experiential Learning Experience as the Source of Learning and Development*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Kudish pkudish1@swarthmore.edu, P., Schlag, E., & Kaplinsky, N. J. . (2015). An Inquiry-Infused Introductory Biology Laboratory That Integrates Mendel's Pea Phenotypes with Molecular Mechanisms. *Bioscene*, *41*(1), 10–15. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eax&AN=108458705&site=ehost-live

Kusch, J. (2016). Learning Experiences of University Biology Faculty: A Qualitative Pilot Study. *Journal of College Science Teaching*, *45*(6), 24–31. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=116361010&site=ehost-live

Lord, T., & Orkwiszewski, T. (2006). Didactic to Inquiry-Based Instruction. *American Biology Teacher*, *68*(6), 342–346. https://doi.org/10.1662/0002-7685(2006)68

Mc Eneaney, E. H. (2003). The worldwide cachet of scientific literacy. *Comparative Education Review*, *47*(2), 217–237. https://doi.org/10.1086/376539

McConnell, T. J., Parker, J. M., & Eberhardt, J. (2013). Problem-based learning as an effective strategy for science teacher professional development. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *86*(6), 216–223. https://doi.org/10.1080/00098655.2013.826486

McLaughlin, C. A., & MacFadden, B. J. (2014). At the Elbows of Scientists: Shaping

Science Teachers??? Conceptions and Enactment of Inquiry-Based Instruction. *Research in Science Education*, *44*(6), 927–947. https://doi.org/10.1007/s11165-014-9408-z

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. (2007). *Learning in Adulthood: A Comprehensive Guide* (3rd ed.). San Francisco, CA, United States of America: John Wiley & Sons, Inc.

Mississippi Department of Education. (2017). No Title. Retrieved from https://msrc.mdek12.org/ReportCard/?EntityID=0000-000&SchoolYear=2017

National Academies of Sciences, Engineering, and M. (2016). *Science Literacy: Concepts, Contexts, and Consequences*. (C. E. Snow & K. A. Dibner, Eds.). Washington DC: The National Academies Press. https://doi.org/10.17226/23595

National Research Council. (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington D.C.: The National Academies Press. https://doi.org/10.17226/9596

National Research Council. (2006). *America's Lab Report: Investigations in High School Science*. (S. R. Singer, M. L. Hilton, & H. A. Schweingruber, Eds.). Washington D.C.: The National Academies Press. https://doi.org/10.17226/11311

National Research Council. (2012). *A Framework for K-12 Science Education:Practices, Crosscutting Concepts, and Core Ideas*. Washington DC: The National Academies Press. https://doi.org/10.17226/13165

Norris, S. P. (1995). Learning to live with scientific expertise: Toward a theory of intellectual communalism for guiding science teaching. *Science Education*, *79*(2), 201–217.

OECD. (2015). *COUNTRY NOTE Key findings from PISA 2015 for the United States*. *OECD Better Policies for Better Lives*. Paris.

Ottander, C., & Grelsson, G. (2006). Laboratory work: the teachers' perspective. *Journal of Biological Education*, *40*(3), 113–118. https://doi.org/10.1080/00219266.2006.9656027

Ozgelen, S., Yilmaz-Tuzun, O., & Hanuscin, D. L. (2013). Exploring the Development of Preservice Science Teachers' Views on the Nature of Science in Inquiry-Based Laboratory Instruction. *Research in Science Education*, *43*(4), 1551–1570. https://doi.org/10.1007/s11165-012-9321-2

Park, J., Kim, Y., Park, Y.-S., Park, J., & Jeong, J.-S. (2015). Development and Application of The Practical on-Site Cooperation Model (Pocom) for Improving Science Teaching in Secondary Schools. *Journal of Baltic Science Education*, *14*(1), Continuous. Retrieved from http://www.scientiasocialis.lt/jbse/view/biblio/year/2015/volume/14/issue/1

Pilitsis, V., & Duncan, R. G. (2012). Changes in Belief Orientations of Preservice Teachers and Their Relation to Inquiry Activities. *Journal of Science Teacher Education*, *23*(8), 909–936. https://doi.org/10.1007/s10972-012-9303-2

Powell, K. C., & Kalina, C. J. (2009). COGNITIVE AND SOCIAL CONSTRUCTIVISM: DEVELOPING TOOLS FOR AN i EFFECTIVE CLASSROOM. *Education*, *130*(2), 241–250. https://doi.org/10.1037/0022-0663.93.3.571

Riggs, I. M., & Enochs, L. G. (1989). Science Teaching Efficacy Belief Instrument. *National Association for Research in Science Teaching*, 31.

https://doi.org/10.1002/sce.3730740605

Serino, L. (2017). What international test scores reveal about American education. Retrieved January 1, 2017, from https://www.brookings.edu/blog/brown-center-chalkboard/2017/04/07/what-international-test-scores-reveal-about-american-education/

Sharma, A., & Muzaffar, I. (2012). The (non)making/becoming of inquiry practicing science teachers. *Cultural Studies of Science Education*, *7*(1), 175–191. https://doi.org/10.1007/s11422-011-9372-0

Shen, B. S. P. (1975). Views: Science Literacy: Public understanding of science is becoming vitally needed in developing and industrialized countries alike. *American Scientist*, *63*(3), 265–268.

Shumow, L., Schmidt, J. A., & Zaleski, D. J. (2013). Multiple Perspectives on Student Learning, Engagement, and Motivation in High School Biology Labs. *The High School Journal*, *96*(3), 232–252. https://doi.org/10.1353/hsj.2013.0010

Splitter, L. J. (2009). Authenticity and constructivism in education. *Studies in Philosophy and Education*, *28*(2), 135–151. https://doi.org/10.1007/s11217-008-9105-3

Tatar, N. (2012). Inquiry-Based Science Laboratories: an Analysis of Preservice Teachers'Beliefs About Learning Science Through Inquiry and. *Journal of Baltic Science Education*, *11*(3), 248–267. Retrieved from http://www.scientiasocialis.lt/journals/index.php/jbse/article/view/248

Todd Hartle, R., Baviskar, S., & Smith, R. (2012). A field guide to constructivism in the college science classroom: Four essential criteria and a guide to their usage. *Bioscene*, *38*(2), 31–35.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Cambridge: Harvard University Press.

Windschitl, M., Thompson, J., Braaten, M., & Stroupe, D. (2012). Proposing a core set of instructional practices and tools for teachers of science. *Science Education*, *96*(5), 878–903. https://doi.org/10.1002/sce.21027

Wong, S. S., Firestone, J. B., Luft, J. A., & Weeks, C. B. (2013). Laboratory Practices of Beginning Secondary Science Teachers : A Five-Year Study. *Science Educator*, *22*(1), 1–9.

Wright, C. M., Benton, K. S., Massey, J., & Oakley, N. (2018). *2018 Mississippi College- and Career-Readiness Standards for Science*. Retrieved from www.mde.k12.ms.us/ESE

Zhao, N., Witzig, S. B., Weaver, J. C., Adams, J. E., & Schmidt, F. (2012). Transformative Professional Development: Inquiry-Based College Science Teaching Institutes. *Journal of College Science Teaching*, *41*(3), 18–25. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=69936134&site=eds-live&scope=site