SCIENCE LEARNERS, SCIENCE TEACHERS, SCIENCE COURSES, AND CURIOSITY: INFORMATION FOR TEACHER EDUCATION PROGRAMS

by

Margene Lenamon, MAT

DISSERTATION

Presented to the Faculty of

The University of Houston-Clear Lake

In Partial Fulfillment

Of the Requirements

For the Degree

DOCTOR OF EDUCATION

in Curriculum and Instruction

THE UNIVERSITY OF HOUSTON-CLEAR LAKE

December, 2019

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APPROVED BY

Renée Lastrapes, PhD, Chair

Sandra Watson, EdD, Co-Chair

Amy Orange, PhD, Committee Member

Cynthia Howard, PhD, Committee Member

RECEIVED BY THE COLLEGE OF EDUCATION:

Lillian Benavente-McEnery, EdD, Interim Associate Dean

Joan Y. Pedro, PhD, Interim Dean

Dedication

To Margo and Gene, my beloved Mom and Dad.

You gave me your names, your support and your unconditional love.

You were the best cheerleaders anyone could ever be blessed to have had.

I know you would be proud of this moment.

Though I know you are with me—I still miss you sorely each and every day.

To Karen

For twenty years you have never ceased to amaze me.

I do not believe that I will ever fully be able to convey to you just

how many "*dreams come true*" you are a part of.

I know you will mind, but it was this important, that I had to put down in words how

wonderful life is with you in my world!

Always and forever.

Acknowledgements

I can hardly believe the great fortune I have had to be a part of this great degree program. I know how hard establishing an educational program truly is. To have joined as a member of only the second cohort and to have experienced so few growing pains along the way, is quite the testament to those of you who worked so hard in creating this unique program.

To my EDCI instructors Drs. Brown, Browning, Carmen, Howard, Kahn (who we all sincerely miss), Lastrapes, Matthew, McDonald, Orange, Weiser, and Willis and to a supporting cast that includes Drs. Corrales, Divoll, McEnery, Pedro, and Peters: I hope I have conveyed in some small measure to each of you the powerful impact each and every one of you have made in my life. You have increased my self-worth and abilities as an instructor, a professional educator, a future researcher, and as a human. You were a huge part of all the events that have made this dream become a reality. This is not my success, but ours! Now I have the glorious task of paying off my debt of gratitude by paying your hard work forward--what a truly wonderful challenge!

To the members of my committee: Dr. Watson—thank you for your valuable input and editing suggestions that enriched my final paper. Dr. Howard—thanks for all the wonderful science I now know due to the three courses I got to spend with you; but most especially thanks for Brazil—I still cannot believe I really got to do that! I have felt the velvet, chamois skin of the wild Boto, watched a Harpy Eagle prune and preen, and marveled at the reflections that danced in and along the inky surface of the Rio Negro—doesn't get much better than that. Dr. Orange—you promised if I tortured the data long enough, it would confess! Thanks for all the work I know you did behind the scenes to help me meet that last-minute deadline! Also, a special thanks for your kind editing remarks—a special talent that serves you and your students well!

And to my committee chair, Dr. Lastrapes—I know I have worked your last nerve, but I also made you laugh—so let's call it even! You know you will never look at apostrophes again in the same way thanks to me! And, none of your future dissertation candidates may have a love affair with block quotes like I have—so sad. But seriously, I have learned more than I often seem to be able to express about statistics and educational research—you have been an excellent mentor. Thanks for encouraging me through the tough year when I lost my father and for all your hard work during this last push to glory! What you thought I could keep this section short—seriously?! Well okay, I'll wrap it up; it's been a real roller coaster ride—thanks for keeping the wheels connected to the tracks! Geaux Tigers!

And to my most wonderful fellow EDCI STEM graduate, skilled editor and master of the template—and most of all, my friend, Monica Trevathan—thank you for helping me through some tough times! Our times spent working in the library and computer lab were always pleasant because of your indomitable and positive spirit. I learned as much from you as almost anyone in this program and I am forever in your debt. And, in the words of my Irish ancestors: May your troubles be less and your blessings be more, and nothing but happiness come through your door.

I am also greatly indebted to the support of my Costa Rica colleagues, Teresa and Tracey! You never failed to flash heart-warming smiles, encouraging words and provide shoulders to cry on through these long four years. I have learned so much about teaching and being a teacher from both of you. You were instrumental to my survival after Dad passed away—God bless you! And, I'm pretty sure I still have a job because of your excellent council and ability to let me vent more intensely than Poas has yet to do! And, to our recent awesome addition, Lillian, you are a true gift, you have added so much in such a short time and have provided me with such great council—I so look forward to what we still will accomplish. And, to Dr. Pedro—when I grow up, I want your energy and your enthusiasm for getting things done even in the face of adversity! Thanks, so much, to all of you!

And finally, to my extended families who help keep by heart beating happily in my chest: Uncle Robert and Aunt Susan, words cannot do justice to the love I have for you and for all your help with Dad—you are both such a blessing. To my Aunt Jorjie who may be miles away, but forever close in my heart—we sure miss Mom, don't we? To the Purpera clan, thanks for including me and cheering me on as one of the family, it truly means so much. To my dear friends Julie and Inge, Peg and Jonathon—can you believe it? What would I do without life-long compadres like you guys? Your words of encouragement through all things, but especially in supporting this long-awaited dream come true, well I'm just saying, we're partying for at least the next year—so get ready!

Therefore, to all of you in the immortal words of the Science Ninja, wait, make that *DR. Science Ninja*, you all ROCK!!!!

ABSTRACT

SCIENCE LEARNERS, SCIENCE TEACHERS, SCIENCE COURSES,

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TEACHER EDUCATION PROGRAMS

Margene Lenamon
University of Houston-Clear Lake, 2019

Dissertation Chair: Renée Lastrapes, PhD
Co-Chair: Sandra Watson, EdD

It requires a unique set of skills to teach science to young children. Not only do future elementary educators need the requisite content knowledge to address the broad base of science topics that fall under the innocuous acronym known as STEM, they also need to be able to effectively respond to their students innately curious natures. And, while mandates for STEM instruction to occur at all grade levels have been a major driving force in the decision-making processes of educational entities for several decades, studies consistently expose problems with science instruction at elementary grade levels.

This is an indication that elementary education degree requirements, which emphasize skills that make for great generalists are failing to provide the amount of science content needed to develop effective instructors of STEM. Compounding matters is the ineffective nature of the few science course types provided to future educators.

Traditional introductory level lecture-based science courses whether intended for non-science or science majors are failing to address the issues of what is being instructed and who is doing the instructing. And, the benefits of fostering curiosity are being under-utilized as a learning tool for future teachers who will, in turn, be expected to foster curiosity within their own students.

This study relied on both quantitative and qualitative data analysis to determine if the choice of science course type, the number of science courses completed, and curiosity levels impacted pre-service elementary educators' views about their own learning of science and their views as future science teachers. Data collection included surveys, interviews, and short answer exercises. Analysis included descriptive statistics processes, Pearson product-moment correlations, inductive coding processes, and thematic study.

Implications for future practices in teacher education included the need for science courses specifically designed for future elementary educators and curriculum within those courses that would include curiosity, wonder, and imagination as learning tools. The combination of specialized science courses that use curiosity to appeal to elementary educators as science learners could provide increased science content knowledge and enhanced science efficacy levels so that future educators could become the science teachers their future students need.

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INTRODUCTION

"I don't know if I have enough knowledge [to] teach it . . . if a student asks me a question will I be able to give him the right answer?" This comment was provided by a participant in a study exploring the self-efficacy of preservice elementary educators by Knaggs and Sondergeld (2015, p. 124). It speaks volumes to the importance that science content knowledge, efficacy, and the associated views with regards to the study of and the teaching of science have for future teachers. And though such a simple question, it belies the myriad assortment of complex issues that surrounds the training of pre-service elementary school teachers (PSTs) emphasizing their roles as generalists while placing far less emphasis on their roles as science instructors (Akerson, Flick, & Lederman, 2000).

Yet science instructors are what they are expected to be, having been tasked to develop a scientifically literate populace with at least enough skills to understand and benefit from the STEM knowledge base; and provide accessible pathways by providing appropriate content knowledge for those who would choose to work within and/or advance the STEM knowledge base (National Science Board, 2007). National, state, and local instructional policies now mandate that STEM instruction be provided at all grade levels within public-school systems (U.S. Department of Education & Office of Postsecondary Education, 2016).

Arguably this mandate impacts elementary educators more so than any other group of teachers of science given that the majority of elementary educators are not science specialists. In fact, while most secondary teachers' certifications require a science degree or previous science related job experience, elementary educators have no such certification requirements, which often leaves them inadequately prepared to meet such mandates (Diamond, Maerten-Rivera, Rohrer, & Lee, 2013). Subsequently, studies point to the problems with elementary science instruction as being symptomatic of inadequate science education requirements for elementary educators (Appleton & Kindt, 2002).

Research Problem

The majority of elementary educators' undergraduate degree programs have historically placed an emphasis on their skills as language arts specialists (Riegle-Crumb et al., 2015) leaving room for only two to three sciences courses at an introductory college level to inform their roles as science teachers (Nadelson et al., 2013). While that course number is now three to four science courses, (Texas Higher Education Board Committee, 2009) the results still create a snowball effect of limits. Limited exposure to science content courses limits science content knowledge, which creates limitations in pedagogical science content knowledge, which ultimately culminates in low science teaching self-efficacy (Appleton, 2006). All those limitations, directly connected to beliefs and attitudes corresponding to efficacy, be they positive or negative, go with preservice teachers when they become teachers in their own classrooms (Kazempour & Sadler, 2015; Menon & Sadler, 2016; Ramey-Gassert & Shroyer, 1992; Riggs & Enochs, 1990).

Compounding matters is the very nature of the science courses being provided to PSTs. Two different studies, that of Michaels, O'Connor, and Resnick (2008) and Nowicki, Sullivan-Watts, Shim, Young, and Pockalny (2012) found that traditional lecture-based science courses offer little opportunity for realistic inquiry; rarely emphasizes reflection on scientific knowledge; and seldom provide an opportunity to participate in science experimentation or "hands-on" learning. Furthermore, they concluded that without an inquiry based curriculum, such courses are failing to provide PSTs with the deep understanding of science concepts they later need to be able to teach inquiry-based science (Michaels et al., 2008; Nowicki et al., 2012) In actuality, one only needs to make a cursory read of course catalogs to find that traditional introductory science courses in colleges and universities throughout the US are intended for future science majors, not elementary educators. The implication being that faculty teaching these courses are often not aware of the role they could play in assisting prospective teachers to "learn and understand the content and concepts that are critical to effective teaching [and have not been provided with] the kind of professional development in teaching that would enable them to model effectively the kinds of pedagogy that is needed for success in grades K-12 classrooms" (National Research Council, 2001, p. 32). Unfortunately, Menon and Sadler (2016) reported that many of the studies they reviewed found that college and university introductory science content courses were more than likely linked to preservice teachers' low science self-efficacy beliefs, evidenced by poor performances in capstone science methods courses, which "of course raises concerns about the effectiveness of the science content courses that preservice elementary teachers take" (p. 652).

Another concerning problem that deserves more attention by PSTs, is that they have chosen to teach a group of students who are often naturally curious, especially with the world of science. Numerous studies indicate that children are innately curious about the world around them; they gravitate toward unknown objects; seek out new experiences; they ask questions, recognize patterns, and try to reconcile anomalous information by developing their own theories and/or using fairly scientific methodology to make sense of things (Callanan & Oakes, 1992; Chouinard, 2007; Driver, 1983; Gopnik, Meltzoff, & Kuhl, 2000; Schulz & Bonawitz, 2007; Tizard & Hughes, 1984). Therefore an expectation that is imperative for PSTs to realize is that "fostering the scholarly attributes of curiosity in learners is an important task; one that is at the heart of education and effective learning as it challenges and promotes active participation in learning" (Stokoe, 2012a, p. 63). Furthermore, it should be of great importance to PSTs that Engle (2013) warns them that teachers who are not themselves curious cannot "fan the flames of a drive (they) rarely experience" (p. 39).

Therefore, the development or enhancement of PSTs' own curiosity levels should allow them to be more effective teachers who are able to better relate to the naturally curious future students they will teach. And getting them to explore their own curiosity could improve their science content knowledge levels and assist them in seeking out and selecting the best possible science content courses available to them.

Significance of the Study

By helping to illuminate a connection between science content courses and the attitudes, beliefs, and curiosity levels of pre-service educators, this research could provide teacher education programs with a stronger argument for the need to develop more science courses explicitly designed for future elementary educators. This research could help codify the unique mixture of science content knowledge needed with the level of wonder and curiosity that would appeal to future elementary educators such that it would enhance their desire to learn more science. This in turn, could actually allow pre-service educators the opportunity to acquire the requisite level of science content knowledge to be effective teachers of science thus ensuring their own students will receive appropriate STEM lessons and will be provided with ample time to explore STEM topics.

Research Purpose and Questions

The purpose of this study was to determine if pre-service elementary educators' views about science, both as learners and as future teachers, are impacted by the choice of science course(s) they take in their degree program. Additionally, the relationship among curiosity levels, course type choice and number of courses completed, and the views PSTs have about their own learning of science and as a future teacher of science were investigated. The research questions that guided this study were:

Quantitative Questions

1. Is there a difference in the views among pre-service elementary teachers about themselves as both learners of and future teachers of science based on the type and/or number of science courses they have taken?
2. Is there a difference in levels of curiosity among pre-service elementary teachers based on the type and/or the number of science courses they have taken?
3. Is there a relationship between the scores of the VASS survey and the SC scale survey?

Qualitative Questions

4. What are pre-service elementary educators' attitudes and beliefs about their own learning in the science courses they took during their degree programs?
5. What are pre-service elementary educators' perceptions about the influence the type of science courses they have taken have had on their beliefs about their future role as science teachers and about their science teaching?
6. What are pre-service elementary educators' perceptions regarding the concept of curiosity, wonder and/or imagination as an attribute for the learning and teaching of science?

Definitions of Key Terms

For the purpose of this study the following definitions were used throughout the document.

Attitudes: the tendencies that regularly affect actions; may impact learners' self-efficacy, achievement, and self-esteem; may be part of a relationship between the teaching/learning of a discipline; may be used as an indicator of a persons' ‘‘like or dislike (of) science’’; may be a ‘‘disposition to behave in certain ways and habits of mind that may result in predictable actions’’; and can be important to teachers in being able to “recognize the strengths and weaknesses of science and maintain a positive outlook toward learning science and toward themselves’’ (Bybee, 2014; McGinnis et al., 2002).

Beliefs: can be a function specifically required to obtain “a satisfactory understanding of teachers' actions requires a complex perspective necessitated consideration of teachers' thinking processes”; can contribute to the “understanding of how and why the process of teaching looks and works as it does’’; and can influence teacher candidates' view of learning and teaching, as well as the process of education” (Clark & Peterson, 1986; McGinnis et al., 2002; Richardson, 1996).

Constructivism: theory of how people learn validated by observation and scientific study. Learners must have opportunities to reconcile new learning with prior knowledge and this is most often accomplished via experience and reflection (Von Glasersfeld, 1989). Additionally, the definitions guiding this research for the terms constructivist view and traditional view are derived from the research of Seung, Park, and Narayan (2010). They determined that PSTs who identified with the paradigm of constructivism paid more attention to the students' learning, as well as the environment where the learning was occurring. Conversely, PSTs who identified with the paradigm of traditionalism were less focused on the process of students' learning and more attuned to the process of teaching.

Curiosity (in a science-learning context): an individual demonstrates curiosity when they “(a) react positively to new, strange, incongruous, or mysterious elements in their environment by moving toward them, exploring them, or manipulating them; (b) exhibits a need or desire to know more about themselves and/or their environment; (c) scans their surroundings seeking new experiences; and/or (d) persists in examining and/or exploring stimuli in order to know more about them" (Harty & Beall, 1984, p. 426)

Efficacy: Bandura's definition of self-efficacy as the "belief in one's capabilities to organize and execute courses of action required to produce given levels of attainments" (1977, p. 3) as well as an individual's beliefs in his or her capabilities to mobilize his or her motivation, cognitive resources, and course of actions needed to exercise control over task demands (Bandura, 1977).

Science Methods Course: an emphasis on curriculum materials and the process approach as science teaching method (course catalog from small, mixed urban and rural, four-year university in Texas).

Teacher self-efficacy: a teacher's perception of his/her ability to be effective in a classroom. It is the belief that student learning can be obtained, even with difficult and unmotivated students (Tschannen-Moran & Hoy, 2001).

The nature of and the teaching of science: the "values and assumptions inherent to the development of scientific knowledge" (Brickhouse, 1989, 1990; Lederman, 1992; Lederman & Zeidler, 1987; McGinnis et al., 2002; Meichtry, 1993; Ryder, Leach, & Driver, 1999).

Traditional introductory science course for science majors (TSM): A general biology course including biochemistry, cell biology, cell metabolism and energetics, photosynthesis, genetics, evolution, taxonomy, bacteria and viruses as described in most four-year university catalogs. Traditional introductory science course for non-science majors (TNM): Provides a survey of biological principles with an emphasis on humans, including chemistry of life, cells, structure, function and reproduction as described in most four-year university catalogs. Introductory science course designed for future teachers: An introduction to basic biological concepts and science teaching pedagogy for prospective elementary/middle level teachers utilizing scientific methodology and hands-on investigative techniques as described (in general) in four-year university catalogs that provide this type course.

Views about science: will also include the associated terms ***attitudes*** as the tendencies that regularly affect actions and have a role teacher education and teacher practices; from Bloom (1976) and Bandura (1986) attitudes can include the impact on learners' self-efficacy, achievement, and self-esteem; and from Meece, Wigfield, and Eccles (1990) attitudes can be used to anticipate when learners' might decide to take additional courses in a discipline; and ***beliefs*** as a function: required to obtain an understanding of teachers' actions requires attention to teachers' thinking processes (Richardson, 1996) and the understanding of the process of teaching, both the mechanism and appearance (Clark & Peterson's, 1986) and finally in the role beliefs have in influencing pre-service teachers' view of learning, as well as teaching, and including the process of education (Richardson (1996).

Conclusion

In the last three decades the rise and resulting economic importance of STEM fields has been an impetus for education reform in the US (Carnevale, Smith, & Strohl, 2010). Thus, the demands for US educational systems, at all levels, to respond to the need for effective science instruction has reached a new zenith. Such reforms have affected science educators at all grade levels, however, elementary school teachers are being called upon to provide science instruction that often exposes gaps in their own educational background that typically did not emphasize their role as science instructors (Akerson et al., 2000; Flick, 1995).

Degree programs that emphasize pre-service elementary educators' roles as generalists, while placing very little emphasize on their role as science instructors are producing future teachers who (a) have limited science content knowledge, (b) limited pedagogical science content knowledge, and (c) low science teaching self-efficacy (Akerson et al., 2000; Appleton, 2006; Flick, 1995). Moreover, the traditional undergraduate science content courses that pre-service elementary educators take are rarely designed for them, providing no improvement to their science content knowledge and science teaching efficacy (Menon & Sadler, 2016; Michaels et al., 2008; National Research Council, 2001; Nowicki et al., 2012). In fact, science content courses are likely linked to preservice teachers' low science self-efficacy beliefs, culminating in poor performances in their science methods course (Menon & Sadler, 2016). An informed discussion among teacher educators and two and four-year school's science departments about the type of science content course that should be provided to pre-service teachers could help remediate their weaknesses and reinforce their strengths. As McDermott, Shaffer, and Constantinou (2000) indicated, "the emphasis in [science] courses for teachers should be on the development of deep understanding of topics included in the K-12 curriculum…(with) each teacher (studying) each topic in a way that is consistent with how they are expected to teach that material" (p. 73).

Finally, pre-service elementary educators need to be reminded of the conscious decision they have made to teach young children and that children are innately curious about the world around them, gravitate toward unknown objects, seek out new experiences, ask questions, recognize patterns, and try to reconcile anomalous information by developing their own theories and/or using fairly scientific methodology to make sense of things (Callanan & Oakes, 1992; Chouinard, 2007; Gopnik et al., 2000; Schulz & Bonawitz, 2007; Tizard & Hughes, 1984). Therefore, a case should be made to pre-service elementary educators to address their own curiosity levels. Gilbert (2013) found that pre-service elementary educators who participated in activities that encouraged a development of a sense of wonder showed a greater desire to learn, a greater interest in science content and developed more positive views about science content knowledge. Retooling teacher education programs to include wonder as part of science education could help science teachers and science educators develop a sense of wonder themselves (Hadzigeorgiou, 2016) and correct the issue of having teachers who cannot "fan the flames of a drive (they) rarely experience" (Engel, 2013).

CHAPTER II:

REVIEW OF THE LITERATURE

Instructional policies at the national, state, and local levels now mandate an emphasis be placed on STEM instruction at all grade levels within our public-school systems (U.S. Department of Education & Office of Postsecondary Education, 2016). While most secondary teachers' certifications require a science degree or previous science related job experience, elementary educators have no such certification requirements, which often leaves them inadequately prepared to meet such mandates (Diamond, Maerten-Rivera, Rohrer, & Lee, 2014). This may be in part due to the fact that the majority of elementary educators' undergraduate degree programs emphasize their role as generalists (Riegle-Crumb et al., 2015) and typically require only three science courses at an introductory college level to address the knowledge base they need in their roles as science teachers (Nadelson et al., 2013). This may be the explanation for why studies consistently expose problems with science instruction at the elementary level as being indicative of the inadequate science education required for elementary educators (Appleton, 2003).

Compounding that problem, a review of numerous studies by Menon and Sadler (2016) found that college and university introductory science content courses were more than likely linked to preservice teachers' low science self-efficacy beliefs, as evidenced by poor performances in capstone science methods courses, which "raises concerns about the effectiveness of the science content courses that preservice elementary teachers take" (p. 652). Effective science instruction is a key component that many researchers agree is intertwined with preservice teachers' (PSTs) beliefs and attitudes that correspond to their own science teaching efficacy, both positive and negative, and go with them when they become teachers in their own classrooms (Kazempour & Sadler, 2015; Menon & Sadler, 2016; Ramey-Gassert & Shroyer, 1992; Riggs & Enochs, 1990).

While there are significant gaps in the current literature that this study hopes to address, this chapter presents a thorough review of current literature addressing the background, factors, and impact on pre-service elementary educators with regards to their (a) science course choices and selection processes (b) their views about the nature of their own learning of and their future teaching of science, and (c) the role curiosity may play as a way to engage them in the learning of, and their future teaching of, science.

STEM Is Being Advocated for a Reason

It is common knowledge that "science" has been at the forefront of most educational missions and curriculum reform for the past 100 years, most especially in the United States, but also worldwide and for a variety of reasons. In the US, each decade of the last 100 years has experienced one or more changes that have spurred the general public to demand action by both the scientific community and science educators (Sahlberg, 2016; Slater, 1997). The nearly 250 year-long storied history of the US has numerous examples of calling into question the missions of its educational institutions and its educators when addressing problems that it faces, both real and sometimes imagined or inflated (Slater 1997). For example, educators were tasked with quickly developing science teaching strategies to provide a well-trained workforce for post-World War I and World War II rebuilding efforts and were further urged to dramatically increase those efforts when the race to space began with the 1950s launch of Sputnik (Marx & Harris, 2006).

In the last three decades the proliferation and resulting economic importance of STEM fields has been an impetus for education reform in the US, evidenced by the request made nearly ten years ago by major industries who predicted a need would exist for 2.8 million competent and trained or trainable STEM workers by the year 2018 (Carnevale et al., 2010). Thus, the demands for US educational systems, at all levels, to respond to the need for effective “science” instruction has reached a new zenith.

Beginning in the late 1980’s and then accelerating throughout the 1990’s and 2000’s, political reactionism to the US’s decreasing global superiority began to demand that educational reform address and include technology, as well as engineering, and thus STEM arrived and became embedded in the educational lexicon (Blackley & Howell, 2015). Originally, reform was evidenced by the development and implementation of new standards, primarily in the areas of mathematics and science and beginning with primary and secondary schools. A variety of groups ancillary to the educational profession have played their parts, (Santau, Maerten-Rivera, Bovis, & Orend, 2017) but contend that the American Association for the Advancement of Science (AAAS), the National Research Council (NRC), the National Science Teaching Association (NSTA), as well as governing bodies at the local, state, and national levels have produced two extremely impactful reform strategies that are currently driving all educational reform initiatives.

The first, the No Child Left Behind Act of 2001 (NCLB), was a federal mandate that impacted all fifty states as a result of their acceptance of Title 1 grant funding which any state could have chosen to forgo, but none did, and while NCLB allowed each state to have some decision making options, it primarily involved high stakes testing as its’ performance measure (Care, 2010). The goal was to create dramatic change in all instruction, not just STEM disciplines, and NCLB proponents anticipated student achievement to increase and gaps between advantaged and disadvantaged student subgroups to be reduced or in some cases even eliminated (Ladd & Sorensen, 2017).

While still the current federal mandate, NCLB is being superseded in the STEM related disciplines in some states by the recently completed second reform stratagem, the

Next Generation Science Standards (NGSS) (Bybee, 2014). Privately funded, the NGSS was developed in response to the perception that science education had in many states been reduced to the memorization and testing of discrete pieces of knowledge instead of requiring that all students have a deep understanding of a smaller number of disciplinary core ideas which they could provide proof of via scientific and engineering practices, as well as making connections with concepts across disciplines (Bybee, 2014; Pruitt, 2014) The NGSS seeks to keep the STEM momentum going, by proposing that science be a determining factor in a student's overall college and career readiness, providing future resources to science related endeavors in both the academic and workforce domains.

Early STEM Education is Essential

As noted in the preceding section, STEM has become one of the major driving forces in the decision-making processes of educational entities. The two key reform systems have arguably created as much controversy as constructive change, but both have components that are in agreement with each other—to achieve improvement in student learning, curriculum and instruction must be addressed, and "highly qualified" teachers are crucial components (Ladd & Sorensen, 2017; Pruitt, 2014). The two key functions "highly qualified" educators are being tasked with are to develop a scientifically literate populace with at least enough skills to understand and benefit from the STEM knowledge base, as well as fashioning accessible pathways for those who would choose to work within and/or advance the STEM knowledge base (National Science Board, 2016). To that end, instructional policies at the national, state, and local levels now mandate an emphasis be placed on STEM instruction at all grades levels within our public-school systems (U.S. Department of Education & Office of Postsecondary Education, 2016).

Teachers at all grade levels are impacted by this edict, but quite possibly it impacts elementary educators more so than any other group of teachers of science.

Research continues to suggest that science education should begin during the early years of schooling which necessitates that instruction begin at grade one and filter up through the elementary school levels (Eshach, 2003; Eshach & Fried, 2005; Ginsburg & Golbeck, 2004; Kallery, 2004; Watters, Diezmann, Grieshaber, & Davis, 2001). Why so early? Many researchers recommend that science education begin during the early years of schooling primarily because it enhances many properties identified as part of a child’s development (Eshach, 2003; Eshach & Fried, 2005; Ginsburg & Golbeck, 2004; Kallery, 2004; Watters et al., 2001). Early school experiences that develop fundamental processing skills, such as observation, inference, and exploration, not only help solidify basic understandings of natural phenomena, which are key to later science achievement, but also appear to reduce the influence of socio-economic status (SES) between high SES children and low SES children as they continue on in elementary school (Sackes, Trundle, Bell, & O'Connell, 2011).

Further research draws attention to the function of science activities and sense-making discussions as a way to allow children to connect the real world with what they are learning, which engages children with their own learning processes and facilitates the formation of scientific mental models (Trundle, 2010). And according to Eshach (2003), there are other studies that reinforce the idea that early exposure to science and mathematics has a positive correlation to later cognitive skill development. However, even though research has created an awareness of the need, and numerous workforce initiatives have generated a demand for more science instruction to occur in U.S. elementary schools, the implementation of such programs has not yet reached a high level of priority (Appleton & Kindt, 2002; Ross & Mason, 2001).

The Failure to Properly Prepare Elementary Educators

Elementary educators can find themselves one day being heralded as the science education leaders needed to develop a science literate citizenry (National Science Board, 2007) and the next day being indicted at the terminus of a downhill flow of criticism as having failed to lay an adequate foundation required by students for future success (Epstein & Miller, 2011). As mentioned earlier in this paper, Appleton (2008) noted that several studies consistently exposed problems with science instruction at the elementary school level as being indicative of the inadequate science education required for elementary educators (Appleton, 2006). This may be in large part due to certification requirements. Most secondary teachers' certifications require a science degree or previous science related job experience, yet elementary educators have no such certification requirements, which may be a major reason they are inadequately prepared to meet such directives.

Indeed, a myriad of complex issues surrounds the training of elementary school teachers—especially those that serve in public schools—starting with the fact that their degree programs typically emphasize their role as generalists, specializing in the use of the language arts and reading to address their students' literacy, and placing very little emphasize on their role as science instructors (Akerson et al., 2000; D. Anderson, 2014; Flick, 1995). Until recently there has been very little room in most degree programs to enhance an educators' background science content knowledge, as the majority of elementary teacher certification programs have typically required only the completion of two science and two mathematics courses at an introductory college level (Nadelson et al., 2013). The State of Texas has adopted a policy of requiring an additional six to nine semester credit hours of science courses above the state's core required six semester credit hours in order to receive an EC-6 and/or 4-8 teaching certification (THECB, 2009) yet this still only equates to four science courses or (on the high end) 15 hours of a 120 hour degree program.

Among the mitigating factors that affect science instruction in elementary schools that should not be overlooked are the low expectations made on PSTs. Epstein and Miller (2011) identified three key areas focused on the learning skills of PSTs, which may have profound implications for their future teaching efforts. First, a review of many elementary education degree programs shows that these programs allow incoming future teachers to not only enter, but to also exit most college education programs with a minimum grade point average (around 2.5 on a 4.0 scale). Next, exit exams were found to typically cover only basic skills, often not exceeding the material they will soon teach in elementary and middle schools. And finally, Epstein and Miller (2011) found that PSTs are often certified in numerous states without having to successfully pass the mathematics or the science section of their licensing exams. Thus it is through no real fault of their own that elementary generalists often lack the background knowledge required to teach life, physical and earth sciences in a manner that would assure that their students are provided with a strong foundation of science content knowledge (Krajcik & Sutherland, 2010; National Research Council, 2000; Nowicki et al., 2012).

Confidence Is What Confidence Does

The literature has shown that public school elementary educators are being called upon to provide science instruction at a level that exposes the gap that exists in their own training between the preparation provided to them as general literacy specialists and preparation provided to them as science instructors (Akerson et al., 2000; Flick, 1995). And while this study is not exploring science teaching efficacy, science content knowledge or pedagogical content knowledge per se, these are underlying issues inherent to the teaching profession. With regards to the views about science learning and science teaching of PSTs, efficacy issues are often the obvious truth that is either being ignored or going unaddressed. Because of that fact efficacy will be part of the theoretical framework for this study and therefore merits a brief overview of important references made to it in the literature.

Research shows that a large number of teachers, when provided a safe avenue to express their concerns over their own educational needs, are well aware of their lack of science content knowledge (SCK) and are concerned that they are being asked to teach increasingly more complex materials than they are prepared for (National Research Council, 2000; National Science Board, 2007). In surveys and questionnaires, numerous teachers indicate that inadequate facilities, lack of resources, funding and support from administration negatively impacts their science instruction efforts; however, increasingly many teachers are now indicating they are more prepared, and more inclined, to teach most core subjects but lack the qualifications, the proper preparation, and a strong enough comfort level to consistently want to teach science (Czerniak & Chiarelott, 1990; Epstein & Miller, 2011; Marx & Harris, 2006; Nadelson et al., 2013; Ramey-Gassert, Shroyer, & Staver, 1996; Zeldin, Britner, & Pajares, 2008). In other words, they lack the science teaching efficacy that might make a difference in their science instruction decision making.

One of the most impactful aspects of being underprepared to teach science is the resulting efficacy issue that manifests within teachers and then is projected onto their students, which is exactly what current teachers in the studies from the previous paragraph are indicating is happening. And since these current teachers are describing a lack of qualifications, preparation and comfort levels, this should cause concern about the prospects for the preparation of future teachers if the training process for them does not do a better job of instilling science teaching efficacy. After all, the role of efficacy is critical when envisaging the amount of time and effort both current and future elementary educators will make towards addressing science in their classrooms (Avery & Meyer, 2012). This is explained best by Bandura, who defined self-efficacy as the "belief in one's capabilities to organize and to execute courses of action required to produce given levels of attainments" (1997, p. 3) as well as an individual's beliefs in their capabilities to mobilize their motivation, cognitive resources, and course of actions needed to exercise control over task demands (Bandura, 1997).

Bandura further emphasized that decisions that affect whether or not tasks are attempted, and equally important, whether persistence to that task continues when it proves to be difficult, are all predicated by the role of self-efficacy (1977, 1982). Moreover, Bandura (1997) concluded that formation of efficacy beliefs is most likely attributed to a combination of four sources of information individuals construct for themselves and although not all are equally effective, each can be connected to properties of both classroom teaching and professional development. They are as follows: a mastery experience is a perceived success in performing a particular task; a vicarious experience is developed from watching others successfully perform a behavior; verbal persuasion consists of feedback and encouragement from others that reinforce one's beliefs that he/she has a capability to perform a task; and physiological responses address the role that stress and fear can have on dealing with complex situations (Bandura, 1997).

Efficacy issues can be related directly back to the preparation PSTs receive. A review of research spanning the early 2000's by Appleton (2006) pointed to three critical concerns with regards to the science education that elementary educators have received. Elementary educators (a) had limited science content knowledge, (b) which in turn, created limitations in pedagogical science content knowledge, which (c) culminated in low science teaching self-efficacy (Appleton, 2006). And this is by no means is a new phenomenon. Palmer (2011) found in his review of several studies carried out during the 1990s that teacher self-efficacy had been a particularly critical issue at the elementary school level, where many elementary educators had low self-efficacy for teaching science (Palmer, 2011). This was preceded by work from Czerniak and Chiarelott (1990), that alarmingly noted that elementary educators fear that they lack adequate training, lack science content knowledge, and lack effective science teaching skills, which more often than not manifests itself as reduced time spent by elementary educators on science instruction.

While raising an alarm about efficacy nearly thirty years ago, Czerniak and Chiarelott (1990) foresaw the path that must be paved to address the problem, suggesting that by providing future teachers with education strategies that positively increased their sense of science teaching efficacy, such preparation would in turn lower their level of anxiety about teaching science, and would allow instruction to occur that increases student performance.

If pre-service elementary educators begin their teaching careers with a low science self-efficacy, then a host of other issues begin to accumulate. Issues include such things as: whether or not a teacher's daily classroom routine includes science activities; the choices made in regards to science lesson planning and implementation; classroom management style to handle lab activities; student engagement strategies that include science demonstrations; and even how a teacher might negatively influence his or her students' own sense of self-efficacy (R. N. Anderson, Greene, & Loewen, 1988). Additionally, low science teaching efficacy can influence a teacher's choice of pedagogical activities that include science. This is due in large part to the amount of effort a teacher is willing to expend, the level of determination he or she can put forth to overcome obstacles, and the willingness he/she may lack to embrace innovations or instructional strategies, which STEM based activities demands (Smith, 1996; Tschannen-Moran & Hoy, 2001; Ware & Kitsantas, 2007). Moreover, the level of efficacy a teacher may or may not possess corresponds to how capable he or she perceives him or herself when promoting students' learning, and directly impacts the persistence teachers have with their students (Ware & Kitsantas, 2007). In fact, of all the things that influence teachers' behavior—knowledge, skills, prior successes, performance, achievement, and goal attainment—the level at which a teacher believes in his or her own ability to execute the behavior, i.e. "I think I can", was by far the most significant (Bandura, 1997).

Therefore, attention should be given to future elementary educators' views about their own learning of science, and conversely, their views about teaching science well before they begin teaching science. Views include attitudes and beliefs. And attitudes may either impact and/or form beliefs—so it is imperative that research explores the connections that PSTs may not have made, and yet need to make, between their roles as both learners and future teachers of science—because this may allow researchers to identify, and effectively address the attitudes and beliefs that could negatively impact teachers' classroom and instructional behaviors (Riggs & Enochs, 1990).

An Underlying Problem

Science content courses and teacher education programs should work in tandem and be designed to help build a strong enough science content efficacy that would provide for a strong science teaching efficacy. As previously established, three, maybe four classes of science content are all the PSTs are allowed with their degree programs. And while increased from previous standards, the hours afforded for science probably will not be increased again anytime soon as most degree programs have been trimmed to 120 hours in totality (THEBC, 2009). A limited exposure to science content is problematic on its own, however another equally important factor is the very nature of the science courses being provided to elementary educators.

As previously referenced, Menon and Sadler (2016) provided tangential evidence that PSTs' low science self-efficacy beliefs and the effectiveness of their science content courses were connected, pointing to poor performances in their science methods course as evidence. And other researchers echo these concerns. A growing consensus over the last two decades notes that formal science courses that use ineffective teaching practices (i.e. standard lecture format) can cause preservice teachers to adopt negative attitudes and beliefs about science, which in turn means they are inadequately prepared to teach science, and may in fact result in a reduction of the time they spend on science instruction in their future classrooms (Appleton, 1995; Appleton & Kindt, 2002; Jarrett, 1999; Mulholland & Wallace, 2001; Rice & Roychoudhury, 2003). Likewise, Hechter (2011) found the personal science teaching efficacy of future elementary educators was significantly impacted by undergraduate science courses taken, as well as prior science experiences at the high school level.

While science instruction reform has provided change in the public-school systems over the last two decades, the same cannot be said regarding four-year institutions of higher education where future teachers are themselves educated. In separate studies, Michaels, O'Connor, and Resnick (2008) and Nowicki et al. (2012) converged on three key problems with lecture-based science courses as modes of instruction for future elementary educators: (a) they offer little opportunity for realistic inquiry; (b) they rarely emphasize reflection on scientific knowledge; and (c) they provide only the rare opportunity to participation in science through individual experimentation or "hands-on" learning. Therefore, these types of courses fail to provide pre-service elementary educators a deep understanding of science concepts that are needed to later be able to teach inquiry-based science (Michaels et al., 2008; Nowicki et al., 2012). This is due in large part to the fact that most science courses taken by elementary educators are not intended for them. The descriptions provided in the course catalogs for most traditional introductory science courses in colleges and universities throughout the US indicate that the intended audiences are future science majors. Which often means that faculty teaching these courses are: (a) often not aware of the role they could play in assisting prospective teachers to "learn and understand the content and concepts that are critical to effective teaching"; and (b) have not been provided with "the kind of professional development in teaching that would enable them to model effectively the kinds of pedagogy that is needed for success in grades K-12 classrooms" (National Research Council, 2001, p. 32).

Because after all, it is not just PSTs who are struggling and would greatly benefit from reform that impacts their own science learning, it is also the next and subsequent generations of students that they will teach science to. The majority of elementary educators are women. In fact, roughly nine of every ten elementary educators are women (Ingersoll, Merrill, & Stuckey, 2014) who are having a profound impact on the young girls they teach, both implicitly and explicitly. All students, but especially young girls, are greatly influenced by the role that teachers play in their educational lives beginning in elementary school and extending into college. And the pre-college years instructors, while not as heavily studied as the college years faculty, seem to play a significant role in the decisions young girls make in regard to pursuing STEM fields as careers (Bottia, Stearns, Mickelson, Moller, & Valentino, 2015). In their study regarding underrepresentation of women in the sciences, Xie and Shauman (2004) remind us that the science classroom experience has a significant role in shaping future achievement and interests in the sciences, especially for women. Therefore, science content courses that successfully engage PSTs and prepare them with the adequate science teaching efficacy to effectively provide STEM instruction is imperative.

If You Build It…

So then how do we help PSTs increase their science self-efficacy so that they become confident in teaching science? Well, as we have seen so far, their own education is currently a barrier, a closed and often locked door. A study by Knaggs and Sondergeld (2015) explored the self-efficacy of preservice elementary students and included the following quote "I don't know if I have enough knowledge to teach it . . . if a student asks me a question will I be able to give him the right answer?" (p. 124). In that one simple question, a perfect summation is provided for the importance of both science content knowledge and science self-efficacy for future teachers. And it also provides an opening to use an alternate approach to appeal to pre-service teachers to construct the learning they need to be teachers of science.

Getting PSTs involved in their own learning could be the master key to unlocking this conundrum. When a student is involved in his or her own learning, that is he or she constructs knowledge from experiences, and in turn, connects those learning experience to prior experiences, he or she can then create a network of related ideas; this is, known as constructivism (Spivey, 1997). In learning theory, constructivism is an important paradigm that places the student at the center of decisions made about his or her instruction. Additionally, the social constructivists emphasize the role that interactions play in learning and point to research that indicate students' interactions with other students create the best learning environments (Vygotsky, 1978). This leads to increased learning benefits, where teachers can ultimately observe their students using a variety of forms to express their knowledge, thus indicating that the knowledge has occurred at a deeper level (Brand & Triplett, 2012).

The opportunity for addressing pre-existing negative attitudes and beliefs by pre-service educators, both in regard to their own science content knowledge and the impact that negativity may have in their future classrooms by infusing the elements of curiosity, wonder and/or imagination has not yet been thoroughly addressed by current research. In fact, until recently the role of curiosity, wonder and imagination has been overlooked as an extremely valuable tool to address science teaching efficacy even though nearly thirty years ago Harty and Beall (1984) anticipated the impact research that explored levels of curiosity could have when they developed the Children's Science Curiosity Scale. While originally designed for use with elementary school children, the developers also envisioned that the scale could help teacher education programs find "possible avenues of interest…including…studies of and interrelationships associated with science curiosity and elementary (pre-service educators) self-concept, locus of control, cognitive style, attitudes toward science, tolerance for ambiguity, interest in science, attentiveness, confidence in learning science, and persistence" (Harty & Beall, 1984, p. 434).

And even twenty years before Harty and Beall, curiosity, imagination and especially wonder already had a champion in Rachel Carson a famed scientist, well known author, and an inspiration to the author of this study. Carson (1965) expressed both a wish and way to help children find a future in the sciences when she wrote: "If a child is to keep alive their inborn sense of wonder…he needs the companionship of at least one adult who can share it, rediscovering with him the joy, excitement and mystery of the world we live in" (p. 55). Just recently, Gilbert and Byers (2017) conducted a study they described as a "modest attempt to address the myriad of issues…(faced) in the preparation of pre-service elementary teachers in the sciences by bringing elements of wonder into a science methods preparation program" (p. 908). In their "modest attempt" Gilbert and Byers (2017) also referred to Carson's petition, further reinforcing it with a quote from a researcher who they credited as being their work's inspiration. The quote they provided by Hadzigeorgiou refers to his suggestion that a "retooling" of science teacher education programs is needed. Hadzigeorgiou (2016) felt a good "…first step towards making wonder an indispensable part of school science education is to help science teachers and science educators develop a sense of wonder themselves, by making them aware of the wonder in science (p. 908).

In fact, Hadzigeorgious' (2016) book about the role that imagination can and should play in education provides numerous examples of the links among science, scientists, and imagination and indicates that literature and the fine arts are not the sole domain of imagination, but that it is indeed a "truism that imagination is central to science" (p. 3). Throughout the history of science, the list of individuals, too long to fully account for here, include Galileo, Newton, Curie, Einstein, Wilson, Feynman, Carson, and Hawking, who are credited with the greatest "discoveries." They repeatedly refer to "wonder, curiosity, and imagination" as key to the work they accomplished. For example, Albert Einstein stated that the best experience is that of the "mysterious" and that it "is the fundamental emotion which stands at the cradle of true art and science. He who knows it not and can no longer wonder, no longer feel amazement, is a as good as dead, a snuffed-out candle" (Einstein, 1951, p. p.5). Additionally, Mary Warnock, in her seminal work on imagination indicated that, "the cultivation of the imagination…should be the chief aim of education" (Warnock, 1976, p. 9).

Shifting A Paradigm

In this concluding section of the literature review, three key points supported by research are discussed as a way to show the importance of embedding the concepts of curiosity, wonder, and imagination into the educational training of PSTs. First and foremost, pre-service educators should be engaged with this concept as part of their learning experiences with the sciences. Secondly, that they recognize the concept as one of the primary attributes their future students will have and is also one that they themselves need. And thirdly, that without the attributes of the concept they cannot continue to engender it within their future students. As Stokoe (2012a) reflected, “fostering the scholarly attribute of curiosity in learners is an important task—one that is at the heart of education and effective learning as it challenges and promotes active participation in learning” (p. 63).

To address the first point, getting PSTs engaged in their own learning of science will require coordinated efforts within university and college teacher education programs and science departments. Science courses will need to be tailored to address the unique needs of preservice teachers as both learners and future teachers. As McDermott et al. (2000) indicated, “the emphasis in (science) courses for teachers should be on the development of deep understanding of topics included in the K-12 curriculum…(with) each teacher (studying) each topic in a way that is consistent with how they are expected to teach that material” (p. 73). Coupled with the addition of wonder, a shift may begin to occur. Gilbert (2013) found that pre-service elementary educators who participated in activities that encouraged them to develop a sense of wonder, showed a greater desire to learn, a greater interest in science content and developed more positive views about science content knowledge.

The second point, that PSTs recognize curiosity, wonder and imagination are important attributes their future students will have and that they themselves need, may in fact require a gentle reminder about who their future audience is. Pre-service elementary educators have made a conscious decision to teach young children, who numerous studies indicate, are innately curious about the world around them; they gravitate toward unknown objects, seek out new experiences, ask questions, recognize patterns, and try to reconcile anomalous information by developing their own theories and/or using fairly scientific methodology to make sense of things (Callanan & Oakes, 1992; Chouinard, 2007; Driver, 1983; Gopnik et al., 2000; Schulz & Bonawitz, 2007; Tizard & Hughes, 1984). In other words, they are open to wonder, curiosity and imagination, which are key to being successful in any of the STEM disciplines but must be encouraged by elementary educators. Engel (2013) noted that when children *want* to learn, they are more likely to do so, and to remember what they learned.

And finally, the third point that needs to be connected to make everything previously mentioned come together, is that PSTs need to have the attributes of curiosity in order to propagate it within their future students. Engle and Randall (2009) noted disturbingly in their research regarding adult influence, especially that of a teacher, that they can either foster or "squelch" children's curiosity, and that as students move up through grade school, teachers who are faced with "umpteen goals and many obstacles" are unwittingly discouraging curiosity. Engle (2013) further noted that teachers who are not themselves curious cannot "fan the flames of a drive (they) rarely experience" (p. 39).

The role of curiosity, wonder and imagination may prove to be an extremely valuable tool to help teacher education programs accomplish what Harty and Beall hoped their instrument would inspire, that being "an interest in science, attentiveness, (and a) confidence in learning science" (1984, p. 434). After all, as Basile and Johnson noted "as teacher educators, we want teachers who are inquisitive and curious because we believe that makes them better teachers and better at engaging students as thoughtful learners" (2010, p. 179).

Theoretical Framework

Three learning paradigms will provide the theoretical framework for this study. The first is an educational application of Bandura's social cognitive theory, which addresses both student and teacher in terms of their motivation and their learning. When applying Bandura's theory in an educational setting, there are four key theoretical components that are important to follow: self-efficacy or student/teacher confidence levels when they contemplate "if…then" scenarios; self-regulation or the setting of a goal and making a plan to meet that goal and the accomplishment of that goal; observational learning (modeling) where the observation of good models increases knowledge and understanding; and finally, reciprocal determinism where the student/teacher internalizes a "do this and get that" mentality (Bandura, 1977).

The second theoretical construct within this study is constructivism. Unlike the first theory, with one author and little debate as to what it ascribes to, the meaning and implications of constructivism varies widely across many disciplines, even within the context of education (Jones & Brader-Araje, 2002). Therefore, the main premise of constructivism (that this study focuses on) is the theory of how people learn, validated by observation and scientific study. Learners must have opportunities to reconcile new learning with prior knowledge, most often accomplished via experience and reflection (Von Glasersfeld, 1989; Vygotsky, 1978).

The third learning theory involves curiosity as a form of "intrinsic motivation key in fostering active learning and spontaneous exploration" (Oudeyer, Gottlieb, & Lopes, 2016, p. 257). In the following synopsis, the researcher promotes how being inquisitive (thus using curiosity) links directly to efficacy, constructivism, and the issue of traditional teaching strategies as used in most college science courses:

> Lecturing has been the predominant mode of instruction since universities were founded in Western Europe over 900 years ago…theories of learning (have) emphasize(d) the need for students to construct their own understanding (which has) challenged the theoretical underpinnings of the traditional, instructor

> focused, “teaching by telling” approach…In the STEM classroom, should we ask or should we tell? Addressing this question is essential if scientists are committed to teaching based on evidence rather than tradition. (Freeman et al., 2014, p. 1)

Additionally, curiosity’s role as theory and its’ applications in education are described by Oudeyer et al. (2016):

> There is not yet a consensus on how to define curiosity operationally…states of curiosity are often associated with a psychological interest for activities or stimuli that are surprising, novel, of intermediate complexity, or characterized by a knowledge gap or by errors in prediction, which are features that can themselves be quantified mathematically…(additionally) such informational features that attract the brain’s attention have been called “collative variables” by Berlyne. (1965) (Oudeyer et al., 2016, p. 258)

Collectively, these three paradigms provide an appropriate theoretical framework upon which to base this study, connecting the role of science course type, its potential impact on PSTs science learning and future teaching efficacy, and curiosity as a way to address those issues and better prepare PSTs as future science teachers.

Conclusion

STEM education reforms in the US are vastly impacting elementary science education, decreeing that science education should begin during the early years of schooling, thus elementary educators have been the most intensely scrutinized (Eshach, 2003; Eshach & Fried, 2005; Ginsburg & Golbeck, 2004; Kallery, 2004; Watters et al., 2001). Elementary school teachers are being called upon to provide science instruction that often exposes gaps in their own educational background (Akerson et al., 2000; D. Anderson, 2014; Flick, 1995). Elementary education degree programs have been restricted to providing a limited amount of science content instruction (THECB, 2009).

The science courses offered are not necessarily designed to provide the type of instruction that would help PSTs obtain a deep understanding of science concepts, which has negative impacts on both PSTs' science content knowledge and science teaching efficacy thereby reducing their abilities to provide their future students with a strong foundation in STEM (Appleton, 2003; Menon & Sadler, 2016; Michaels et al., 2008; National Research Council, 2001; Nowicki et al., 2012).

Thus, the literature indicates there is a need for further informed discussions about the type of science content courses that should be provided to pre-service teachers. To that end, a "retooling" of teacher education programs to include curiosity, wonder and imagination as indispensable parts of how PSTs learn science could help to reinforce or engender a sense of wonder within themselves (Hadzigeorgiou, 2016), which is a potentially more successful approach to help them improve their science content knowledge levels and thus their science teaching efficacy. This in turn could help alleviate the problem of having teachers who are not themselves curious and therefore cannot "fan the flames of a drive [they] rarely experience" (Engel, 2013, p. 39).

CHAPTER III:

METHODOLOGY

Overview of the Research Problem

Instructional policies at the national, state, and local levels now mandate that an emphasis be placed on STEM instruction at all grades levels within our public-school systems (U.S. Department of Education & Office of Postsecondary Education, 2016). However, the majority of elementary educators are not science specialists and studies consistently indicate that problems with science instruction at the elementary level are symptomatic of the inadequate science education required for elementary educators (Appleton & Kindt, 2002). A report that reviewed several studies found college and university introductory science content courses were more than likely linked to preservice teachers' low science self-efficacy beliefs, as evidenced by their poor performances in capstone science methods courses, which raises concerns about the effectiveness of those science content courses for preparing PSTs (Menon & Sadler, 2016).

Effectual science instruction is crucial as associated beliefs and attitudes that correspond to efficacy, both positive and negative, go with preservice teachers (PSTs) when they become teachers in their own classrooms and are necessary to provide their future students with a strong foundation in STEM (Kazempour & Sadler, 2015; Menon & Sadler, 2016; Ramey-Gassert & Shroyer, 1992). To assist PSTs with acquiring sufficient science content knowledge and to enhance their science teaching efficacy, PSTs' attitudes and dispositions should be considered critical learning mechanisms as well (Basile & Johnson, 2010). The role of curiosity in teacher preparation has been found to develop positive shifts in PSTs' desire to learn in more positive attitudes toward science content knowledge (Gilbert, 2013). To see elementary classroom practice change in meaningful ways, teacher education that includes and fosters the use of curiosity in both PSTs' learning and in their teaching should be a priority (Basile & Johnson, 2010).

Operationalization of Theoretical Constructs

This study included three constructs: views about science, science course type, and curiosity levels. The constructs have been operationalized below.

Views about science were based on the Views About Science Survey (VASS) designers' rating system that established a range of scores from the expert view (the one found to be most common among philosophers of science, scientists and educators and has a score value of 33), while the opposite end was designated the folk view (considered most often held by the lay community and science students at all grade levels and has a score value of 165) contained within the VASS (Halloun, 1997). A range for categorizing student scores to facilitate discussion was created based on the tables (Appendix A) provided in the scoring rubric of the research and are as follows: 33-65 = *expert*; 66-99 = *high transitional*; 100-132 = *low transitional*; and 133-165 = *folk* (Halloun & Hestenes, 1998). Views about science is also connected to the associated terms ***attitudes*** and ***beliefs***, previously described in the definitions section.

Science course types were based on descriptions of an introductory biology course found in the degree requirements of five four-year university catalogs within the state where this research was conducted. They are as follows:

1. Traditional introductory science course for science majors (TSM)
    a. A general biology course that includes biochemistry, cell biology, cell metabolism and energetics, photosynthesis, genetics, evolution, taxonomy, and an overview of bacteria and viruses.
2. Traditional introductory science course for non-science majors (TNM)

   a. Provides a survey of biological principles that emphasizes humans, and includes the chemistry of life, cells, structure, function and reproduction.
3. Introductory science course designed for future teachers
   a. Described (in general) in two four-year university catalogs that provided this type course as: An introduction to basic biological concepts and science teaching pedagogy for prospective elementary/middle level teachers utilizing scientific methodology and hands-on investigative techniques.

Curiosity levels were based on the work of Harty and Beall (1984) as rated by their Science Curiosity Scale survey. The range of scores is from low curiosity (30) to high curiosity (150). The scores were grouped by the researcher for this study to provide a simpler way to compare to the previous four groupings of the VASS survey. The groups are as follows: 30-60 = *low curiosity*; 61-90 = *low transitional;* 91-120 = *high transitional;* and 121-150 = *high curiosity*.

Research Purpose and Questions

The purpose of this study was to determine if pre-service elementary educators' views about science, both as learners and as future teachers, are impacted by the choice of science course they take in their degree program. Additionally, the relationship between curiosity levels, course type choice and number of courses completed, and the views PSTs have about their own learning of science and as a future teacher of science were investigated. The research questions that guided this study were:

Quantitative Questions

1. Is there a difference in the views among pre-service elementary teachers about themselves as both learners of and future teachers of science based on the type and/or number of science courses they have taken?
2. Is there a difference in levels of curiosity among pre-service elementary teachers based on the type and/or the number of science courses they have taken?
3. Is there a relationship between the scores of the VASS survey and the SC scale survey?

Qualitative Questions

4. What are pre-service elementary educators' attitudes and beliefs about their own learning in the science courses they took during their degree programs?
5. What are pre-service elementary educators' perceptions about the influence the type of science courses they have taken have had on their beliefs about their future role as science teachers and about their science teaching?
6. What are pre-service elementary educators' perceptions regarding the concept of curiosity, wonder and/or imagination as an attribute for the learning and teaching of science?

Research Design

The researcher used both quantitative and qualitative data analysis for this sequential explanatory mixed method study (Creswell, Plano Clark, Gutmann, & Hanson, 2003). The collection and analysis of quantitative data occurred first, followed by the collection and analysis of qualitative data. Data collection included surveys using a large group, followed by face-to-face interviews and post meeting short answer exercises with a small focus group. Analysis of the quantitative data included descriptive statistics processes of an independent-samples *t* test followed by an analysis of variance (ANOVA) and Pearson product-moment correlations. Analysis of the qualitative data utilized inductive coding processes and thematic study.

In the first quantitative phase of the study, the researcher used a survey to collect data from preservice elementary educators to determine their views about science and their curiosity levels. In the exploratory follow-up using interviews and written responses, qualitative data collection from PSTs included an exploration of connections between the type of science course they took; the process they used when selecting their course; what skills they think a science course should provide them with to be an effective future teacher of science; and the type of connections they may have between their level of curiosity and their attitudes about the learning and future teaching of science.

Population and Sample

The population consisted of all PSTs enrolled in an undergraduate degree program for future teachers at a small, mixed urban and rural four-year regional university located in Texas.

To capture as many PSTs who intended to teach students in grades 1-6, a sample of approximately 300 PSTs for the quantitative portion of this study came from those PSTs who were enrolled in either the bachelor of science interdisciplinary studies elementary certification core subjects (EC-6) early childhood concentration or the bachelor of science interdisciplinary studies middle school teacher certification core subjects 4-8. Those PSTs who were enrolled at the beginning of the spring semester of 2019 in one or more of the sixteen senior level methods courses (science, mathematics, and/or social studies) being offered constituted the pool of eligible candidates for this study. PSTs typically take these courses when they are juniors or seniors and have completed all their required science courses, which would have decreased or eliminated those respondents who did not have all the required science courses. Only those PSTs who indicated they will be teaching in grades 1-6 and who had not yet completed the Science Methods course were left in the final results. The exclusion of PSTs who had completed a Science Methods course was due to the nature of the science methods course, which is designed to prepare and instill confidence in PSTs to teach science, and to reinforce, but not necessarily to provide, science content. This is in distinct contrast to traditional science content courses which are intended to provide science content knowledge, not science pedagogy. Thus, completion of a Science Methods course may have unduly positively influenced PSTs views about teaching science.

Sample Selection

For the qualitative portion of this study a purposeful sample originated from those PSTs who indicated they will be teaching in grades 1-6; had successfully completed the assessment instrument and voluntarily requested to be included as a participant for the focus group discussions and/or activities. The sample drawn demographically represented the PSTs population of their small, mixed urban and rural four-year regional university located in Texas.

Instrumentation

For the quantitative portion of this study two survey instruments were utilized. The Views About Science Survey (VASS) was developed to obtain information from science learners about basic dispositions concerning both knowledge of and learning of science (or mathematics) (Halloun, 1997). The VASS survey is a 33-question survey which consists of six dimensions organized into pairs of contrasting views about science or science education (i.e. learning). The designers' rating system placed science learners on a scale, at one end being the expert view (the one found to be most common among philosophers of science, scientists and educators and has a score value of 33), while the opposite end was designated the folk view (considered most often held by the lay community and science students at all grade levels and has a score value of 165).The objectives used for this study are:

(a) To ascertain significant differences between the views of students, teachers and scientists.

(b) To identify patterns in student views and classify them in general profiles.

The VASS survey has undergone expert review validating its success in measuring what was intended; both internal consistency and test-retest reliability tested found reasonable results over several administrations including Pearson's correlation coefficient values with the "respective values of .40, .61 and .78 when correlating the dimensions of structure, validity and methodology" (p. 12); and is currently being used with thousands of students in several institutions as well as countries, with results published in at least four papers (Halloun, 1997).

Finally, to provide groups for the discussion of results, a range for categorizing student scores was created based on the tables (Appendix A) provided in the scoring rubric of the research and are as follows: 33-65 = *expert*; 66-99 = *high transitional*; 100-132 = *low transitional*; and 133-165 = *folk* (Halloun & Hestenes, 1998).

The second survey used for this dissertation is the sixth version of the Children's Science Curiosity Scale (SC) developed by Harty and Beall (1984). While originally developed for use with elementary school children, the developers encouraged its use in correlational and/or treatment research (Harty & Beall, 1984). The SC is composed of 30 items that examine broad curiosity factors including novelty, complexity of stimuli, change, etc., in the context of a science learning setting. When administered to fifth graders, the time to complete the survey was approximately 10 to 15 minutes. Participants are asked to rate the items on a Likert scale that ranges from 5 (*strongly agree*), 4 (*agree*), 3 (*uncertain*), 2 (*disagree*), to 1 (*strongly disagree*). Scores can range from low curiosity (30) to high curiosity (150). The items are scored in the direction of high curiosity with reverse coding used on eight negatively stated items (items 5, 6, 10, 15, 21, 25, 28, and 29). A Cronbach's alpha score of 0.83 established reliability, while concurrent validity scores were 0.64 and construct validity scores were 0.77 (Harty & Beall, 1984). The survey was modified from its original design, but only slightly, to edit two dated references to the "space shuttle" which were replaced with the following words "spacecraft or space station." It was piloted with adults, assessed for reliability with valid results before its use in this study with the PSTs.

Data Collection Procedures

Quantitative

Prior to collecting data, the researcher obtained approval from the Institutional Review Board (IRB). Once approval was received the researcher recruited participants by providing a formatted email to the sixteen instructors of the methods courses offered in the spring of 2019. The design of the email allowed an easy way to forward to all the PSTs that the methods instructors had as current students and contained the purpose of the study and a web link to the instrument. The researcher requested instructors of the methods courses to provide whatever they would accept as appropriate inducement for the participation by their students (i.e. extra points, extra credit, etc.). The link provided PSTs with access to Survey Monkey which was the platform used to host an instrument that included: the VASS; the SC; a series of questions about their science course work history (including type of course, name of course, semester taken in and at what college, and the result of the attempt), their status with regards to the science methods course (previously taken, not attempted yet, or currently enrolled) as well as demographic questions (gender, age, and race). Instructions to the PSTs indicated the entire instrument would take approximately 30 to 45 minutes to complete. Presentation of the consent form occurred by clicking on the provided link and those who proceeded to take the assessment/survey implied consent by their participation.

The researcher asked instructors to inform their students that the email had been sent on the first meeting day of the school week (Monday/Tuesday). Students were then given one week to complete the instruments. The researcher provided a reminder email to the instructors that they could forward to the PSTs on the second-class meeting day of the week (Wednesday/Thursday). Successful completion of the entire survey directed PST's to the acknowledgment and documentation forms to print and provide to their instructor confirming both their participation and completion of the instrument. The last step of the process included a request of the participants to consider voluntarily participation in interview sessions, either individually or as a part of a focus group, as well as a willingness to complete any other associated activities. An affirmative answer took PSTs to a drop-down menu to provide contact information (email, phone number, etc.).

Qualitative

For the qualitative portion of the study, the researcher contacted those participants who fully completed the surveys and indicated their willingness to voluntarily participate as member of a focus group and/or with related activities during the summer of 2019. Due to a limited response by survey completers (n = 1), in the second summer session of 2019 a request was made to PSTs enrolled in an education course to participate in a focus group. The instructor of that course provided incentive for participation and eleven students agreed. An open classroom at the university was chosen for the meeting site so that PSTs could easily get there after a short break at the completion of their class, where they were joined by the sole member of the original survey group who had agreed to participate.

The researcher led a semi-structured focus group session to collect data. The format consisted of a face-to-face focus group session that lasted approximately an hour and forty-five minutes. Each of the participants received a copy for their own records of the informed consent, with contact information for the researcher and her supervising professor. All participants received instruction allowing them to choose or be provided a pseudonym and that their comments would be collected and held confidentially, with only the researcher able to identify the participants. The researcher also informed all participants that data collected from the focus groups are kept in a secure environment and will be kept for five years and then destroyed. Furthermore, instructions included assurances that identifying names, locations, or descriptions of participants would not appear in the results presented in the final study.

The researcher then explained that the focus group would last at least one hour but no more than two hours and that the focus group meeting would be recorded, using two recording devices, in case one was to malfunction. Further instructions indicated that participants could control the recorders if they so choose, so that if at any time they felt uncomfortable or wanted the focus group session to stop, they could stop the recorders and end the session. The concluding instructions indicated that notes would be taken, as needed, for follow up questions by the researcher.

Topics associated with the qualitative research questions guided the discussion in the focus groups. While the format of questions asked within the focus group was held as consistently as possible, a certain amount of flexibility was inherent to the focus group sessions. Upon completion of the focus group transcription of audio files occurred as detailed in the analysis section of this paper. Once the focus group session was transcribed, analysis of the word documents occurred to determine what key concepts, themes and common perceptions would emerge. Additional assignments after the conclusion of the face-to-face session provided materials to address two of the qualitative research questions (numbers five and six). Information provided to PSTs informed them that not all information gathered in those assignments would necessarily be used within this study.

Before beginning the assignments, the researcher requested that PSTs who had not yet done so needed to complete the online survey discussed previously in the quantitative section. This was to allow for data within that instrument to be used as needed for comparison with the qualitative data. A text message to all members of the face-to-face session included a link to the survey and instructions to reply back with a screenshot of the last page when completed. Upon receipt of the screen shot, the researcher provided the first assignment.

The first assignment involved a short response activity developed by the researcher of this study based on a reference in an article by Engel (2013). The article addressed the concept of curiosity and referenced a study Engel conducted where teachers were asked to look at a list of adjectives and select choices they deemed as important qualities they would want in their students. Curiosity was an adjective provided on the list and was circled by many, however, when teachers were asked to make their own list of important student qualities without prompts to choose from, curiosity barely made the list.

An email provided initial instructions to participants. PSTs received a second set of instructions after they submitted their responses to the first section by email back to the researcher. This was done in an effort to prevent any undue influence on the participants responses, as the word “curiosity” was an adjective provided in the second half of the exercise (the instructions are provided as Appendix B). Instructions for the first step indicated that PSTs needed to create a list of ten adjectives or short phrases that would best describe themselves as students. The next step required them to select what they perceived as their best attribute, designate it as number “1” and then provide subsequent rankings down to the number “10”, and to return via text message to the researcher. Analysis of the transcriptions of their emailed answers then occurred to determine what key concepts, themes and common perceptions would emerge.

After participants provided the researcher with the responses to the first half of the activity, they received an email with instructions for the second half. This exercise provided a list of 25 adjectives and instructions for PSTs to select from that list, ten adjectives they considered to be the best attributes their future students could have and to rank them starting with number 1 being the “best” attribute and following through to number 10. Additional instructions required that PSTs provide an additional ten adjectives of their choosing, ranked accordingly, to describe attributes they “wished” they had as students. They returned their responses to the researcher via email attachments for analysis to see what key concepts, themes and common perceptions would emerge.

The concluding assignment for the PSTs consisted of a quasi-replication of a metaphor writing activity conducted by Seung, Park and Narayan (2011). Prior to its implementation, an email requesting permission had been responded to in the affirmative and is provided in Appendix C. The research done by Seung et al., was a pre- and post-science methods course activity that identified 16 categories related to pre-service teachers’ beliefs about the role/image of a science teacher and science teaching. From those categories, three themes emerged, two of which were used for this study, the traditional view and the constructivist view (see definitions Ch. 1). The neutral view emerged more as a result of the post-science methods writing portion and because all PSTs for this study were selected for not having completed a science methods course, that view was omitted. Figure 1 shows the categories and themes and is provided with permission by the authors for reference (Seung et al., 2011).

Table 1 Preservice teachers' beliefs about the role/image of science teacher/teaching (N = 106)

#	Traditional view (T)	Constructivist view (C)	Neutral (N)
1	Transfer knowledge and information	Give students an opportunity for exploration	Make class fun with enthusiasm/ positive attitude
2	Guide/lead students with authority	Understand/adjust to students' needs and level of learning	Exert a great deal of effort in preparing a class
3	Take care of students	Scaffold/facilitate students' learning	Learn from experience as a life-long learner
4	Manage and control the class	Nurture students by providing a desirable learning environment	Develop various teaching methods/ skills
5	Mold/transform students' minds to obtain desired products	Encourage students' interactions with peers/teacher	
6		Probe students' preconceptions and connect these to the learning process	
7		Give students autonomy to choose what they want to know	

Figure 1. Categories and themes of preservice teachers' beliefs
Used by permission from Seung, E., Park, S., & Narayan, R. in "Exploring elementary pre-service teachers' beliefs about science teaching and learning as revealed in their metaphor writing." 2011, Journal of Science Education and Technology, 20(6), p.706.

Directions for the ranking activity and the writing prompts provided instructions to the participants as well as an overview for them to read about metaphors prior to starting the exercise (see Appendix D). Sequential completion of both exercises required PSTs to rank a series of 10 randomly assorted metaphors from 1-10 with number one being their choice as the best match to their beliefs. The first set of metaphors addressed PSTs' role or image of themselves as a future science teacher and the second set focused on the role, or image, they associated with the concept of science teaching. Participants had the option to write in a metaphor if they felt none of the choices provided an acceptable representation to match their own role and/or image.

The researchers' goal for this exercise involved establishing which theoretical framework, traditionalist or constructivist, PSTs' choice and ranking of metaphors placed them in at this point in their educational path. The additional important detail for this activity was the fact that all participants in this exercise had completed two or more science courses but had not yet completed a science methods course. The importance of which is that the focus of this study is to explore the impact science content courses, not science method courses, may have on PSTs' beliefs and attitudes. For clarification, as described in the course catalog for the university where these PSTs attended, science courses are those intended to provide science content knowledge, while a science methods course is intended to provide pedagogical skills for teaching science and is not intended to necessarily add science content knowledge. In other words, the PSTs are expected to take a science methods course after having obtained the prerequisite science content knowledge. As noted in Seung et al. (2011), the completion of the science methods course their participators were enrolled in did have a measurable impact on their participants' post course responses.

Upon receipt of the responses to both exercises via email, the researcher transcribed and analyzed them to see what key concepts, themes and common perceptions would emerge. A small gift card was given to participants in appreciation for their participation.

Data Analysis

Quantitative

The data collected from the quantitative instrument via Survey Monkey was downloaded as a Microsoft Excel 2016 file, which was organized and then exported to SPSS (Version 26). Data was sorted into groups that included the VASS survey, the SC survey, demographic data and the course information data (including number of science courses taken and type of science courses taken). For this study, a statistical significance value of .05 was used.

To answer whether there a difference in the views among pre-service elementary teachers about themselves as both learners of and future teachers of science based on the type and/or number of science courses they have taken, data collected for the VASS was initially analyzed using an independent-samples *t* test followed by an analysis of variance (ANOVA) to answer research question number one. The independent-samples *t* tests used the VASS composite score as the dependent variable and two categorical independent groups, the types of science course, constituted the grouping variables. The independent-samples *t* test was used to evaluate whether the mean of the test score for one group (traditional science majors) differed from the mean of the test score for the other group (traditional non-science majors) (Green & Salkind, 2016). Following that analysis, a one-way between-subjects ANOVA was used to examine whether PSTs' scores on the VASS was a function of the number of science courses they had completed. The independent variable represented the three different levels of completion: 1) two science courses; 2) three science courses; and 3) four science courses. The dependent variable was the students' score on the VASS.

To answer whether there a difference in levels of curiosity among pre-service elementary teachers based on the type and/or the number of science courses they have taken, data collected for the SC survey was analyzed using an independent-samples *t* test. The independent-samples *t* tests used the SC composite score as the dependent variable and two categorical independent groups, the types of science course, were the grouping variables. The independent-samples *t* test was used to evaluate whether the mean of the curiosity score for one group (traditional science majors) differed from the mean of the curiosity score for the other group (traditional non-science majors). Matching the format followed for research question one, a one-way between-subjects ANOVA was used to examine whether PSTs' scores on the SC was a function of the number of science courses they had completed. The independent variable represented the three different levels of completion: 1) two science courses; 2) three science courses; and 3) four science courses. The dependent variable was the students' score on the SC.

To answer whether a relationship exists between the scores of the VASS survey and the SC scale survey, a Pearson product-moment correlation coefficient was used to assess the relationship between the composite score of the VASS and the composite score of the SC Survey.

Qualitative

For the qualitative portion of this study, the researcher used the data analysis tool *NVivo 12 for Mac* to analyze transcriptions made from the focus group face-to-face session and the written assignments. This allowed for data to be coded and themed to look for views related to both the learning and future teaching of science, and as applicable, the levels of science curiosity and any additional key concepts, themes and/or common perceptions that might have emerged. The following details with regards to analysis processes address each of the three qualitative research questions.

To explore pre-service elementary educators' attitudes and beliefs about their own learning in the science courses they took during their degree programs, analysis from the qualitative data followed two major question stems: (1) the process of learning science and experiences in science classes; and (2) the process of science course selection.

To investigate pre-service elementary educators' perceptions about the influence the type of science courses they have taken has had on their beliefs about their future role as science teachers and about their science teaching, analysis centered around a written activity that involved the ranking of metaphors and writing narratives from the eight members of the original twelve-member focus group that completed this assignment in its entirety. The goal of this exercise was to see which theoretical framework or view, traditionalist or constructivist, PSTs choice and ranking of metaphors placed them in. The number of top 5 rankings within one theme determined the final view identification for the participants. Or in other words, if a PST ranked three (or more) of the top five selected rankings within a theme, then that was considered to be the view identified with by that participant. The researcher then analyzed the data by using a deductive coding processes that include constructing a table to show the codes used for each metaphor (T1-5 = traditional view choices, C1-5 = Constructivist view choices), the rankings given to each choice by the PSTs, and the scoring that determined which theoretical framework PSTs had identified with (completed table is provided in Ch 4).

Two identical writing prompts, one focused on the role of teacher and the other on teaching, followed the completion of the ranking exercise. These provided feedback from participants on their decision-making processes for their rankings and an explanation of their overall first metaphor choice with regards to themselves as science teachers and their views about science teaching. The researcher then analyzed the data by using deductive coding processes, reviewing and revising, until common themes emerged.

To address pre-service elementary educators' perceptions regarding the concept of curiosity, wonder and/or imagination as an attribute for the learning and teaching of science, PSTs completed a short response exercise. This was actually the first exercise assigned after the initial interview took place and completion of the online survey occurred. The results reflect only the eight members from the original twelve-member focus group that completed this assignment in its entirety. The exercise was analyzed using an inductive coding processes by the researcher including the creation of tables for each of the three parts to compare and code results. The tables included the PSTs pseudonym, the adjectives they provided (or selected in part 2) and the rankings for each. In addition, the table also included the number of times multiple PSTs selected an adjective (completed tables are provided in Ch 4). And finally, the researcher made a word list using the transcripts from the three exercises to allow the *NVivo 12* data analysis software program to generate a word cloud. The top 14 terms were used to allow the word cloud to more graphically emphasize participant choices (completed word clouds are provided in Ch 4).

Qualitative Validity

For this study, the researcher used several methods employed in qualitative research to help insure validity. They are as follows: careful monitoring of the purposeful sample to ensure that they in fact are representative members of the population described; preparation of focus group questions in advance and reviewed by committee members prior to use; the use of triangulation which included data from the completed surveys, the focus group interviews, and the short answer exercises order to see if participants' responses might converge upon the same answers and/or if other issues or concepts presented themselves; and in an effort to provide full disclosure, the researcher provided some information about herself as a researcher and educator (Creswell & Miller, 2006). In other words, as part of the data reporting, the researcher revealed that she is a science instructor as well as providing information about her viewpoint and potential personal biases with regards to views about science and the teaching of science.

Privacy and Ethical Considerations

The researcher will secure data collected from participants at all times and maintain the data for five years which is the required time set forth by IRB. Passwordprotected folders on the researcher's computer and on a flash drive are being maintained in a safe and secure environment. Once the deadline has passed, the researcher will destroy all data files.

For the quantitative portion of the study, PSTs identifications are kept confidential by the researcher. However, PSTs who chose to print off the proof of completion page to provide to their instructor acknowledged this vacated their anonymity with regards to participation in the study. For the qualitative portion of this study, a copy of the consent form with contact information for the researcher and her supervising professor was presented to each of the participants for their own records in person at the face-to-face interview. The researcher allowed all participants to choose or be provided with a pseudonym with only the researcher able to identify the participants. Additionally, the researcher informed all PSTs that the focus group sessions and all written exercises, and data collected from them, are to be kept in a secure environment and that identifying names, locations, or descriptions of participants will not appear with the results presented in the final study.

Conclusion

A well-qualified educational force is paramount to prepare today's youth as tomorrow's decision makers and STEM workers. Based on the type of instruction PSTs may be receiving due to the type of science course PSTs enroll in, they may have developed negative attitudes and beliefs about teaching science. Assessing educators' attitudes and beliefs would provide for an informed discussion about the type of science content course that should be provided to PSTs that would help remediate their weaknesses and to reinforce their strengths.

Likewise, many PSTs have not considered the role that their levels of curiosity play in their own education and may have not been adequately reminded of the inherent curiosity they will face each and every day as future teachers of elementary age students. By using the argument that developing or enhancing pre-service elementary educators' own curiosity levels will allow them to be more effective teachers, as well as being able to relate to the naturally curious future students they will teach, may be a much more successful approach to getting them to willingly work to improve their science content knowledge levels and assist them in seeking out and selecting the best possible science content course available to them.

By helping to highlight any connections between science content courses and the attitudes, beliefs, and curiosity levels of pre-service educators, this research could provide teacher education programs with a stronger argument to present to their institutions for the need to develop more science courses implicitly designed for future elementary educators. Ultimately, this research could help codify the unique mixture of science content knowledge needed with the level of wonder and curiosity that would appeal to future elementary educators such that it would enhance their desire to learn more science. This in turn, could actually allow pre-service educators the opportunity to acquire the requisite level of science content knowledge to be effective teachers of science thus ensuring their own students will receive appropriate STEM lessons and will be provided with ample time to explore STEM topics.

CHAPTER IV:

RESULTS

Introduction

This chapter will present the findings of both the quantitative and qualitative data analysis obtained by this study. The participants' demographics for the quantitative and qualitative data study, as well the results that addressed the associated research questions will be presented. Finally, a summary of the findings is presented.

Participant Demographics

Quantitative

The population for the quantitative portion of this study consisted of pre-service teachers enrolled in an undergraduate degree program for future teachers at a small, mixed urban and rural four-year regional university located in Texas. Only those respondents seeking an EC-6 certification and had not completed a science methods course were kept in the pool. Of the eighty PSTs who responded to the survey, 79 were female and 1 was male. Of those eighty, seventeen participants were unable to complete every question and were ultimately removed from the overall results, thereby leaving a final $N = 63$. Table 4.1 presents PSTs' demographics information.

Table 4.1
Demographics of Quantitative Participants

Age	Asian	Black/African American	Hispanic/Latino	White/Caucasian
18-20	0	0	2	1
21-23	1	1	13	10
24-26	0	0	4	5
27-30	0	0	3	6
31+	0	1	8[a]	8
Total	1	2	30	30

Note. [a] Only male participant was in this group.

Research Question One

Research question one, *Is there a difference in the views among pre-service elementary teachers about themselves as both learners of and future teachers of science based on the type and/or number of science courses they have taken?*, was initially analyzed using an independent-samples *t* test followed by an analysis of variance (ANOVA) based on responses to Halloun's (1996) Views About Science Survey (VASS). The preliminary descriptive statistics measured the mean for the VASS composite scores, the results of which are summarized in Table 4.2.

Table 4.2
VASS Survey Means Total Scores

Type of Science Course	No. of Courses Completed[a]	*n*	Mean score	Std. Deviation
Traditional Science Majors	1	20	103.2	12.8
	2	22	99.2	13.1
	3	10	98.5	11.2
	4	10	99.3	13.6
Traditional Non-science Majors	1	43	99.2	15.5
	2	41	101.0	15.3
	3	49	101.1	15.2
	4	28	101.5	16.1

Note. [a] Most expert score = 66; Most folk score = 133.

Next the 63 participants, who had all completed at least one science course, were grouped according to type of science course: traditional introductory science course for science majors, $N = 20$; traditional introductory science course for non-science majors, $N = 41$; and introductory science course designed for future teachers $N = 2$. In order to determine whether there was a difference in VASS composite score by type of course taken, an ANOVA was initially conducted, however there were unequal groups and the smallest group ($n = 2$) was recoded into the non-science majors group, as that would be the designation given it in most college course catalogs, and an independent t-test was conducted.

The independent-samples t-test was conducted to compare views by PSTs about themselves as both learners of and future teachers of science in traditional majors' and non-majors' science courses after having completed one science course. Results indicated there was not a significant difference in the scores for traditional science majors courses ($M = 103.2$, $SD = 12.8$) and non-majors science courses ($M = 99.2$, $SD = 15.5$) conditions; $t(59) = .98$, $p > .05$. These results suggest that the type of science course taken does not have an effect on views by PSTs about themselves as both learners of and future teachers of science.

To further investigate the potential influence of course type, a second measure was taken using their different levels of science course completions. The 63 participants were grouped by the number of science courses indicated that they had completed and were as follows: those having completed two science courses, *N* = 4; those having completed three science course, *N* = 11; and those having completed four science courses, *N* = 48. A one-way between-subjects ANOVA was conducted to compare the effect on the views of PSTs about themselves as both learners of and future teachers of science after completing two, three and four science courses. Results indicated there was not a significant effect on the views of PSTs about themselves as both learners of and future teachers of science on completed science course number for the three conditions $F(2, 60) = .19$, $p > .05$. Table 4.3 provides the descriptive statistics and rating groups.

Table 4.3
VASS Survey Results

Type of Science Course	No. of Courses Completed[a]	*n*	Mean score	Rating Groups[b]
Traditional Science Majors	2	22	99.2	High Transitional View
	3	10	98.5	
	4	10	99.3	Range 66-99
Traditional Non-majors	2	41	101.0	Low Transitional View
	3	49	101.1	
	4	28	101.5	Range 100-132

Note. Most Expert score = 66; Most Folk Score = 133. [a]Overall mean for 1 course 100.4; Std. Deviation = 14.5. [b]Rating groups based on profiling schemes by Halloun (1997).

Research Question Two

Research question two, *Is there a difference in levels of curiosity among pre-service elementary teachers based on the type and/or the number of science courses they have taken?*, was answered using an independent samples *t* test applied to the responses of a revised version of Harty and Beall's (1984) Science Curiosity Scale (SC) survey. The preliminary descriptive statistics measured the mean for the SC composite scores and the results are summarized in Table 4.4.

Table 4.4
Science Curiosity Scale Survey Means Total Scores

Type of Science Course	No. of Courses Completed[a]	n	Mean score[b]	Std. Deviation
Traditional Science Majors	1	21	113.5	19.3
	2	22	113.3	18.7
	3	10	117.6	5.6
	4	10	107.7	20.8
Traditional Non-science Majors	1	42	111.2	14.1
	2	41	113.2	14.1
	3	49	112.9	16.9
	4	28	116.6	15.6

Note. [a]High curiosity score = 150; low curiosity score = 70.

Duplicating the process used for the first survey data, the fact that all 63 participants had completed at least one science course allowed for groups to be made according to type of science course: traditional introductory science course for science majors, *N* = 20; traditional introductory science course for non-science majors, *N* = 41; and introductory science course designed for future teachers *N* = 2. From the previous attempts on assessing the VASS, the researcher used the same process of equalizing the groups by taking the smallest group (*n* = 2) and recoding it into the non-science majors' group following the designation it would be given in most college course catalogs. Then an independent t-test was conducted.

The independent-samples t-test was conducted to compare curiosity levels by PSTs in traditional majors' and non-majors' science courses after having completed one science course. Results indicated there was not a significant difference in the scores for traditional science majors courses (M = 113.48, SD = 19.27) and non-majors science courses (M = 111.22, SD = 14.14) conditions; $t(60) = .52$, $p > .05$.

To further investigate the potential influence of course type, a second measure was taken using their different levels of science course completions. The 63 participants were grouped by the number of science courses indicated that they had completed and were as follows: those having completed two science courses, $N = 4$; those having completed three science course, $N = 11$; and those having completed four science courses, $N = 48$. A one-way between-subjects ANOVA was conducted to compare the difference in levels of curiosity between pre-service elementary teachers after completing two, three and four science courses. Results indicated there was not a significant difference in levels of curiosity between pre-service elementary teachers based on completed science course number for the three conditions $F(1, 61) = .62$, $p > .05$.

Research Question Three

Research question three, *Is there a relationship between the scores of the VASS survey and the SC scale survey?*, was answered at the conclusion of analysis for both surveys by computing a Pearson product-moment correlation coefficient to assess the relationship between the composite score of the Views About Science Survey and the composite score of the Science Curiosity Scale Survey. There was a significant correlation between the two variables, $r = 0.445$, $n = 63$, $p < .05$. See Figure 2 for a scatterplot of the relationship).

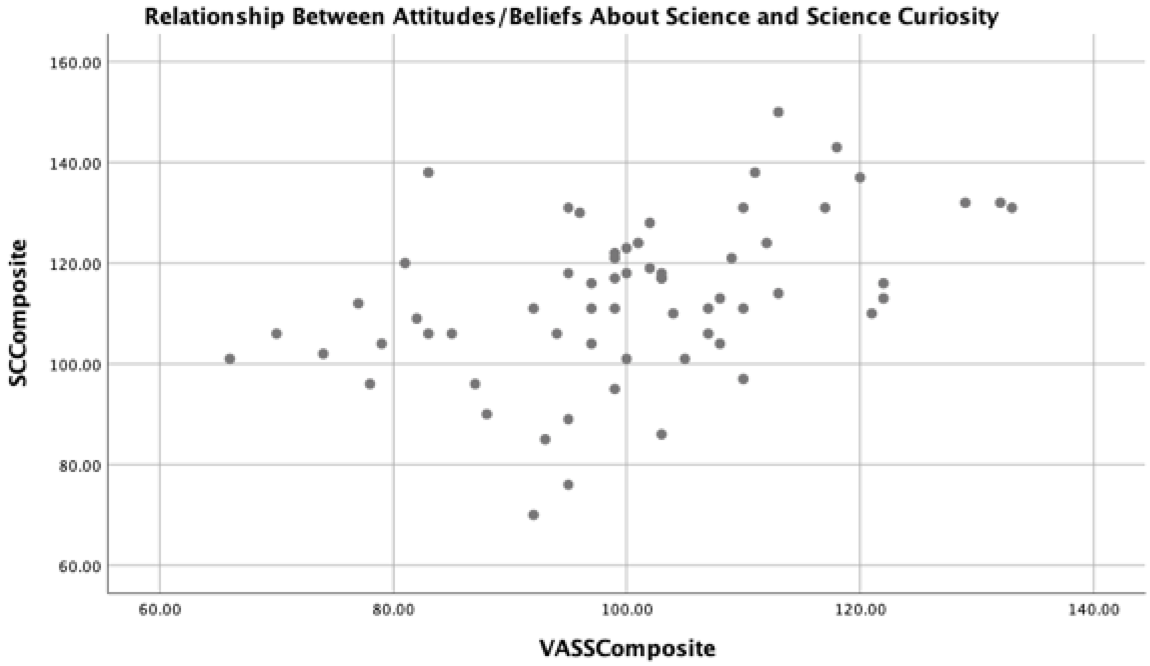

Figure 2. Correlation between survey scores

Participant Demographics

Qualitative

The population for the qualitative portion of this study consisted of pre-service elementary teachers (PSTs) enrolled in an undergraduate degree program for future teachers at a small, mixed urban and rural four-year regional university located in Texas. A purposeful sample was drawn from the population including only those PSTs seeking an EC-6 certification and who had not completed a science methods course. Participants were then selected based on their willingness to complete the entire assessment protocol, including two surveys, demographic information and type and number of science courses attempted and/or completed; and who voluntarily requested to be included as a participant for the focus group discussions and activities.

Based on these criteria a focus group of twelve female PSTs met for the initial interview session and written activity. Of those twelve, eleven were concurrently enrolled in the same educational class which seemingly provided a willingness to interact and expand upon each other's answers. The lone PST who was not a member of that particular class had however been in other classes with some members of the group. Due to that fact, a comfort level was established fairly quickly, and she was able to participate at similar levels with the rest of the group.

Of these twelve who met in the face-to-face interview session, only eight completed the additional written assignments assigned thereafter. Therefore, research question four will use data collected from all twelve participants, while research question five and six will only provide data from the eight completers. For the discussion provided in this study, all focus group member names have been replaced with pseudonyms. Table 4.5 presents PSTs demographic information for the entire focus group and indicates the eight who completed all parts of the protocol.

Table 4.5
Demographics of Quantitative Participants

Age	Asian	Black/African American	Hispanic/Latino	White/Caucasian
21-23	1[a]	1	3[a]	1
27-30	0	0	2[a]	2[a]
31+	0	0	1[a]	1[a]
Totals	1	1	6	4

Note. Focus group = all female. [i]Indicates at least one member of the final eight members within this grouping.

Research Question Four

Research question four, *What are pre-service elementary educators' attitudes and beliefs about their own learning in the science courses they took during their degree* *programs?*, was answered using an inductive coding process. Analysis from the qualitative data revealed themes that emerged around the major question stems provided by the researcher that provided data regarding this research question. In this section an overview of the two major question stems will be provided, what they were attempting to elicit from the participants, and the results provided through participant comments.

Question Stems Part One

The first set of major question stems were focused on obtaining PSTs' feelings about the process of learning science via their experiences with taking science courses. The researcher was attempting to gauge the level of confidence about taking a science course, i.e. what were the PSTs thoughts prior to taking their science courses or as the class began. Due to the fact that these questions were near the beginning of the interview session, participants were often hesitant to provide long or detailed answers. Another factor for hesitancy on the parts of the PSTs may have arisen due to the fact they were aware that the researcher conducting the interview was a science teacher.

Out of the twelve members of the focus group, only two PSTs were enthusiastic about the topic of science. Both expressed their enjoyment of being a student of science and eagerly looked forward to one day teaching science. The remaining ten members referred at some point and in some way to their concerns about taking science courses. From the responses provided, the major theme that emerged was “negativity”. Terms such as “nerve-wracking, struggle, intimidated, anxious, and hate” showed up in the participants responses. Beginning in a slow and hesitant fashion, Hazel started responses off by saying:

> Science is not like my best subject, so it's already difficult for me. The lecture part that was like nerve-wrecking. It was really hard and I just worried if I was going to pass/fail, pass/fail ... and really, I was thinking more like, "I'm going to fail."

Then Stella followed with:

> I hate science as well and I went in thinking like, "I was just wanted to pass and get it over with."

Based on the ensuing participants comments, it appeared that the PSTs shared similar thoughts and the majority of responses thereafter spoke to a similar theme. Naomi expanded upon the theme when she added:

> I hate science. I liked math and I hated science. I hate both now. College algebra changed that for me. So, I hated science, so I learned about Rate my Professor, and honestly my attitude was, "Let me pick the professor that sounds like they know what they're talking about, that they're easy, and let me just get it done."

As the discussion continued a theme surrounding their experiences with science courses slowly emerged, that being one of negativity. After the initial use of the word “hate” by one participant, several PSTs used the same term in their descriptions. Their comments collectively seemed to reflect a level of unease with the both the subject of science and a lack of positive experiences with the process of learning within the context of a science class. Kinsley continued the theme by saying:

> I was just going to say a little comment, that it's not that I don't like science. I appreciate it, I do. Like I really do. But it is very complex. I'm not saying that I wouldn't commit to it one day, maybe I'll just ... get into science one day, but today is not that day.

Unlike Kinsley, Paisley was excited at the prospect of teaching science in the future even though she expressed a dislike for science:

> I want to say even though I hate science and could care less about it, I always had great teachers. I like them personally, but when it came down to that actual material, Ooh. I think I should just let you know that even though I'm pretty lost

> in the whole science thing, and I’m kind of just like, "Oh gosh." Like, whoa. I am excited to teach it because honestly, truly I feel like when I teach the science to my students, I'll probably be teaching myself, it, right there and then, to where I'm getting it, so I'm still fascinated. It's not my favorite thing but when I go do it, they'll have no idea.

The conversation began to organically segue into the subject of the “type” of science course, not just solely the experience of taking any particular science course. The comment that follows speaks to Nova’s experience of taking science courses, with terms like “hard” and “easy”, as she was possibly following others who had previously used those terms. Additionally, her summary was a good example of the beginning transition that occurred in the conversation about what type of courses PSTs were seeking out and some of the factors that helped them make their decisions. Nova provided the following:

> I've taken multiple science classes and I took, the first science class that I took was anatomy and physiology. And then, that class was just like, it wasn't ... I liked it because I wanted to be a nurse before ... so it wasn't as hard for me but the class started with like 60 people. And we ended with ten. And our professor was Russian. It was a hard class because we couldn't understand him. And then after I decided to change my major I took geology, and it was like, mostly everybody was going to be a teacher takes geology, because it's an easy science class. So I could tell the difference. Everybody who stayed, passed the class because they were teaching differently. They weren't focusing that much on it. They were, but not as much as they would in science and in anatomy. Anatomy is like something you're working for that you're going to use for your career. As well as geology, mostly you're just doing it for a credit. So, that's the difference between the both of them.

While the conversation of the focus group had a more negative tone at the outset, by the end it began to take on more positive tendencies as the transition into the next segments began.

Question Stems Part Two

The last set of question stems used to answer this research question shifted to how PSTs went about choosing their science courses. Students' confidence levels in answering questions had increased by the time this line of questioning began and longer answers were offered, typically building or referring to answers provided by their peers. Questions included topics such as factors they may have used to make a selection, and more specifically, if they purposefully delineated between courses for science majors and non-science majors. The responses provided a common theme built around the concept of "difficulty levels". Words such as "easy", "technical and/or detailed", "enjoyment", "interactions", "intimidated", and/or "hard" were used by several of the participants with a majority of other students nodding their heads in agreement. Paisley got a lively conversation started and brought up the concept of choice between face-to-face offerings versus online courses. Additionally, as the conversation began to transition from experiences in a science course to how they got into that science course, there still remained an element of how "hard" or "easy" the PSTs considered a course to be. Based on the continuing comments both with her and with those that follow, it appears that these descriptors played a role in course selection. Paisley explained:

> I'm going to be completely honest. So, I took a geology class online, ask me if I know any type of rock? I would say no. Why? Because everything I got, it (was) off Google. All my quizzes, everything. All the answers were online, everything. So, I took geology online and that's how I did it. But in biology I did learn a little bit, but it was different because I was a non-science major. During lab, my

> professor, he didn't really care. Because he was just like, "Do the lab and you're done, go." That's it. So, I didn't learn much in my biology class. And geology I took it online, I didn't learn anything. In chemistry, same thing. I'm just like ... and I'm more of a visual person but I decided to take it online because I was like, "Maybe it will be a lot easier." Which is was a lot easier online. But I kind of regret it because now I'm completely blank on rocks and eventually I'm going to have to learn that to teach it to my students.

Another aspect of course choice was brought into the conversation by Everly when she introduced the concept of the role counselors often play in PSTs science course selections. She described her experience in both course type and selection process like this:

> I took two science classes, biology and then geology. The biology one my counselor sent me to was for a science major. I guess it was an accident, or something. But then she was able to fix me back to my non-science major. And she led me to biology and geology and then, here, I took chemistry, this summer. I decided on chemistry because I didn't want to take astronomy because I was like, "It sounds hard." So, I went ahead and did chemistry. It was really easy. I did learn something.

This theme persisted and evolved from alluding to the role counselors have in the decision-making process, but also the potential influence outside sources such as friends and/or peers, as well as “rating” programs from online platforms. Nearly every PST had an example of an experience with a science course that caused them to become aware of the differences in types of course offerings; a few representative examples follow. Kinsley provided the following details about how her course selection process developed:

> For me, I took my science classes at a community college. And I had to take a biology class in order to graduate with my associates. So, then I chose myself, I chose the wrong biology class. I chose the one for science majors. And then I (found out I) needed another science, so I decided to take Stars and Galaxies, and I just took that because I heard it was really easy. So now my process for picking science classes is, if I can find the easiest class, it's like that's the one I go for.

Naomi responded with a similar strategy, however, she also circled back to a comment earlier about the role of the professor in the class. Where Nova mentioned that struggle might be connected to the instructor (in her case a perceived language barrier), Naomi introduced a strategy that relied solely on the perceptions of the instructor by others to help guide her decision-making process.

> I (took) geology, chemistry, biology and basically it felt like a long list. But I took (them and) the way I (chose to) take them is I try to take them in short semesters, because I really didn't want to do it. I get my friends' opinions, and I go to ratemyprofessor.com.

But then Quinn described something different, albeit a similar experience, she however noted how a change in course type made a significant difference to her experience:

> At (a community college) I was actually taking a science major class which I was a non-science major. So, I was in there for two weeks and I sat in the very back and I did not participate at all, because I didn't enjoy it. It wasn't the class I was supposed to be in. So, I went to my counselor and he switched me to a non-science. And I felt like once I stepped into the non-science major it was like completely ... the environment was completely different. Everyone in there was helpful, I was starting to participate and actually made an A in the class because I thought I was going to fail but I didn't.

And Aurora quickly agreed with this idea of a course filled with future teachers, adding:

> So, if I was to take a class where I'm with science majors I would be intimidated. So, I'm not going to participate or answer or know the stuff like they do. But if I'm with peers and know that we're all going for the same thing, I'm going to interact. I'm going to make group text messages and I'm going to ask questions, "What did the professor want? What are we supposed to do?" So that makes a difference with me. Being with people in my field and being with people where I'm comfortable.

From this comment, the conversation quickly evolved into a discussion of what PSTs would like to see as options for the type of science courses they appeared to prefer, specifically for themselves as future teachers. As advocated by Paisley:

> I think that type of class would be more successful. I know for me when I take classes that are more about teaching, I do way better versus just basic classes that we have to take. And I'm actually more motivated to take it and to learn the material.

Supporting the same idea about the type a type of science class options she would prefer, Kinsley furthered the discussion along, but with some concern:

> I'm not sure if I'm going to answer this quickly- But what it seems like ... to me as a student ... What I'm getting is I would get more of the content. I would get more of what I would need to know as a student. I feel like as if I were in a ... if I was the teacher being taught or I guess being taught how to teach it ... You're getting less of the content and more of just, "How you would do it. How you would give it to your kids." So, it's kind of a give and take it seems. It seems like you wouldn't get as much of the content as you needed to actually be able to like get it- but you would understand more of what you did get.

And finally, Emilia offered a short and succinct summation for this part of the interview, when she replied to Kinsley:

> I was going to kind of say the same thing. I think it would be more engaging in some way versus the traditional, you're just sitting down and taking notes while the teacher talks, and in the teacher classroom, right ... in the science classroom where they're teaching future teachers, they'll want to interact and get more of their input.

Over the course of the face-to-face interview, PSTs shared thoughts about their experiences as science students in classes where most of them seemed to have had negative experiences. Those experiences seemed to have had a role in how PSTs made science course selections. For about half of the group, counselors had a role deciding which course they took. Some talked about the material or topic of the course, as a deciding factor, while others used criteria that also included the role of the instructor and looked to outside influences like friends, peers or online apps that provide rating systems for more often professors than course content. Most implied that non-majors' science courses were preferred to science majors' courses, which led to a closing conversation about options for science courses that would be designed where the target audience were future teachers like themselves.

Research Question Five

Research question five, *What are pre-service elementary educators' perceptions about the influence the type of science courses they have taken have had on their beliefs about their future role as science teachers and about their science teaching?*, was answered using a ranking exercise followed by two writing prompts to allow participants to provide a narrative describing their ranking decisions and metaphor choices. The researcher used deductive coding processes to analyze the exercises provided by the eight members of the original twelve-member focus group who completed this assignment in its entirety. Additionally, data from the quantitative analysis of the Views About Science Survey (VASS) are provided at the end of this review of results.

Constructivists versus Traditionalist: Science Teacher

Six of the eight PSTs ranked metaphors that indicate they have constructivist views of themselves as science teachers, choosing metaphors that imply their attention is focused on students' learning and the learning environment. Table 4.4 shows how these results were scored. The code for each metaphor (T1-5 = traditional view choices, C1-5 = Constructivist view choices) is provided as well as the rankings given to each choice by the participants. The scoring that determined which theoretical framework PSTs had identified with was based on the number of top five rankings within one theme. Or in other words, if a PST ranked three (or more) of the top five selected rankings within a theme, then that was considered to be the view identified with by that participant.

Two of those six PSTs selected four of their top five metaphors from the constructivist choices, while the other four all had the requisite three of five (see to Table 4.6). Five of the six chose the exact same metaphor for their first choice, that of a "coach, adventurous guide, and/or a road map". It is worth noting that in fact all eight PSTs chose that same metaphor within their top five choices. It was the only metaphor selected within the top five by all participants. The idea of a type of "guide" appears to be a common thread that linked these participants to the constructivist ideology. Each of the five used the word "guide" in both the description of their decision process as well as their explanation of why they felt their top choice of metaphor best fit their own beliefs. Other related adjectives used to describe PSTs' perception of characteristics of the guide were "giving, encouraging, supporting", which were used in a similar context in the responses provided by all five.

Table 4.6
Metaphors and Identification for Role/Image as a Science Teacher

Student ID Metaphors	Nova Rank	Everly Rank	Willow Rank	Aurora Rank	Luna Rank	Hazel Rank	Quinn Rank	Amelia Rank
T1: a dictionary, the ocean, and a pitcher filled with water	7	**5**	**1**	9	9	7	**5**	6
T2: a coach, a rafting guide, a cook, and a road sign	6	7	7	8	**3**	**4**	**2**	**5**
T3: a king lion or a mother duck	10	6	**5**	10	6	8	6	10
T4: a house builder, a referee, an umpire, or a judge	8	**3**	**2**	**2**	7	**3**	7	8
T5: a potter;	**3**	10	9	**3**	**5**	**2**	8	7
C1: a tour guide; a detective	**2**	**2**	**3**	**4**	**2**	**5**	10	**1**
C2: a chameleon; a gardener	**4**	8	10	6	**4**	10	9	**4**
C3: movie director	9	9	6	**5**	10	6	**3**	9
C4: a gardener; a cook; a bumblebee	**5**	**4**	8	7	8	9	**4**	**3**
C5: a coach; an adventurous guide; a road map	**1**	**1**	**4**	**1**	**1**	**1**	**1**	**2**
Number of Traditionalists	1/5	2/5	3/5	2/5	2/5	3/5	2/5	1/5
Number of Constructivists	4/5	3/5	2/5	3/5	3/5	2/5*	3/5	4/5
Final Determination	**C**	**C**	**T**	**C**	**C**	**T***	**C**	**C**

Note. Answer choices provided to PSTs were randomly ordered; they were sorted by theme for this table only. * = Choice ranked number 1 not in final determined view

The short answer narrative responses provided by the PSTs spoke to the type of guide they perceived themselves as being in their role as future teachers. These first two examples summarize the views reflecting the choice of adventure/coach/road map guide as a "supportive or encouraging" guide. As Aurora stated:

> My job will be to encourage my students, to guide them through the learning process, and to lead them into knowledge. I want to engage and encourage them at all times, while they are in my care within my classroom.

Likewise, Nova converged on the same idea of a teacher committed to having a supportive role as she commented: "I chose something that talked about adventure and discovering because it had the elements that convey the act of supporting and guiding which I plan to do". The sole constructivist PST to choose a different number one was Amelia, who chose the metaphor "tour guide; detective" (which was selected as a second choice for three of the six). She too used the word "guide" in her description; however, her perception of guide appears to be more directional in nature, providing direction ("tour") more so than support. She provided the following rationale:

> I chose "tour guide; detective" because as a teacher we are a tour guide and the students are the detectives when learning science. We will guide the students on a tour that allows students to become aware of how science is intertwined in everything.

Representing the opposite theme of traditionalist, two of the eight PSTs focused on the process of students' learning and were more aware of the actual process of teaching in their selections of metaphors. However, one of the two selected the same first choice that the five constructivist view teachers selected. She also had a fourth choice (T2) with similar verbiage (guide) that was coded with the traditionalist views. Hazel's narrative provides insight into student focused ideology as she indicates here:

> I believe a science teacher is a coach. A coach only helps the students to get better. They train and model how to do certain exercises. When a coach is training a team, the coach models and then allowed the team to do it on their own. The coach stays on the sideline observing and helping the players who need help or telling the players how they can get better. That's what a teacher during science does a well.

The other PST who identified with the traditionalist view chose "a dictionary, the ocean, a pitcher filled with water" as her top choice. Her comments echo the description of a traditionalist belief system which see teachers as a source and/or provider of knowledge and information (Seung, et al. 2011). She provided these descriptions in her narrative:

> The metaphor I chose describes what I see as my role as a future science teacher, as if I'm filled with knowledge like a dictionary, ocean, and pitcher of water. Dictionaries are full of words that help us gain knowledge on what words mean and help us learn new words. The ocean is big and full of so many fascinating things, and can't be explored all in one day, just like science. And the pitcher filled with water is how I see my role as a future teacher and my knowledge that I want to pass on to my students about science.

While two of the eight PSTs did not identify with the constructivist ideology after all choices were tallied, all eight did have one metaphor in common. It is an interesting finding that all PSTs identified themselves as teachers who would at some point in time need to be a "coach, adventurous guide, and/or a road map." In fact, PSTs felt so strongly about that metaphor, they all selected it within their top five choices.

Constructivists versus Traditionalist: Science Teaching

For the second half of the exercise PSTs were again instructed to rank a series of 10 randomly assorted metaphors from 1-10 focused on what they thought science teaching in an elementary school would be similar to. Table 4.7 shows the code for each metaphor (T1-5 = traditional view choices, C1-5 = Constructivist view choices), the rankings given to each choice by the participants, and the scoring (as in last exercise 3 of 5) that determined which theoretical framework PSTs had identified with.

Table 4.7
Metaphors and Identification for Role/Image of Science Teaching

Student ID Metaphors	Nova Rank	Everly Rank	Willow Rank	Aurora Rank	Luna Rank	Hazel Rank	Quinn Rank	Amelia Rank
T1: growing a tree	**2**	**1**	**5**	**2**	**1**	**4**	**3**	9
T2: lighting a light bulb	**4**	6	8	**3**	**2**	**3**	**1**	**3**
T3: creating a stained-glass window	**5**	8	**4**	9	9	7	9	10
T4: applying a blueprint	7	**3**	7	6	10	9	**4**	6
T5: spinning and making something from clay, building a pyramid, a caterpillar transforming into a butterfly	6	**2**	**3**	7	**3**	**2**	7	**2**
C1: deep sea diving; leading students on a treasure hunt	**3**	**5**	**2**	**5**	7	8	10	**1**
C2: seed growing; snowboarding; looking through rose-colored glass	10	9	9	10	**5**	10	8	8
C3: a bridge	8	**4**	10	**1**	6	**5**	**5**	7
C4: farming; seed growing	**1**	10	**1**	**4**	**4**	**1**	**2**	**5**
C5: a flock of geese; climbing a mountain	9	7	6	8	8	6	6	**4**
Number of Traditionalists	3/5	3/5	3/5	2/5	3/5	3/5	3/5	2/5
Number of Constructivists	2/5*	2/5	2/5*	3/5	2/5	2/5*	2/5	3/5
Final Determination	**T***	**T**	**T***	**C**	**T**	**T***	**T**	**C**

Note. Answer choices provided to PSTs were randomly ordered; they were sorted by theme for this table only. * = Choice ranked number 1 not in final determined view

While the majority of PSTs connected to the paradigm of constructivism as a teacher, the opposite was true when exploring the concept of teaching. Once again, six of the eight identified with one view—but now as traditionalist—while the other two identified with the constructivist view. It is noteworthy that these two identified with constructivist views for part one as well, and that the two PSTs who identified as traditionalists in part one also identified as traditionalists in this activity. Thus, one half of the PSTs did not shift from one paradigm to another between exercises, while the other half did just that.

There were three PSTs who had the same first choice in metaphors, farming and seed growing (C4), which was a constructivist option. All three ultimately had scores identifying them as traditionalist. Two of those three were PSTs who did not change paradigm identification overall from exercise one, and identified as traditionalist, nonetheless they selected the opposing constructivist option as their top choice. Two other PSTs had the same choice for number one, growing a tree (T1), while the remaining three had choices not replicated by other PSTs. In fact, C4 (farming; seed growing) was chosen as a top five selection by seven of the eight PST's and the same is true for T1. Both C4 and T1 were chosen by all but two PSTs as one of their top five metaphors.

While these top two choices were not categorized in the same paradigm, a commonality did emerge related to both choices' similarities. Each participant remarked at least once about the need for "watering", which was not a term provided in the actual metaphor itself. Additional commonalities in responses included portraying the seed as a "starting point" with a goal of "growth". The three PSTs who selected C4 but who's ultimate score identified them as a traditionalist, all wrote similar narratives and the following description provided by Willow is a good summation of their thoughts:

> Science teaching in elementary schools is similar to farming and growing seeds because like farmers (it involves) planting the seed, watering their crop, and then harvesting it. Teaching can be similar to farming. Checking for understanding is like watering the seed. If you don't water the seed, it won't grow. Teaching and farming have the same goal: a successful crop.

And finally, Lunas' response, even though she chose T1 as her overall number one and in the final tally identified as a traditionalist, seemed to resonate with the previous constructivist's answers:

> Trees need nurturing and protection to grow—they cannot do it all by themselves. Trees need the sun and water just as students need their teachers and parents. When you grow a tree, you don't want to hinder its growth, so you attempt to give it its best shot. Science class is simply adding the necessary knowledge students need to expand their knowledge.

Of the remaining first choices of metaphors, T2 (chosen by a traditionalist) and C3 and C1 (chosen by constructivists), all provided narratives that converged around a concept of "connecting" with responses that included: "connections", "bridging gaps of knowledge", and "pathways to knowledge". This statement by Aurora encompassed what the other two PSTs also reflected on in their responses:

> I will need to bridge gaps of knowledge and understanding for my students. I will need to guide them to get them to the place I will need to them to be. I cannot expect a child to "arrive" at any type of knowledge and understanding if I am not doing my job at bridging any gaps.

Providing PSTs with metaphors to select from, that then allow for some insight into their views of being a science teacher and their concepts of science teaching has provided some rich data. These two themes of constructivist and traditionalist viewpoints have allowed a glimpse into the way these PSTs think of themselves. None of the participants have yet to take a class specifically in science teaching pedagogy (science methods). Therefore, the choices made about metaphors are potentially linked solely to their own thinking and beliefs about themselves as future teachers, where they nearly all identifies as constructivists. Conversely, their thoughts about being involved with the field of elementary science teaching led them to almost unanimously to identify with the thoughts of traditionalists.

Research Question Six

Research question six, *What are pre-service elementary educators' perceptions regarding the concept of curiosity, wonder and/or imagination as an attribute for the learning and teaching of science?*, was answered using a short response exercise to assess their cognizance of curiosity as a trait related to their own science learning. For this exercise, the researcher used an inductive coding processes to analyze the data from the eight members of the original twelve-member focus group who completed this assignment in its entirety

Out of Sight, Out of Mind

Ranking initially provided a tool to explore PSTs' perceptions of curiosity. Without any prompts, PSTs supplied ten terms that they felt best described themselves as students. The results provided in Table 4.8 emphasize the top five selections made by participants. The researcher was interested in whether or not PSTs would select "curiosity" as a descriptor of their own learning traits. Only one participant provided the word "curious" and only one other student provided "ask questions" (which the researcher deemed an equivalent answer). Reflective of Engels' (2013) work, without the prompt of the word "curiosity" itself, the majority of students did not include it within their list.

Table 4.8
Adjectives Selected by Participants Describing Themselves as Students

Student ID	Adjective No. 1	Adjective No. 2	Adjective No. 3	Adjective No. 4	Adjective No. 5	Adj. 6-10[a]
Nova	Honest	Responsible	Diligent	Courteous	Attentive	Cooperative, Patient, Good listener, Observant, Flexible
Everly	Respectful	On time	Honesty	Accepting	Positive	Generous, Open-minded, Responsible, Polite, Kind
Willow	Punctual	Persistent	Responsible	Reliable	Energetic	Prepared, Studious, Attentive, Ambitious, Adaptive
Aurora	Hard worker	Motivated	Patient	Sympathetic	Loyal	Determined, Passionate, Sincere, Disciplined, Efficient,
Luna	Great support system	Responsible	Willingness to learn	Self-driven	Punctual	Efficient, Creative, Organized, Problem solver, Easy going
Hazel	On time to class	Dedicated	Work on time	Great listener	Ambitious	Notetaker, Cooperative, Responsible, Adaptable, **Curious**
Quinn	Understanding	Happy	Caring	Positive	Creative	Patient, Committed, Tenacious, Resourceful, Busy
Amelia	Enjoys class; learning	Goes beyond requirements	Interested	Engaged	Meticulous	Attentive, Persistent, **Ask questions,** Patient, On time to class

Note. [a]Listed in order of ranking.

Next, participants generated a list of ten adjectives, ranked one through 10, that described attributes they “wished” they had as students (results shown in Table 4.9). As before, the researcher’s interest was in seeing if curiosity would show up as a descriptor in the “wished” for list if it had not shown up in the original list. Paralleling the previous activity, without the term “curiosity” as a prompt, no participant listed curiosity or any other attribute that closely correlated to curiosity as an attribute they would wish for themselves as students.

Table 4.9
Top 5 Attributes PSTs Wished for Themselves as Students

Student ID	Adjective No. 1	Adjective No. 2	Adjective No. 3	Adjective No. 4	Adjective No. 5
Nova	Punctual	Time-management	More confidence less shy	Better communication skills	More involved
Everly	Confident	On time to class	Turning in work on time	Positive	Patient
Willow	Resourceful	Balanced	Assertive	Eloquent	Outspoken
Aurora	Easily adaptable to change	Flexible	Decisive	Assertive	Scheduled
Luna	Communication skills	Relaxed (not stressed as easily)	Confidence	Work better under pressure	More approachable
Hazel	Outspoken	Quick-witted	Prepared	Not afraid to volunteer	Positive attitude towards studying
Quinn	Risk taker	Leader	Forward thinker	Enthusiastic	Energetic
Amelia	Less test anxiety	Reading the textbook	Using technology more	Better understanding of math	Having less frustration

Next, the researcher made a word list using the transcripts from the participants to allow the *NVivo 12* data analysis software program to generate a word cloud to help visually interpret the choices of adjectives; this was done for both lists. The top 14 terms were used to allow the word cloud to more graphically emphasize participant choices. Figure 3 shows both of these word clouds side by side for comparison. On the left is the word cloud depicting how PSTs described themselves as students and on the right are the traits they wished they had as students. There is a distinct contrast between the two type of words PSTs selected for this exercise. The terms they feel they already have could arguably be considered more passive in nature and even described as “studious” choices. Whereas the terms expressing their wished-for traits appear to be more active type terms, ones that could be identified with possibly burgeoning leadership qualities as they get closer to taking on their roles as leaders in a classroom.

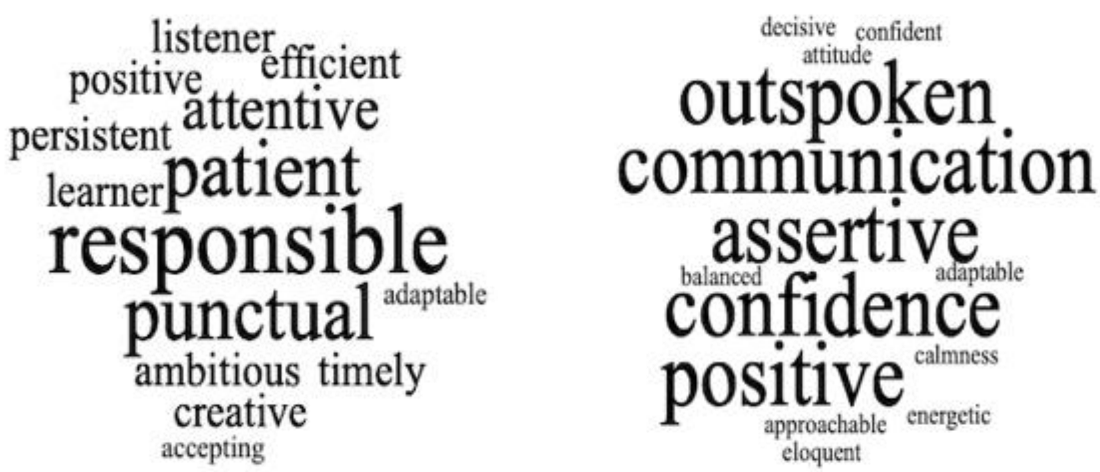

Figure 3. Word cloud of adjectives student traits and wished for traits

Shifting the Focus

As opposed to the first activity, instead of generating and ranking their own list of adjectives, this exercise provided PSTs with a list of 25 adjectives and instructions to select the ten best attributes they would hope their future students would have. The provided list of adjectives contained the word “curious” and a synonym “full of wonder”. Ranking again required PSTs to indicate the “best” attribute as number one and following through to number 10.

Unlike the previous exercise where curiosity/wonder were not brought to the PSTs’ attention, now however, all but one of the PSTs selected one of the two terms as a top ten attribute they hoped their future students would have (Table 4.10). Five of the eight participants chose the term “curious”, with two of those indicating it was the number one or “best” attribute their future students could have. Two others chose the synonym “full of wonder”, both of whom listed it as their number one choice as the “best” attribute their students could have. However, none of the eight selected both terms in their list.

Table 4.10
Ranking of Provided Adjectives of Future Student Attributes

Student ID Adjectives	Nova Rank	Everly Rank	Willow Rank	Aurora Rank	Luna Rank	Hazel Rank	Quinn Rank	Amelia Rank	Total
adaptable				5	4	8			3
adventurous	6	9						4	3
considerate				6	3		5	9	4
courteous			5	10					2
curious	3	4			6				5
diligent	7							6	2
eager	4		9				6	3	4
empathetic					9		9		2
enthusiastic			2	4				7	3
full of wonder				9		5			4
generous		10				9			2
gregarious						10			1
helpful	5	6	10		5	6	2		6
imaginative	8		4 & 6	7	10		3		6
inventive							5		1
motivated		5			2	7	7	2	5
passionate	10	7	7	8	7				5
persistent			8				8	8	3
positive	9	2				2		10	4
practical						4			1
resourceful				2	8				2
responsible			3					5	6
self-motivated		3		3					2
well-behaved	2	8				3	10		4
witty									0

Selections by five of the eight PSTs included the terms, “imaginative” and “inventive”; one of whom chose both terms, while the other four only chose the term imaginative. It is worth noting that these two terms on the list, while not literally synonyms of curiosity, are often associated with it (Hadzigeorgious, 2016). They were purposively placed on the list of attributes as options, like curiosity and wonder, that are largely considered beneficial, if not crucial attributes of students, especially science students (Basile & Johnson, 2010). Collectively, four participants chose both curious/full of wonder and imaginative/inventive within their list of best ten attributes for their future students.

Transcriptions of this exercise submitted from the eight focus group PSTs included replicating the terms to match the number of selections by the participants (i.e. curious was typed five times as it was selected five times). The data analysis software *NVivo 12* used those terms to generate a word cloud showing the relationship between term choices (Figure 4). Narrowing the focus to the top 14 terms allowed the word cloud to more graphically emphasize participant choices and to adhere to the same structural pattern as the two previous word clouds. The choices made by PSTs for their future students appear to be full of energy, and perhaps could qualify as being less “studious” than those chosen about themselves. The term “obedient” was used as a replacement for the response “well-behaved” as the software does not recognize hyphenated words. It is interesting to note that obedient showed up amidst all these active verb terms.

Figure 4. Word cloud of ranked adjectives of future student attributes

Summary

The results provided in this chapter came from an investigation into the impact science courses options may have on pre-service elementary teachers' (PSTs) views about themselves as both learners of and future teachers of science. Additionally, the relationship between the curiosity levels and the attitudes and beliefs of pre-service elementary educators with regards to the nature of themselves as teachers and the teaching of science was investigated.

The researcher made use of both quantitative and qualitative data analysis for this embedded experimental mixed method design. Data collection included surveys using a large group, followed by face-to-face interviews and post meeting short answer exercises with a small focus group. Analysis of the quantitative data included descriptive statistics processes and Pearson product-moment correlations. Analysis of the qualitative data utilized inductive coding processes and thematic study.

CHAPTER V:

SUMMARY, IMPLICATIONS AND RECOMMENDATIONS

The purpose of this study was to determine if pre-service elementary educators' views about science, both as learners and as future teachers, are impacted by the choice of science course they take in their degree programs. Additionally, the relationship among curiosity levels, type of science course chosen, and number of science courses completed, and the views PSTs have about their own learning of science and as a future teacher of science were investigated. A summary of the findings for each research questions follows.

Views of Science as Learners and Future Teachers and Science Courses

Future science teachers have to at some point become science teachers. PSTs must at some point begin the segue from a learner of science with novice thinking skills, to become the content professional at their designated future teaching grade level. This requires obtaining the requisite amount of science content knowledge to feel confidently able to pass that knowledge on to their students. That type of confidence is determined by whether or not PSTs have the appropriate level of efficacy. Efficacy in the science content, the science teaching strategies and in one's self are critical components (Bandura, 1977) to predicting the amount of effort, time and quality of experience elementary educators will make towards addressing science in their classrooms. Bandura emphasized that decisions that affect whether or not tasks are attempted, and equally important, whether persistence to that task continues when it proves to be difficult, are all predicated by the role of self-efficacy (1977, 1982).

The data gathered here address whether PSTs are developing the mindset to shift their thinking from learners of science to teachers of science. The reasoning provided by

Halloun for developing the VASS instrument is also an explanation of how and why it was chosen for this study. Halloun (1997) explained:

> Educational researchers have observed that students at all levels are encumbered with folk views about the nature of science and science education that are incompatible with the views of scientists and educators. Introductory science courses do little to change student folk views and, more often than not, the changes are negative. Furthermore, students' achievement in science courses may be negatively affected by their folk views. (p. 2)

This is important because it establishes what the scores on the survey actually indicate. The scores collected by the survey are inverse to the way scores are normally reported. The developers established their scoring rubric such that a low score indicates the participant is moving towards a more expert score, where the developer has indicated teachers of science should be; while a high score indicates participants are located at the folk end, where science students are typically found (Halloun & Hestenes, 1998). For both teacher educators and PSTs, the desired result would be to see these future teachers making a strong transition from the folk end of the results to the expert end of the results after the completion of each of their science courses. Therefore, the fact that scores on this study show PSTs are only at a midpoint score and have not achieved more “expert” scores has value.

Findings in the present study indicated that there were no significant differences among the preservice teachers’ scores regarding their views about science either by type of science course taken or by the number of science courses they took suggesting that neither have an effect on the views of PSTs about themselves as both learners of and future teachers of science. However, while the results suggest that there is no credible evidence that course type and number of courses had an impact on PSTs’ views, according to Lane (2019) insignificant results do not offer proof that no impact has occurred. Thus, the premise that the type of science course chosen, and the number of courses taken, may be impacting PSTs science efficacy is an important construct to continue to explore.

A place for further exploration that might well be of special significance is the comparison of scores of PSTs who had only completed two science courses (of either type) with the scores of PSTs who had completed all four of the required science courses (of either type). There is less than a .05-point difference. This could be evidence supporting the possibility that science courses that are not designed for future teachers are not adequately preparing PSTs for their role as a science teacher who is a content expert. Descriptions provided in course catalogs for most traditional introductory science courses in colleges and universities indicate they are for future science majors. The literature indicates this often means that faculty teaching those courses are: (a) often not aware of the role they could play in assisting prospective teachers to "learn and understand the content and concepts that are critical to effective teaching"; and (b) have not been provided with "the kind of professional development in teaching that would enable them to model effectively the kinds of pedagogy that is needed for success in grades K-12 classrooms" (National Research Council, 2001, p. 32). Moreover, related research indicates that ineffective science courses may be a harbinger of future negative implications for PSTs. These studies propose that standard lecture format may in fact cause preservice teachers to have negative attitudes and beliefs about science (Appleton, 1995; Mulholland & Wallace, 2001), which in turn means they are inadequately prepared to teach science (Appleton & Kindt, 2002), and could ultimately result in a reduction of the time these teachers in training will spend on science instruction in their future classrooms (Rice & Roychoudhury, 2003).

Properly prepared PSTs require teacher educators who will pay heed to recommendations of a National Research Council (2001) report that advocates "improvements in teacher education need to be aligned with recommendations about what students should know and be able to do at various grade levels, which means that teachers need to become expert at what is called content-oriented pedagogy" (p. ix).Two results from this study, the midpoint scores and the nearly identical scores of two and four science course completers, are valid data to advocate for change in teacher education science course options.

Curiosity Levels of Science Learners and Future Science Teachers

Researchers who explore curiosity scores have determined that curiosity is fundamental to motivation, as well as learning and security (Kashdan et al., 2009). The scores of PSTs on the SC survey did not provide any significant evidence that either science course type or number of science courses completed influenced their curiosity levels. However, what the scores did indicate was that PSTs have above average curiosity, placing them in the high transitional range group as described in Chapter III. In fact, only 10 participants (see Table 4.4) failed to score within ten points of being ranked in the highest scoring group. Gilbert (2013) found that PSTs who were encouraged to embrace curiosity in their own learning efforts showed increases in the following: their desire to learn, interest in science content, and positive views about science content knowledge. However, traditional science courses are often not effective and can be linked to low science self-efficacy of PSTs (Menon & Sadler, 2016). Change is not necessarily easy for college instructors who are trying to meet instructional objectives within the very defined time frame of 96 contact hours (ACGM, 2019). Indeed, Stokoe (2012a) pointed out the struggle that educators in general face, saying "our challenge is that curiosity and curriculum are antithetical concepts with the curriculum often acting to limit student empowerment rather than enable for the most part. As educators we need to embrace curiosity and discovery in our thinking and planning" (Stokoe, 2012b, p. 63).

Advice collected from several renowned researchers in the field of curiosity could apply to both PSTs as goals for themselves as future educators and to current teacher educators in advocating for science course change. Ostroff (2016) gathered and presented the following compilation:

> Teachers [are]…critical in helping students transform their curiosity into inquiry, by facilitating, focusing, challenging, and encouraging students in active engagement (Zion & Slezak, 2005)…supporting curious children is best achieved when teachers themselves are curious, when they are excited, involved, self-directed, and trying new things (Deci & Ryan, 1985; Engel, 2011; Ostroff, 2012). In that way, the curiosity classroom creates a culture of learning that emerges at the intersection of the students and the teacher. (p. 6)

Thus, the findings in this study that indicate PSTs have above average curiosity scores can provide value to conversations surrounding a way to make science courses more effective in helping build science content efficacy.

Connections Between Science Views and Curiosity

The results of the Pearson product-moment correlation computed for this study indicated that a positive correlation exists between scores from the two surveys used to address the previous two research questions. The correlation indicates that as the SC scores (curiosity levels) increased, the level of scores at the folk level (science student type views versus science instructor type views) in the VASS increased as well. This could be interpreted as an indication that PSTs fairly high curiosity levels are incumbent upon a fairly static student (folk) view of science. This could be extremely advantageous information to present during conversations regarding the development of specialized science courses for educators. Science content courses should be designed to move students from a folk view of science as a learner to a more expert view as future teachers. However, if PST's curiosity levels were to decrease as their expert level increased it could be counter-productive to their future jobs as educators. Therefore, more information should be gathered to address this interesting correlation.

After all, Grossnickle (2016) in his review of articles from 2003-2013 exploring the use of curiosity in educational settings, suggested that finding out what students are curious about could lead to discovery of other levels of curiosities. He further went on to reference the seminal work of Dewey who felt curiosity was critical to stimulating fruitful learning and could be used in education as a motivator (Grossnickle, 2016). So, it seems incumbent for teacher educators to better understand the factors needed to use curiosity, wonder and imagination to create learning environments, lessons, and texts conducive to increasing PSTs' expert science views. However, the key will be to find a way to do so that does not adversely impact their current curiosity levels. Data from this study provides information for future research to explore this interesting relationship between curiosity and growth mindsets of PSTs.

Learning Science and Course Type

Face-to-face interviews provided data offering insight into PSTs' feelings about the process of learning science and/or their experiences with taking science courses. Of the twelve PSTs who participated in the focus group, only two were enthusiastic with regards to their experiences as science students. Negative attitudes toward science have been shown by numerous researchers as being prevalent among current in-service teachers, who indicated they are more prepared, and more inclined, to teach most core subjects but feel they lack the qualifications, the proper preparation, and a strong enough comfort level to consistently want to teach science (Czerniak & Chiarelott, 1990; Epstein

& Miller, 2011; Marx & Harris, 2006; Nadelson et al., 2013; Ramey-Gassert, Shroyer, & Staver, 1996; Zeldin, Britner, & Pajares, 2008). Moreover, poor science efficacy has been shown to negatively influence teachers' thoughts, attitudes, choice of activities, effort put forth, determination to overcome obstacles, and a willingness to embrace innovations or instructional strategies, which STEM based activities demand (Smith, 1996; Tschannen-Moran & Hoy, 2001; Ware & Kitsantas, 2007). These published reports show how reduced science efficacy presents itself in current teachers' classrooms and indicates that they have not been properly prepared to meet the challenge of teaching STEM effectively. The findings from this portion of this study support and further indicate that the root cause for poor science instruction in elementary schools is during the science learning phase of PSTs' degree programs. It appears that during a time when science efficacy should be being positively influenced and confidently established, that PSTs are having undesirable experiences with the majority of their science classes and are developing negative attitudes towards science destined to follow them into their future classrooms.

The concluding half of the focus group used questions to shift the conversation to a discussion about how PSTs chose their science courses. While negative experiences expressed in the first half of the discussion provided some insight into how PSTs made subsequent science course selections, additional factors were revealed as the conversation proceeded. The discussion became less and less about the material or topic of the course, and more about the role "others" had in their decisions about what courses to take. Heavy weight was given to outside influences including counselors, who were blamed by PSTs if the experience was negative but were also praised if the experience was positive. Additional outside influences included friends, peers, and even online apps that provide rating systems focused more on professors than course content. Eventually students conceded that traditional non-majors' science courses were significantly preferred to traditional science majors' courses. However, the discussion concluded with PSTs expressing a strong desire to have the option to choose a science content course designed specifically for future elementary educators like themselves.

A review of several course catalogs of two and four-year colleges that offer teacher education programs in Texas indicate that PSTs are relegated to enrolling in science courses designated as courses for future science majors. The literature indicates that the majority of faculty teaching those types of courses are often not aware of the role they could play in assisting prospective teachers, and typically lack the professional development to effectively model pedagogy needed for success in K-12 classrooms (National Research Council, 2001). Thus, this study appears to help support an important imperative—PSTs need to be provided with courses designed to help them build their science content efficacy.

Constructivist and Traditionalist Views in Transition

Results analyzed when collecting these data were from the eight members of the original twelve-member focus group that completed this assignment in its entirety. These data reflected which theoretical framework, traditionalist or constructivist, PSTs identified with. Six of the eight PSTs ranked metaphors that indicate they have constructivist views of themselves as science teachers. Five of the six chose the exact same metaphor for their first choice, with an emphasis on the idea that teachers were to act as "guides". It is worth noting that in fact all eight PSTs chose that same metaphor within their top five choices, the only metaphor to garner that designation. In their descriptions, PSTs indicated that guides were "giving, encouraging, supporting". The remaining two PSTs identified as traditionalists even though one of the two selected the same first choice that the five constructivist view teachers selected. Their metaphors were about “coaches” and “dictionaries” and their narratives focused on imparting training and knowledge to their students.

The fact that all eight PSTs selected one and only one metaphor collectively is an interesting finding. The researchers who developed the metaphors (Seung et al., 2011) indicate that this choice is indicative of PSTs who believe that collaborative interactions among peers, i.e. using tactile explorations, allows for misconceptions to be addressed, modified or even removed, resulting in knowledge that is constructed through social interaction (Vygotsky, 1978) which this study uses as one of its theoretical frameworks. This suggests that these PSTs see the value in interactions between students as well as with the teacher, which two studies indicated are excellent ways for PSTs to learn science for themselves. Both Michaels, O’Connor, and Resnick (2008) and Nowicki et al. (2012), while noting several problems with lecture-based science courses in being to properly prepare future elementary educators, singled out the lack of consistent opportunity to participate in science that used “hands-on” learning. Lacking those experiences, these types of courses fail to provide pre-service elementary educators a deep understanding of science concepts that is needed to later be able to teach inquiry-based science (Michaels et al., 2008; Nowicki et al., 2012).

In the second half of the exercise, PSTs were asked to choose metaphors they felt described their perceived notion of what they thought science teaching in an elementary school would be similar to. Once again, six of the eight identified with one view, but surprisingly it was the traditionalist viewpoint. Intriguingly, the two who identified now as constructivist, had also done so for part one. And the two traditionalists from part one, remained traditionalist for part two, which means one half of the PSTs shifted views while the other half did not. The shifts, or lack thereof, is reflective of work by Kutz (1991) who postulated that classroom teachers were, in fact, neither traditionalists nor constructivists in that they often tend to teach as they were taught and in ways that they anecdotally see as “work”. Consequently, these results could be an indication that PSTs may be at a crossroads of sorting out the ways they have learned science in traditional lecture style classes and how they are being introduced to different methodologies in the pedagogical offerings of their education courses. This would also be in keeping with similar findings provided by Seung et al. (2011), who found that their participants were reticent to completely break with their traditional views even while diligently attempting to accept constructivist ones.

Furthermore, with these findings PSTs have indicated an unconscious awareness of what may be needed to help themselves as students. By “unconscious” the researcher is referring to the fact that in this study PST’s were provided with information about the use of metaphors but were not provided with any instructions concerning the two paradigms they were being asked to identify with. Consequently, PSTs were not making distinctions between ideologies, just between metaphorical descriptions they could relate to as having attributes they found applicable and/or desirable. Because PSTs were allowed to select metaphors via an unconscious or unfettered process, their identification with constructivists could be a powerful tool for designing science content courses that would actively engage them. Getting PSTs involved in the process of their own learning is paramount to obtaining the science content they will need to be effective science teachers. As the research indicates, adopting a constructivist ideology gets students involved in their own learning, using experiences to construct knowledge and then connecting that learning experience to prior experiences, creating a network of correlated ideas (Spivey, 1997). These networks of correlated ideas leads to increased learning benefits and students who can use a variety of forms to express their knowledge, thus indicating that the knowledge has occurred at a deeper level (Brand & Triplett, 2012).

The fact that a majority of the PSTs identified that being a teacher requires constructivist methodologies may well indicate they have true predispositions toward being a teacher, already choosing metaphors that imply their attention is focused on students' learning and the learning environment. Conversely, the fact that PSTs perceived that science teaching in an elementary school would be similar to a traditionalist ideology which see teachers as sources and/or providers of knowledge and information may be an artifact of the instruction they themselves are receiving. This instructional artifact seems to reinforce the findings from research question number one that addressed the difference in the views among pre-service elementary teachers about themselves as both learners of and future teachers of science based on the type and/or number of science courses they have taken. In both responses, PSTs appear to identify as students who are subject to what is being provided to them and have yet to adopt a greater desire to control their own learning so that they can become the "experts" they need to be in their own future classrooms. Accordingly, PSTs' notions that teachers are purveyors of knowledge and students are passive recipients is indicative of the studies by Michaels, O'Connor, and Resnick (2008) and Nowicki et al. (2012) who noted lecture-based science courses offer little realistic inquiry or reflection on scientific knowledge; and minimal "hands-on" learning thus reinforcing the concept that learning is a submissive activity. Furthermore, those type of courses do not provide sufficient content knowledge efficacy to teach inquiry-based science (Michaels et al., 2008; Nowicki et al., 2012), which in turn might consequentially cause PSTs to repeat the same methodology in their own future classrooms.

The Attributes of Curiosity

Gilbert and Byers (2017) conducted a study suggesting preparation of pre-service elementary teachers in the sciences should include the element of wonder as part of their science methods preparation program and in doing so, might very well positively address a multitude of issues. But data collected for this part of the study indicated that for the PSTs when curiosity was out of sight, it definitely did not come to mind, which has major implications for the PSTs as both learners and future teachers of science. As learners, PSTs did not readily identify the need for curiosity. However, their scores on the SC survey indicated they had above average curiosity levels. And yet, being curious was something they thought their future students should have. This could be because wonder and curiosity are not being used as instructional tools within PSTs science content courses. Hadzigeorgiou (2016) indicated that he believes change is required, and that a good first step in "retooling" science education should be to embed wonder into science curricula, which would help science teachers (like PSTs) and science educators who teach teachers alike to encourage their own levels of wonder by using the wonder afforded in the sciences.

As the research indicates, children are innately curious—confirmed by their attraction to unknown objects and new experiences (Callanan & Oakes, 1992; Tizard & Hughes, 1984); they ask questions, recognize patterns, and develop their own theories(Chouinard, 2007; Driver, 1983), and even use a natural form of scientific methodology to theorize and/or to make sense of things (Gopnik et al., 2000; Schulz & Bonawitz, 2007). Engel (2013) noted an important attribute that young children as learners have—when they want to learn, they are more likely to do so, and are more likely to remember what they learned. If PSTs could receive science instruction in a way that encouraged them to want to learn, they would be obtaining science knowledge and being modeled to in ways that could encourage learning in their future students. After all, Basile and Johnson (2010) noted that those who are educators of teachers want teachers who are inquisitive and curious, as they believe those qualities make teachers more thoughtful learners, in turn, making them better teachers who can truly engage their future students.

Implications

Science has a well-documented history as being a driving force for educational missions and curriculum reform in the United States as well as worldwide. Educators have been asked to provide a well-trained workforce beginning with rebuilding efforts after the World Wars and continuing with the race to space in the 1950s and '60s (Marx & Harris, 2006). In the past ten years, major industries requested science programs that would help the fill nearly 2.8 million jobs that came into existence by the year 2018 (Carnevale et al., 2010). Beginning in the late 1980's and accelerating through to the present, political reactionism to the US's decreasing global superiority demanded that educational reform address and include technology, as well as engineering, and thus STEM arrived and is now embedded in the educational lexicon (Blackley & Howell, 2015).

National, state, and local policies have mandated an emphasis be placed on STEM instruction at all grade levels within our public-school systems (U.S. Department of Education & Office of Postsecondary Education, 2016). Research indicates that science education begin during the early years of schooling (Eshach, 2003; Eshach & Fried, 2005; Ginsburg & Golbeck, 2004; Kallery, 2004; Watters et al., 2001). Thus, while science teachers at all grade levels are impacted by these edicts, quite possibly those being impacted the most are elementary educators.

The results of this study have relevance to a group of extremely important stakeholders in the continuing push to provide STEM education. Pre-service elementary educators are expected to be able to provide early school experiences that develop fundamental processing skills, such as observation, inference and exploration, that not only help solidify basic understandings of natural phenomena, which are key to later science achievement, but also appear to reduce the influence of socio-economic status (SES) between children with high and low SES as they continue on in elementary school (Sackes et al., 2011). Therefore, the results from this study are believed by the researcher to have the following implications for future practices in teacher education programs.

Science Courses Designed for Future Teachers are Needed

Both quantitative and qualitative results suggest that PSTs are not benefiting from the traditional form of science education they are currently receiving. While statistical analysis did not provide concrete significance that problematic issues with science course type exist, survey scores provided important implications. The VASS scores by PSTs who had finished all their science content courses and who should have developed a certain degree of science content knowledge, should have indicated a more pronounced shift towards the expert end, yet they did not. Qualitative interview data collected from PSTs indicated they have negative attitudes about their science courses, conceding that non-majors' courses were preferred to major courses, but a preference would be to have a course that addressed the needs of future teachers. These combined results appear to agree with research that proposed ineffective teaching practices, i.e. standard lecture format (Jarrett, 1999) can cause preservice teachers to have negative attitudes and beliefs about science (Appleton, 1995; Appleton & Kindt, 2002), which leave them inadequately prepared to teach science, and may in fact result in a reduction of the time they spend on science instruction in their future classrooms (Mulholland & Wallace, 2001; Rice & Roychoudhury, 2003)

Rekindling Curiosity Could Help Prepare Future Teachers

Gilbert (2013) found that PSTs who were encouraged to embrace curiosity, showed increases in the following: their desire to learn, interest in science content, and positive views about science content knowledge. Both quantitative and qualitative results in this study point to the possible positive impact infusing curiosity into science instruction could have for PSTs. Scores on the SC indicated all PSTs had high levels of curiosity, yet the qualitative data found PSTs did not readily identify curiosity as an attribute needed for their own learning, but strongly felt it was an attribute desirable in their future students. Maybe the introduction of wonder and curiosity as a teaching tool for PSTs in their science courses is the hook needed to get them to fully engage in their own science learning and will better prepare them to propagate wonder and curiosity within their future students.

Quite possibly the results of this study may indicate the traditional style of instruction PSTs are currently being subjected to are analogous to what Engle and Randall (2009) noted when they observed that teachers can often fail to foster curiosity, or even worse, can squelch it entirely. Data provided by PSTs indicating negative experiences associated with their science courses might be in part due to science instructors who have unwittingly failed to foster, and/or quite possibly even squelched PSTs own inherent curiosity.

The need for STEM teachers means we need PSTs to be engaged learners of science. Hadzigeorgious' (2016) book about the role imagination and curiosity can, and should have, in science education provides numerous examples of the link among science, scientists, and imagination. Hadzigeorgious further adds that literature and the fine arts (which is where a more heavily placed emphasis in PSTs educational programs exists) are not the sole domain of imagination, and that teacher educators should be remined that it is in fact a "truism that imagination is central to science" (2016, p. 3). Modifying teacher education programs to include curiosity and wonder as an indispensable part of how PSTs learn science could help to reinforce or engender a sense of wonder within themselves (Hadzigeorgiou, 2016) and provide a successful approach to help improve their science content knowledge levels ergo enhancing their science teaching efficacy.

Recommendations for Future Research

This study has contributed to the existing body of research relating to preparing future elementary educators as teachers of science by providing information to help address gaps in the current literature. The information generated from this study helps to further address the background, mitigating factors, and impact confronting pre-service elementary educators specifically with regards to their (a) science course choices and selection processes (b) views about the nature of their own learning of and their future teaching of science, and (c) the role of curiosity in science learning and teaching.

A future rendition of this study that would include several four-year schools with similar populations and who offer elementary education degrees would allow for further explore and potentially more meaningful results. A longitudinal study could track PSTs as they progressed thru their four science courses, either tracking scores at the end of each of the four courses, or just look to see if a difference after the fourth course is significant from scores after the first. Many more surveys to access PSTs views on science have been recently developed and as their validities are confirmed, may provide alternate pathways to access PSTs.

Curiosity in adult learners is a rapidly expanding field and is currently being explored by more psychologists than educational researchers. Therefore, the potential for work with broad reaching implications is wide open and extremely intriguing based on the small, but fascinating, results from this study. There are also several new curiosity scales that have been developed that may lend themselves to assessing science curiosity as well. The correlation between the VASS scores indicating PSTs were still in the “folk” range of scores and the SC scores that indicate PSTs have above average curiosity require further research. A longitudinal study that used both the VASS and SC as pre and post-tests connected to the four science courses PSTs are required to take might help guide curriculum programs to help move PSTs to a more expert score, but without reducing their curiosity levels.

Findings from the qualitative portion of this study concerning metaphor choices warrant further study. The reversal from one theoretical viewpoint to its opposing view as PSTs differentiated between their roles as teachers to the role of teaching could be explored on multiple levels. The first level would be to explore a way to gather findings post-science methods course and compare them to the pre-science methods score in this study. Another level would be to conduct a focus group allowing PSTs to provide their perceptions about the word clouds that were generated using their descriptive adjectives. An interesting research question would be to ascertain from PSTs whether those words were indicative of expectations that PSTs have been taught implicitly or explicitly. For example, are the pedagogy classes that focus on the perfunctory nature of classroom management, assessment, and lesson planning that future teachers are destined to face influencing the skills sets students described themselves as having? This could be then followed by further research into why the traits PSTs wished they had appeared to be a following an entirely different thought pattern.

Research Design Limitations

While the *Views About Teaching Science Survey* and the *Children's Science Curiosity Scale* have been documented to be valid and reliable, they are still dependent upon participants' due diligence in attempting to understand the intent of each question, as well as providing the best, most honest responses to the instruments' questions. Participant focus group sessions are subject to the same problem as the surveys. Even if the interviewer is able to establish a certain level of trust with the interviewees, answers may still be provided in part based upon a perception of what a “good” answer should be. Due to the subject matter (views about the learning and teaching of science and science curiosity) participants may have concerns about being inadequate, or conversely, may be defensive about being perceived as being inadequate, to the task of teaching science if they perceive their answers reflect negatively upon their future ability as a teacher of science. The concern about negative implications could have a profound impact on participants’ willingness to explore, in deeply honest ways, answers to both the surveys and focus group interview questions. Finally, the small sample size can potentially limit the generalizability of the findings to the greater population.

Conclusion

The purpose of this study was to determine if pre-service elementary educators’ views about science, both as learners and as future teachers, are impacted by the choice of science courses they take in their degree program. Additionally, the relationship among curiosity levels, course type choice and number of courses completed, and the views PSTs have about their own learning of science and as a future teacher of science were investigated, all of which are critical in helping prepare effective science teachers for the next generation of science learners.

Both quantitative and qualitative data analysis was used for this embedded experimental mixed method design and uncovered several interesting findings. Two implications for future practices in teacher education programs were found: the need for science courses designed specifically for future elementary educators and the positive impact of using curiosity to help PSTs with their own science learning and for their performance as future teachers of science. Additionally, all six research questions produced findings that would provide the opportunity for additional enquiries that could, and should, be further explored as well as stimulating numerous ancillary pathways that still need to be investigated.

STEM education reforms in the US have and will continue to impact the preparation of future elementary educators. The gaps need to be closed in the educational background of PSTs to allow them to confidently be the teachers their future students need them to be. The science content courses that should be preparing PSTs in remediating their weaknesses and reinforcing their strengths have not yet emerged. Novel pathways that include curiosity, wonder and imagination could be used as a guide in developing dynamic science courses to build science efficacy in our future PSTs.

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APPENDIX A:

VASS SURVEY TABLE

Table VI

Profiling scheme associated with VASS Form P12 (Halloun, 1997)

Profile		Number of Items
Type	Code	out of 30
Expert	EP	19 items or more with *expert views*
High Transitional	HTP	15 to 18 items with *expert views*
Low Transitional	LTP	11 to 14 items with *expert views* and an equal or smaller number of items with *folk views*
Folk	FP	11 to 14 items with *expert views* but a larger number of items with *folk views,* or 10 items or less with *expert views*

APPENDIX B:

CURIOSITY EXERCISE INSTRUCTIONS

Thoughts on Curiosity
This activity based on Hackmann & Engel, 2002

> "Public school teachers from a school district in suburban Massachusetts were given a list of twenty-five qualities and asked them to circle the five they most wanted to nurture in their students over 75 percent circled "curiosity". Yet, when we asked teachers to come up with the five qualities they most wanted to encourage in their students, few said "curiosity."

Part 1
Please take about 15- 30 minutes to do the following: In this activity you will need to think of and list 10 adjectives or short phrases that describe your *best* attributes as a student (for example, "*on time to class*" or "courteous"). Write them on a piece of paper—you do not need to type this!

It might work best to do the writing as opposed to typing! THIS is about YOU as a student—what do you do best as student!

When you are finished, please place them in order from what you consider to be the "best" of the 10 as number 1 and then down to number 10. Please include the original list and then show your order list second—I would like to see your thought process! OR—you can simply put the numbers 1-10 beside the words and just write one list! Let's keep this simple!

THEN: To finish this activity please make another list of 5 attributes you "wish" you had in order 1-5, with 1 being the most desired.

Part 2: I hope that my future students are ______.
Please take about 15- 30 minutes to do the following: In this activity you will select 10 adjectives from the 25 provided in the list below that you think would describe *the best attributes* of a good science student in your future class.

Please place them order from what you consider to be the "best" of the 10 as number 1 and then down to number 10.

You may print this and then circle them and number them 1-10 OR you can write/type the list 1 to 10 in the reply of the email.

Here are your choices!

adaptable	responsible	practical	persistent
courteous	adventurous	self- motivated	resourceful
eager	curious	considerate	well-behaved
full of wonder	empathetic	diligent	witty
helpful	generous	enthusiastic	
motivated	imaginative	gregarious	
positive	passionate	inventive	

APPENDIX C:

PERMISSIONS FROM AUTHORS

Eulsun Seung
Center for Science Education, Department of Chemistry and Physics, College of Arts and Sciences, Indiana State University, Terre Haute, IN 47809-9989, USA
elsun.seung@indstate.edu

Soonhye Park
Department of Teaching and Learning, College of Education, The University of Iowa, Iowa, IA 52242, USA
e-mail: soonhye-park@uiowa.edu
spark26@ncsu.edu

Ratna Narayan
Department of Curriculum and Instruction, College of Education, Texas Tech University Lubbock, Lubbock, TX 79409, USA
Ratna.narayan@unt.edu

Good morning Professors!

My name is Margene Lenamon. I am a science instructor (Introductory Life Sciences) at Lee College, in Baytown, Texas, but more importantly I am a doctoral candidate with the University of Houston, Clear Lake, Texas—and it is as such that I am contacting you. I realize you are all probably quite busy—but I respectively ask that you spare me a few minutes to read the following.

My program through the College of Education, Curriculum and Instruction with a STEM emphasis requires that I do a mixed methods dissertation. I am using surveys and science course background information for my quantitative portion. For the qualitative portion I would like to use part of your methodology and findings from your 2011 paper titled "Exploring Elementary Pre-service Teachers' Beliefs About Science Teaching and Learning as Revealed in Their Metaphor Writing". This paper really resonated with me as a way to get thoughtful responses, and thus deeper insights into these future teachers' thoughts.

My dissertation is a study of the impact (negative/positive) science course choice and selection have on future elementary educators. I am looking at how they learn and then how that correlates to how they think they will teach. By science course choice I am looking at three categories: traditional science courses for science majors, traditional science courses for non-science majors, and courses that are intended for future educators. My hypothesis is that very few students will have even had a choice for a course intended for them as future elementary teachers—and that most will have had to make a choice between science courses classified for majors or non-majors.

As a science teacher I have witnessed the struggle that these future elementary teachers have with both types of introductory science courses. Anecdotally I also know that the majority of future elementary teachers prefer to teach ELA or Social Studies, not science—they fear science, often even loath it due to that fear—and this does not bode well for the instruction their students will get. The proverbial STEM pipeline gets closed off at the point where it really needs to begin. I want to help begin a conversation for the type of science courses that need to be developed to address these issues.

Overview for permission request
I have struggled to get participants—and have a very small N. None of my participants have had a Science Methods course. A majority of participants have completed most of their science course work with a minority still in need of at least one more course. For my qualitative work I managed to get about 75 (to date) and for the qualitative, which is where your work fits in, I have a small focus group of 12. My proposal is to change the format you used so that I can use what you found to help support my findings. Changes include:

- I will only be using the traditional and constructivist themes as they had metaphor examples provided.
- Instead of developing the metaphors themselves, I am asking my participants to rank the examples that were included from your paper in the order they think most accurately reflects their own sentiments (attached is the assignment that they will be given).
    - Participant's selections will then be counted and scored as described in the paper (70% places them in a category) to see if the majority of their rankings placed them into one of the two themes your work established.
    - A new "neutral" category will be established for those participants who may select options that would be at level of about 50/50 traditional/constructivist.
- Then participants will have a free writing section to expound upon why they selected what they did which will be analyzed using NVivo qualitative analysis software to look for themes.

I would gladly share my results as well as my dissertation with you upon completion. I have received a sabbatical for this fall and my goal is to finish and graduate in December. Your help with this would be much appreciated and of course well sited in my paper.

Thank you for the time it took to read all this! If you have any questions, concerns, comments or advice please feel free to email me at the two emails I have provided.

Appreciatively indebted,
Margene Lenamon

APPENDIX D:

METAPHOR INSTRUCTIONS

Before you get started, below is an excellent description of what metaphors are so that you can review. Please consider reading it before you start. I chose the sight specifically because it would be an excellent resource for you and your students in the future!
Here is the URL https://examples.yourdictionary.com/metaphor-examples-for-kids.html

A metaphor is a figure of speech that is used to make a comparison between two things that aren't alike but do have something in common. Unlike a *simile*, where two things are compared directly using like or as, a metaphor's comparison is more indirect, usually made by stating something is something else. A metaphor is very expressive; it is not meant to be taken literally. You may have to work a little to find the meaning in a metaphor.

For example, a river and tears aren't very alike. One is a body of water in nature, while the other can be produced by our eyes. They do have one thing in common, though: both are a type of water that flows. A metaphor uses this similarity to help the writer make a point:

Her tears were a river flowing down her cheeks.

As a river is so much larger than a few tears, the metaphor is a creative way of saying that the person is crying a lot. There are so many tears that they remind the writer of a river.

Metaphors help writers and poets make a point in a more interesting way. They also help the reader see something from a new perspective. By describing tears as a river, for example, the writer found a creative way to describe how great the girl's sadness was and helped the reader see a similarity between tears and a river that they might not have noticed before. This makes reading more fun and interesting.

The Difference Between Similes and Metaphors
Similes are another way to compare two different things, but a simile does so more directly, using the words like or as. For example:

Her tears flowed like a river down her cheeks.

In this case, the simile tells the reader that the tears are similar to a river, but not the same. A metaphor, on the other hand, says that something is something else; that is, the girl's tears are equal to a river. A metaphor is not exactly true. It's meant to be understood as a figure of speech, not a factual statement.

Implied Metaphors
While simple metaphors make a direct comparison between two things, saying that one thing is the other, not all metaphors are as easy to understand. Implied metaphors don't directly state one of the objects being compared. Instead, they describe one item with the words you would typically use to describe another. For example:

The girl stalked her brother before finally pouncing on her prey.

In this case, the girl is being described as something else, but what is it? The word stalked and the phrase pouncing on her prey give a clue. These words are often used to describe predatory animals, such as a tiger or lion. By describing the girl this way, the writer is making an implied comparison that the girl is like a big cat, without actually coming out and saying it.

Implied metaphors can be difficult to figure out when you're first learning about them since they have to trust their imaginations to understand what the comparison is about. This is a skill that can be learned over time, but it's best for most kids to start with direct metaphors for practice.

Part 1: Rank the metaphors!

Below you will find two sets of metaphors; the first refer to what you see as YOUR role as a science *teacher* and the second refers to your perceptions on science *teaching*.

Ranking system to use:
1 = what *best* matches your beliefs through **10** = which *least* matches your beliefs

For **a science teacher**

Complete this statement with the metaphorical choices below: **"I think that my role/image as a science teacher at the elementary school is similar to a...."**

Rank you would give each metaphor Using the numbers 1 through 10	Metaphors • When more than one descriptor is provided it indicates that they are similar • Some descriptors show up in more than one selection—if that one descriptor fits you then pick the statement with other descriptors you can also agree with • Not each descriptor may be your first choice—but if one statement best describes you go with that row as you rank them
	chameleon; gardener
	coach; adventurous guide; road map
	cook; road sign; coach; rafting guide
	dictionary; the ocean; pitcher filled with water
	gardener; cook; bumblebee
	house builder; referee; umpire; judge
	king lion; mother duck
	movie director
	potter
	tour guide; detective
My name is:	

For **science teaching**

Ranking system to use:
1 = what *best* matches your beliefs through **10** = which *least* matches your beliefs

Complete this statement with the metaphorical choices below: **"I think that science teaching in elementary schools is similar to...."**

Rank you would give each metaphor Using the numbers 1 through 10	Metaphors • When more than one descriptor is provided it indicates that they are similar • Some descriptors show up in more than one selection—if that one descriptor fits you then pick the statement with other descriptors you can also agree with • Not each descriptor may be your first choice—but if one statement best describes you go with that row as you rank them
	a bridge
	applying a blueprint
	being part of a flock of geese; climbing a mountain
	creating a stained glass window
	deep sea diving; leading students on a treasure hunt
	farming; growing seed
	growing a tree
	lighting a light bulb
	snowboarding; looking through rose-colored glass; seed growing
	Spinning/making something from clay, building a pyramid, a caterpillar transforming into a butterfly
My name is:	

Optional: If none of the metaphors listed above provided really best described you as a future science teacher and/or what you see as the role of science teaching—please feel free to provide your own and then do **Part 2** using YOUR metaphor.

Part 2: *Final assignment*

Part A: Science Teacher
"I think that my role/image as a science teacher at the elementary school is similar to a...."

1. **Decision process**
   a. Please describe why or what decisions influenced how you chose to rank these choices
   b. Specifically why and how you selected your **first** choice.

Start typing your answer here!

2. **Explanation**
   a. Take the metaphor you selected as **number 1**
   b. Use as much detail as possible using no less than1/2 a page and no more than 2 pages (explain each word, its' meaning' its' application—use the introductory material I provided to help you –more is better!)
   c. Explain how that metaphor best describes what you see as YOUR role as a future science teacher

Start typing your answer here!

Part B: Science Teaching
"I think that science teaching in elementary schools is similar to...."

1. **Decision process**
   a. Please describe why or what decisions influenced how you chose to rank these choices
   b. Specifically why and how you selected your **first** choice.

Start typing your answer here!

2. **Explanation**
   a. Take the metaphor you selected as **number 1**
   b. Use as much detail as possible using no less than1/2 a page and no more than 2 pages (explain each word, its' meaning' its' application—use the introductory material I provided to help you –more is better!)
   c. Explain how that metaphor best describes what you see as YOUR role as a future science teacher

Start typing your answer here!

APPENDIX E:

VASS SURVEY COVER PAGE

University of
Houston Clear Lake

Future Elementary Educators Views, Curiosity Levels and Experiences with Regards to Learning Science

Greetings Future Elementary Educator!

Thank you for making the time to take this survey. You are a vital asset in the ongoing efforts to address learning processes so that educational programs can adequately prepare confident, effective, and enthusiastic teachers. In return for your valuable time, completing this survey allows you to become eligible to win a $50 Amazon gift certificate.

The purpose of my study is to see if views about learning and teaching science are impacted by the choice of science courses that are required in the degree program. I am also investigating potential relationships between views about science and curiosity levels. There are no direct benefits for participation or any obvious undue risks to be endured and you may stop participating at any time.

If you have any questions, please contact myself, Margene Lenamon (LenamonM8548@uhcl.edu), or my dissertation chairperson, Dr. Renée Lastrapes, (Lastrapes@UHCL.edu).

Directions

There are 5 parts to this survey which should take approximately 30 to 45 minutes to complete.

Please answer each question honestly and to the best of your ability. There are NO right or wrong answers. Only your most honest and thoughtful responses can make the survey data effective for this study. Your responses will remain CONFIDENTIAL.

You will be able to stop and start and your work will be saved by following these directions:

- Click on the same link you were emailed
- Use the same browser on the same computer
- Do not clear browsing history between your sessions

The deadline to finish the survey is (TBA).

Please NOTE: You must complete this survey on a computer or smart phone that has access to a printer in order to print the Proof of Completion document provided at the end of the survey.

By checking the agree box below, you consent to your participation in this survey and acknowledge the following:

- that your participation in the study is voluntary,
- you are 18 years of age or older,
- and that you are aware you may choose to terminate your participation in the study at any time and for any reason.

Thank you!

Sincerely,
Margene Lenamon

1. By checking this box, I am agreeing to participate in this survey.

☐ Agree