EDUCATOR PREPAREDNESS TO TEACH ENVIRONMENTAL SCIENCE IN SECONDARY SCHOOLS

By

LINUS JOSEPH GUILLORY, JR.

Bachelor of Arts in Biology
Texas A&M University
College Station, Texas
1999

Master of Education in Educational Administration
Prairie View A&M University
Prairie View, Texas
2002

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
May, 2012

EDUCATOR PREPAREDNESS TO TEACH

ENVIRONMENTAL SCIENCE IN SECONDARY

SCHOOLS

Dissertation Approved:

Dr. Kevin Allen

Dissertation Adviser

Dr. Steven K. Marks

Committee Member

Dr. John D. Vitek

Committee Member

Dr. Caroline Beller

Outside Committee Member

Dr. Sheryl A. Tucker

Dean of the Graduate College

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Introduction

From the protective blankets that make up the atmosphere to the powerful forces that exist in our residential zones to the magnanimous forces occurring under our feet, an understanding of how Earth systems interact and impact living organisms must be developed and instilled within society. “Earth is a complex, dynamic system we do not yet fully understand. The Earth system, like the human body, comprises diverse components that interact in complex ways. We need to understand the Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system. Our planet is changing on all spatial and temporal scales” (NASA, 2011). Understanding Earth, the resources it provides, and how the life sustaining systems operate is an important component of environmental science. The citizens of the world must have an understanding of how the natural world operates to improve the human relationship with Earth. Understanding natural systems is spread throughout numerous state and national education standards and is transmitted in formal institutions of learning.

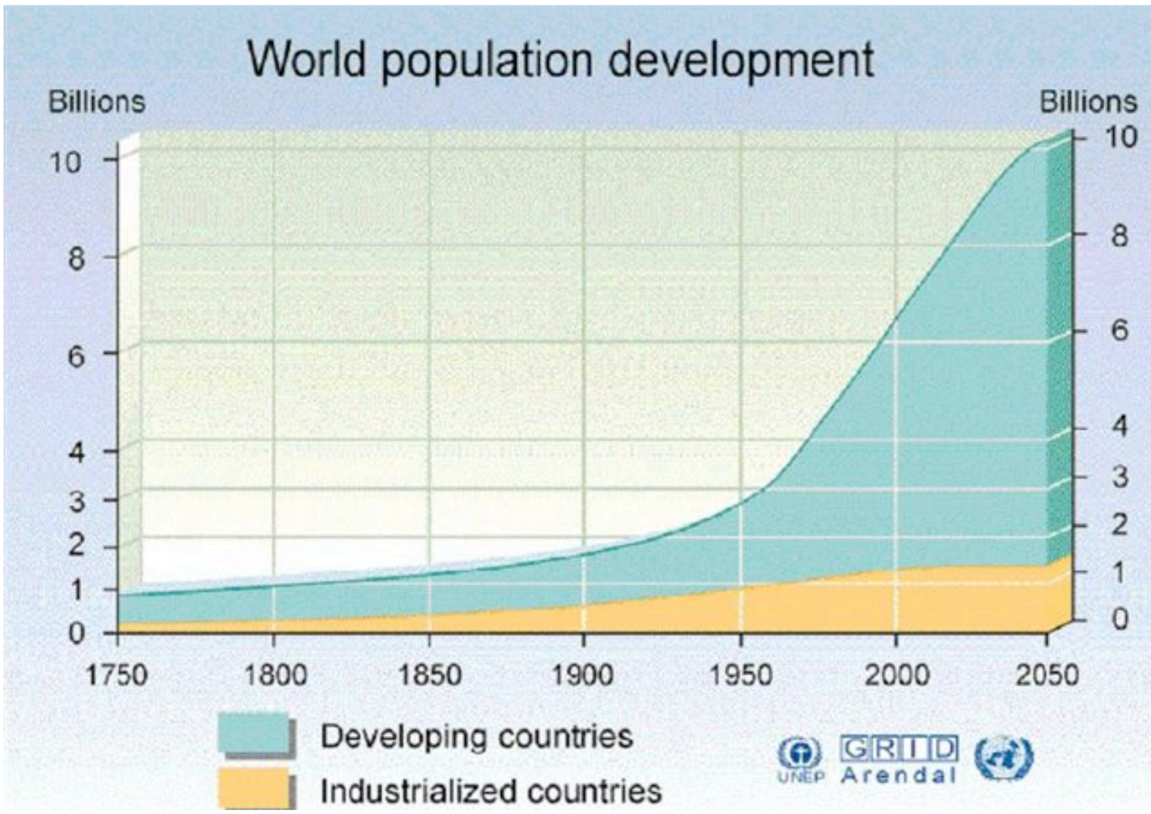
Science is the process humans use to learn aspects of the universe. Science is the systematic observation of natural events and conditions to discover facts and to formulate laws and principles based on these facts. We explore; we discover; we understand through the world of science. Science is simple and complex. We discover and evolve based on knowledge gained through our interactions. Through science, our society advances and makes advances in medicine, education, food, and improves technologies and systems that we currently have in place for human benefit and the benefit of other species. Science is everywhere. Science surrounds our being and provides avenues for us to explore what we see and invent things that we do not see.

The human population of Earth is growing exponentially (Figure 1). We are a species dependent on Earth for survival. The planet, in conjunction with energy from the sun, provides needed resources for survival. As more humans inhabit this planet, the space per person becomes smaller and more resources are needed to maintain and sustain a quality of life for all. Some of the resources required for survival are non-renewable. The direct and indirect usages of those resources inflict harm on living species, rendering some species extinct and/or driving some resources to ecocide.

Within a 50-year time span (1950-2000), the human population of the world doubled. At the time of this writing, more than 7 billion people inhabit the planet. The population development chart outlined in Figure 1 shows projected human growth through the year 2050. If the projections are correct and the human population grows as predicted, the human population will exceed 10 billion by the year 2050. Humans make up a small fraction of the living species on the planet. According to research conducted by Mora, Tittensor, Adl, Simpson, and Worm (2011), approximately 8.7 million different species inhabit Earth. Currently, 1,244,360 cataloged species live on Earth and 194,409 species cataloged live in the ocean.

Figure 1

World Population Development



(United Nations Environment Programme, 2010)

As the human population continues to grow, the need for a literate society increases. Societal needs, wants and advances will continue to tap into natural resources, strain natural processes, and continue to compete with other living species to ensure their chances of survival. According to the population reference bureau, the ten most populated countries currently are: China, India, the United States, Indonesia, Brazil, Pakistan, Nigeria, Bangladesh, Russia, and Japan (Table 1). How can the human population continue to grow uncontrollably and maintain a thorough understanding of the life-sustaining resources?

Table 1

2011 Ten Most Populated Countries in the World

Population (millions)	**Population (millions)**
China 1,346	Pakistan 177
India 1,241	Nigeria 162
United States 312	Bangladesh 151
Indonesia 238	Russia 143
Brazil 197	Japan 128

(Population Reference Bureau, 2011)

Education is the answer to maintaining and sustaining a quality environment that continues to support life and ecobalance. The human population must be educated so that the vast majority understand how their everyday interactions impact the planet and the chances of survival for all species. Many people understand the call and need to educate, but few take the necessary steps to implement it. For each person engaged in mutualism, taking the time to recycle, conserve water, properly dispose of litter, two other people do the opposite (USEPA, 2008). Whereas the inconveniences of doing the right thing seem large at the time, they are miniscule compared to the long-term impact that is sustained and felt by human society for many years to come.

In March 2010, President Barack Obama reauthorized the Elementary and Secondary Education Act to elevate the need for and importance of having an educated body of people ready to problem-solve current and future issues that impact society. The simple act of reauthorizing this statute communicates to the nation that we must continue improving and refining our teaching and learning systems; we want our students to continue making new discoveries but more importantly, we need a populace that takes responsibility for its actions and is able to problem-solve. At the heart of this issue is what is often referred to as “our future”-the children. The President’s blueprint for education reform is aimed at revolutionizing the American education system (US Department of Education, 2010). I contend that this revolution can and needs to start in environmental science education.

Statement of the Problem

Environmental science literacy continues to gain international recognition as a cause worthy of pursuing. Researchers state the importance of having an environmentally literate populace and have noted a substantial deficit in the general environmental science knowledge of most citizens. Understanding the nature of the environment is critical. Individuals increase their chances of survival when they can recognize and understand the natural processes of Earth.

Educational institutions have an opportunity to begin closing a knowledge gap in society by ensuring that teachers of environmental science standards have the required prerequisite content knowledge; as the number of students that matriculate through the formal learning systems continuously grows, the importance of having environmentally literate educators increases. Science educators, who are prepared to teach environmental science, are necessary in the education system that will nurture present and future environmental stewards.

For educators to fill the societal need, they must have environmental science content knowledge and the knowledge of how to teach science and assess science learning. Little research exists on environmental science preparation portion of programs in colleges and universities in the United States (Mckeown, 2000). Whereas teachers are the critical lynch pin in student learning, it is imperative that the educators have the necessary knowledge and skills needed to be effective science teachers. They must know their subject content and how to engage students in the learning process.

Schools are not producing students that have a basic understanding of environmental issues. Whereas the national science education standards are thorough in the global presentation of what students should learn, little attention is focused on the initial preparation of teachers of environmental science. Schools must do more to instruct students on environmental issues. Environmental science must be relevant to the lives of the students and not be so broad that the students exit schools knowing and doing very little relative to the environment. More environmental educating must be done in schools so that when students graduate, they are able to make informed, conscious, rationale decisions regarding their impact on life–sustaining support systems. According to Membiela, DePalma, and Suarez Pazos (2011):

> Education, and in particular science education, should involve a dialogue with place and go beyond the physical world to encompass the meanings and sense of attachment local residents feel for places. Place-based science education engages with the laboratories of complex reality where natural processes combine with social practice, places are fundamentally pedagogical because they are contexts for human perception and for participation with the phenomenological, ecological, and cultural world. (p. 361)

A society that does not know its history and the paths to its present is doomed to repeat the steps that led prior civilizations to extinction. Humans must be deliberately taught to understand and how to care for and interact with Earth. This teaching must happen through widespread distribution of information and experiences through environmental science education in schools. Environmental science addresses the interactions between humans and natural systems. I contend that students must be taught how to flourish and survive within their local environment, understanding issues that are local to them and engaging in creative environmental problem solving. The educator in the classroom is the important connector. Through the deliberate actions of the teacher, direct and indirect learning happens in educational settings. The well-prepared teacher is critically important to instilling in students necessary skills, processes, and information that will begin to close the environmental literacy gap that has been identified by multiple researchers.

This study evaluates whether Texas secondary life science educators, certified from 2003 to 2011, demonstrated proficiency in environmental science content knowledge and the knowledge of how to teach science and assess science learning. A multitude of factors influence student learning; however, none is more significant than the preparedness of the educator to convey the information and engage students in learning. An educator's preparedness is their knowledge of the subject that they will in turn impart to students. Science educators must have the prerequisite content knowledge and science teaching skills, themselves, before they are able to thoroughly share knowledge with the students. According to Dani (2009), "teachers are considered the most influential factor in educational reform intended to promote student learning" (p. 290).

Purpose of the Study

Studying science teacher knowledge at the beginning of the teaching career gives educator preparation programs the opportunity to determine the effectiveness of their preparation programs. Colleges and universities that offer life science preparation programs are able to use the findings from this study to aid them in making decisions regarding the future of their current environmental science preparation programs and whether or not the preparation programs serve the intended purpose: to prepare future educators that can maximize student learning. School districts will be able to use the information presented in this dissertation to plan professional development activities to support newly certified science teachers.

As a science educator and now a school administrator with management responsibilities for science, I have become more concerned about the decline in US student performance on state and national science exams. The motivation to look at the science teacher preparation grew out of my experiences as a public school administrator seeking to hire knowledgeable individuals to teach science.

Significance of the Study

Everything that is taught in schools is to prepare the students for the world outside of the classroom. All science comes together in the environment; it is difficult to separate the different science subjects into individual silos in the natural world. This study aims to raise awareness that teachers of science must be well-prepared themselves to provide the quality education needed to understand and solve environmental issues so that students are able to assimilate the individual content strands presented in schools into useable factions. Teacher preparedness to teach environmental science is the key issue that will be specifically assessed by this research. Through the teacher "environmental values" get transferred. "Good teachers of science create environments in which they and their students work together as active learners" (NRC, 1996).

Texas is the second largest state in landmass (after Alaska) as well as the second most populated state (behind California) in the United States; Texas has an abundance of natural resources that include forests, oil, coastline waters, lakes, rivers, deserts, and plains. Whereas Texas has optimum resources for studying the environment, environmental science has reached an all time low when it comes to being taught as a required high school science course. In Texas, environmental science is an elective in the high school state science curriculum. Many of the larger school districts offer the elective course. Smaller school districts do not offer environmental science course as an option.

All Texas high school students are required to take one course in biology to graduate. Additionally, all Texas high school students are exposed to environmental science standards in the biology course. According to the Texas Education Agency (2012), 390,665 students were enrolled in the 9th grade in the 2010-2011 school year. In the 2010-2011 school year, 391,974 Texas high school students were enrolled in biology. 3,187 certified teachers taught these courses. Table 2 depicts the student enrollment and teaching units associated with biology courses from 2007-2011.

Table 2

Numbers of Students Enrolled in Biology and Teachers Teaching Biology

School Year	Teachers	Students
2007-2008	3260	411,374
2008-2009	3256	396,996
2009-2010	3246	385,616
2010-2011	3187	391,874

(Texas Education Agency, 2012)

This study will open the door for states that are struggling with student performance in science to take a closer look at the educator in the classroom to determine if the teacher is actually prepared to teach the subject matter. As a practicing administrator, we continuously provide professional development for teachers and have become excellent practitioners of studying data. Little is done, however, to assess the background knowledge of the educator i.e. what foundation information does the teacher have that qualifies them to teach the subject matter and then layout a plan to close educational gaps of the teacher.

Statement of the Hypothesis

This quantitative research project will assess the overall question: did Texas secondary life science educators, who became certified in the years 2003 to 2011, demonstrate proficiency in environmental science (ES) content knowledge and beginning knowledge of how to teach science to students; and does a strong, positive correlation exist between performance on domain

V (environmental science content knowledge) and domain VI (knowledge of how to teach science and assess science learning) for individuals who passed the exam?

The null hypotheses are:

H1: No significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2: No significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess student learning in science.

The alternative hypotheses are:

H1a: A significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2a: A significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess student learning in science.

Assumptions

The key assumptions made to conduct this study are that individuals taking the TExES 138 life science 8-12 exam are professional teaching candidates who seek to improve student learning in science classrooms. The subjects approached the exam seriously by accurately responding to each question based on their background content knowledge. Because of admission hurdles associated with taking any high stakes exam, I assume that examinees responded to the questions based on their background/prerequisite content knowledge. Examinees must seek and gain approval to take their first content exam and pay for the associated registration cost. The current registration fee associated with taking this exam is $120.00 USD. The third assumption is that the exam is an adequate/valid measure of the intended domains and competencies. Exam questions are sealed and are not released. The test writers provide sample questions that illustrate the types of questions an examinee may experience on the exam.

Limitations

This study concentrates on educator exam scores on the TExES 138 life science 8-12 exam from the first nine-years of implementation. This study is limited to the educators' performance on the exam. No college transcripts or professional trainings are associated with the data and it is difficult to ascertain how much environmental science preparation each individual received in their particular educator preparation program.

This study represents a moment in time when the educator sat to take the exam for the four hour time period. The researcher recognizes that aspects of environmental science are taught in other high school required subject strands such as social studies and world geography. The life science strand was chosen because *Texas Essential Knowledge and Skills* (TEKS) in environmental science are clearly spelled out in the biology subject strand and life science educators are tested on environmental science standards.

Summary

Cabrera, Mandel, Andras, and Nydam (2008) identify the pressing global crisis facing humanity. Their research culminated in identifying seven clusters of challenges that will have to be addressed with interdisciplinary resources and disciplines. They are: environment and resources, health and disease, education and technology, influence, social institutions, human nature/perspective, and economics and poverty. In the environment cluster, the identified sub-strands are: shortage of potable/clean water, lack of sustainable energy sources, loss of biodiversity and species extinction, climate change and effects on ecosystems, and overpopulation. Six of the seven importance ratings found in their research pertained to environmental issues and science education. An educator's ability to prepare students to live and interact within the local environment will begin to close the societal "lack of knowledge" gap and work in humankinds favor to begin reducing our negative impact on environmental systems.

With the rapid human population growth, it is essential that schools impart as much scientific knowledge as possible. The role of educational institutions will take center stage during this period to produce the next body of literate citizens. It is important to identify the key elements that impact student learning. Numerous factors that impact student learning include home environment, socioeconomic parameters, educational policy, parents, and teachers. Of all of these elements, the classroom teacher is the most significant in influencing student learning. Are newly certified science teachers proficient in the environmental science TEKS in Texas secondary schools? This question is the driving force of this research project.

Essential Terminology and Acronyms

Competency Statement – broadly defines what an entry-level educator in this field in Texas public schools should know and be able to do. (TExES Preparation Manual, 2011)

Content Knowledge – the knowledge of the subject matter held by the teacher.

Descriptive Statement – statement that describes in greater detail the knowledge and skills eligible for testing for Texas certification. (TExES Preparation Manual, 2011)

Domain – subject matter content organized into broad areas. (TExES Preparation Manual, 2011)

Ecology – The study of the relationships between living organisms and between organisms and their environment, especially animal and plant communities, their energy follows and their interactions with their surroundings. (Porteous, 2008)

Ecosystem – The plants, animals and microbes that live in a defined zone (it can range from a desert to an ocean) and the physical environment in which they live comprise together an ecosystem. (Porteous, 2008)

Education Standards – the established curriculum that articulates the minimum knowledge the students should have and performance level; what a student know and be able to do.

Educator Preparation Program – an entity approved by the Texas State Board for Educator Certification to recommend a teaching candidate for the appropriate credentialing.

Elementary and Secondary Education Act – ESEA - Public Law 89-10, passed in 1965, established under President L.B. Johnson, aimed at strengthening and improving educational quality and educational opportunities in the Nation's elementary and secondary schools.

Environmental Education – a means of producing an environmentally literate citizenry, empowered and motivated to solve environmental problems. (Parlo and Butler, 2007)

Environmental Science – ES - the study of the interactions between humans and natural systems.

House Bill 3 – HB 3 - An act, passed by the Texas Legislature, relating to public school accountability, curriculum, and promotion requirements.

National Science Educator Standards – NSES- outline what students need to know, understand and be able to do to be scientifically literate at different grade levels.

No Child Left Behind Act – NCLB - 2001 reauthorization of the 1965 ESEA, requiring states to test students in reading and math in grades 3–8 and once in high school. All students are expected to meet or exceed state standards in reading and math by 2014. Pillars of the NCLB act are accountability, flexibility, parent choice and researched-based education

Pedagogical Content Knowledge – PCK– the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to diverse interests and abilities of learners, and presented for instruction. (Shulman, 1987, p. 8)

Pedagogy – the art and science of teaching, incorporating instructional methods that are developed from scientifically-based research (TEA, 2012).

Preservice teacher – one who is in the process of learning to teach and tracking towards certification.

Secondary school – the portion of the K-12 education focused on grades 9-12.

State Board for Educator Certification – SBEC – created by the Texas Legislature in 1995 to recognize public school educators as professionals and grant educators the authority to govern the standards of their profession. (Texas Education Agency, 2012)

Texas Education Agency – TEA

Texas Essential Knowledge and Skills –TEKS –the state standards for what students should know and be able to do. (Texas Education Agency, 2012)

Texas Examinations of Educator Standards Program – TExES –certification exam required by Texas law. (Texas Education Agency, 2012)

CHAPTER II

REVIEW OF LITERATURE

Introduction

Science instruction at the secondary level has remained relatively the same over the past 50 years (Rutherford, 2005). Dani (2009) writes, "teachers are considered the most influential factor" in education to promote student learning (p. 290). This study will address whether or not Texas life science secondary teachers, certified from 2003 to 2011, demonstrated proficiency requirements necessary to teach introductory environmental science standards and how to teach science and assess science learning as evidenced by their domain scores. Whereas Texas offers numerous secondary science certificates, the TExES 138 life science 8-12 exam was chosen because it assesses the educator on environmental science content standards. Texas does not offer an independent environmental science certificate and students are not required to take an environmental science course to graduate from high school. All Texas high school students must take biology. Because all science connects in the environment and students must be prepared to replace the existing body of scientific knowledge, environmental science is the focal point of this research project.

A challenge facing current and future generations is to build a quality existence not dependent on fossil energies that are non-renewable. Alternate, renewable energies are being implemented and explored. Wind and solar energy are gaining much momentum in the new millennia. By teaching students that the environment itself is an important natural resource, they can understand that deliberate care must be taken to use the resources wisely. Students must become prepared to take on critical environmental issues: water quality, energy conservation, energy development, air pollution, climate change, and wildlife protection. This is not just an American issue, however, but is one that people must embrace all over the globe.

Environmental science, ubiquitous in biology textbooks, is often combined with other science courses, therefore, rendering it optional. When environmental science is explored, it is often viewed as an opportunity to discuss population and pollution. All to often, it is reduced to a listing or memorization of key vocabulary terms and fails to connect the individual to their actual environment and decision-making processes. A quick Internet search on the historic British Petroleum oil spill can reinforce how disconnected environmental science in public schools has become; the same is true for environmental science in published articles, websites and books. Many employ passive techniques or approaches. Students were asked to write essays, collect pictures, and participate in other abstract events, but rarely did they engage in actual interactive problem solving with the changed environment as a result of the disaster.

After researching educator preparation programs, limited work exists on the induction of preservice secondary high school teachers in science or environmental science. The vast majority of preservice teacher research exists primarily on elementary and middle level grades. This research project will focus on the question did Texas secondary life science educators, who became certified in the years 2003 to 2011, demonstrate proficiency requirements in environmental science (ES) content knowledge and beginning knowledge of how to teach science and assess science learning; and does a strong, positive correlation exist between performance on domain V (environmental science content knowledge) and domain VI (knowledge of how to teach science and assess science learning)?

In our digital, tech-savvy, fast-paced society, the citizenry needs to be scientifically literate as they are expected to make responsible decisions and vote on issues that require some knowledge and understanding of science and how their actions impact others (Robinson and Crowther, 2001). As people become more connected through technological advances, the opportunities gained by prior generations through face-to-face engagement with others and the natural world is easily lost. As cities get larger and daily survival modalities become more automated, the opportunity for our understanding of how nature works can get further distorted. Because we live in a fast-paced, automated world, we tend to give up some of the thinking responsibility that we once held when we were "dependent on nature" for guidance.

Education standards drive what teachers are supposed to teach in the classroom. Teacher knowledge and comfort level with the curricula materials dictate what actually happens in the classroom. Parlo and Butler (2007) state that inadequate teacher training is a primary reason that educators do not teach about the environment. They also recognize "the pressures of current reforms that focus on standards-based teaching and teacher accountability, teachers may lose sight of the value of environmental education" (p. 32). By understanding the preparedness of the educator to teach environmental science and convey appropriate levels of environmental literacy, we can determine if schools are producing environmentally literate citizens.

Scientifically Literate

Before we address the idea of environmentally literate, we must first understand scientific literacy. What does it mean to be scientifically literate? Paul Hurd (1958) used a similar term, science literacy, in the 1950s in his work *Science Literacy: Its meaning for American schools* and is credited with coining the term (Laugksch, 2000). Hurd summarized many of the scientific and technological advances that were happening at the time and surmised that most students graduating high school at that time would have little understanding of the science unfolding before their eyes. Hurd questioned whether the school systems would be able to morph into entities that would be able to keep up with the societal evolution occurring outside the classrooms. He noted the expansive gap between the "scientific achievements" of the time and "the poverty of scientific literacy in America" (p. 14). In 1958, questions were raised about the scientific literacy in America. In 2012, researchers and policy makers are still discussing the need to alleviate the lack of scientific literacy in America. Hurd (1958) wrote:

> Progress in science and technology has reached the place where their future is dependent upon an education that is appropriate for meeting the challenges of an emerging scientific revolution. The problems facing American education are complex and urgent. (p. 14)

Holbrook and Rannikmae (2009) write that the terminology scientific literacy is simple and it sums up the intentions of science education at the public school level. They believe that whereas the term has literal meaning, it also has meaning metaphorically; it "means all things to all people" (Holbrook and Rannikmae, 2009, p. 277). General, wide-scale agreement exists on the meaning of scientific literacy; the two major points of view are that scientific literacy encompasses the knowledge of science and that it is useful to society. Holbrook and Rannikmae

(2009) state that those who hold the view point that scientific literacy is the knowledge of science seems to be prevalent among science teachers. "It builds on the notion that there are 'fundamental ideas' in science that are essential and that there is content of science which is a crucial component of scientific literacy" (Holbrook and Rannikmae, 2009, p. 278). This point of view can be considered very basic and low-level i.e. things committed to short-term memory. Holbrook and Rannikmae (2009) write that the second viewpoint of societal usefulness is considered long term. This view of scientific literacy means that an individual takes what has been taught and learned, synthesizes it and applies it to daily life.

According to the *National Science Education Standards* (1996), scientific literacy means:

> A person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and apply conclusions from such arguments appropriately. (p. 22)

Fang (2005) states, "An understanding of science and the processes of science is essential to full participation in life. Despite the centrality of science to our life and to the progress of our society, many students fail to acquire scientific knowledge, understanding, and abilities" (p. 335-

336). Are teachers drawing students to science so that they are able to appreciate the richness of science or are students being driven away from science? Lemke (2001) believes that the majority of students become disenchanted with science as they advance through grade-levels. Lemke suggests that it is the teaching that alienates the students. Neither he nor I believe that this is intentional, but it is a by-product of teachers not fully grounded in pedagogy and/or content knowledge. We cannot afford to disenfranchise students.

Feinstein (2011) describes scientific literacy as being useful in a person's daily life. "I am referring to the very specific notion that science education can help people solve personally meaningful problems in their lives, directly affect their material and social circumstances, shape their behavior, and inform their most significant practical and political decisions" (Feinstein, 2011, p. 169). In this regard, the knowledge gained becomes a part of a persons very being. Feinstein's position is clear, scientific literacy is personal for each individual. It is impossible to prescribe a body of knowledge that will be consistently present in all individuals. The larger idea is for individuals to have a working knowledge of science, not that every person has to be a scientist or see the world scientifically. Feinstein (2011) writes:

> I propose that science literate people are competent outsiders with respect to science: people who have learned to recognize the moments when science has some bearing on their needs and interests and to interact with sources of scientific expertise in ways that help them achieve their own goals. It follows from this definition that the pursuit of science literacy is not incidentally but fundamentally about identifying relevance: learning to see how science is or could be significant to the things you care about most. (p. 180)

The United States is losing its footage as producers of scientifically literate students. In 2006, the US ranked 23rd in science amongst countries reporting in the Programme for International Student Assessment (PISA). The PISA (2010) report states, "the quality of an education system cannot exceed the quality of its teachers and principals, since student learning is ultimately the product of what goes on in classrooms" (p. 4). PISA assesses how far students near the end of compulsory education have acquired some of the knowledge and skills that are essential for full participation in society. In all cycles, the domains of reading, mathematical and scientific literacy are covered in terms of mastery of the school curriculum, and also in terms of important knowledge and skills needed in adult life. At the core of the PISA report lays the importance of the teacher. A teacher that knows the content, knows how to make the content digestible and understandable to the student, and understands how science should be taught is critical. Teachers today need to realize that they are competing against unseen forces. Students today are very different from those ten years ago. The "iGeneration" of students have grown up with technology constantly at their fingertips. Current students are accustomed to having multi-stimuli. Educators must understand the inherent difficulties in teaching students that are accustomed to multiple interfaces happening simultaneously. Students essentially have to "power-down" each time they enter the classroom and focus on one person-the teacher. A well-prepared teacher knows how to keep the students learning and recognizes this is no easy feat. Ryan, Scott, and Walsh (2010) state that classrooms today must include opportunities for students to work with a range of 'new' texts and resources: the Internet, digital programs, and mobile technology; students are more familiar with these technologies than their teachers (p. 477).

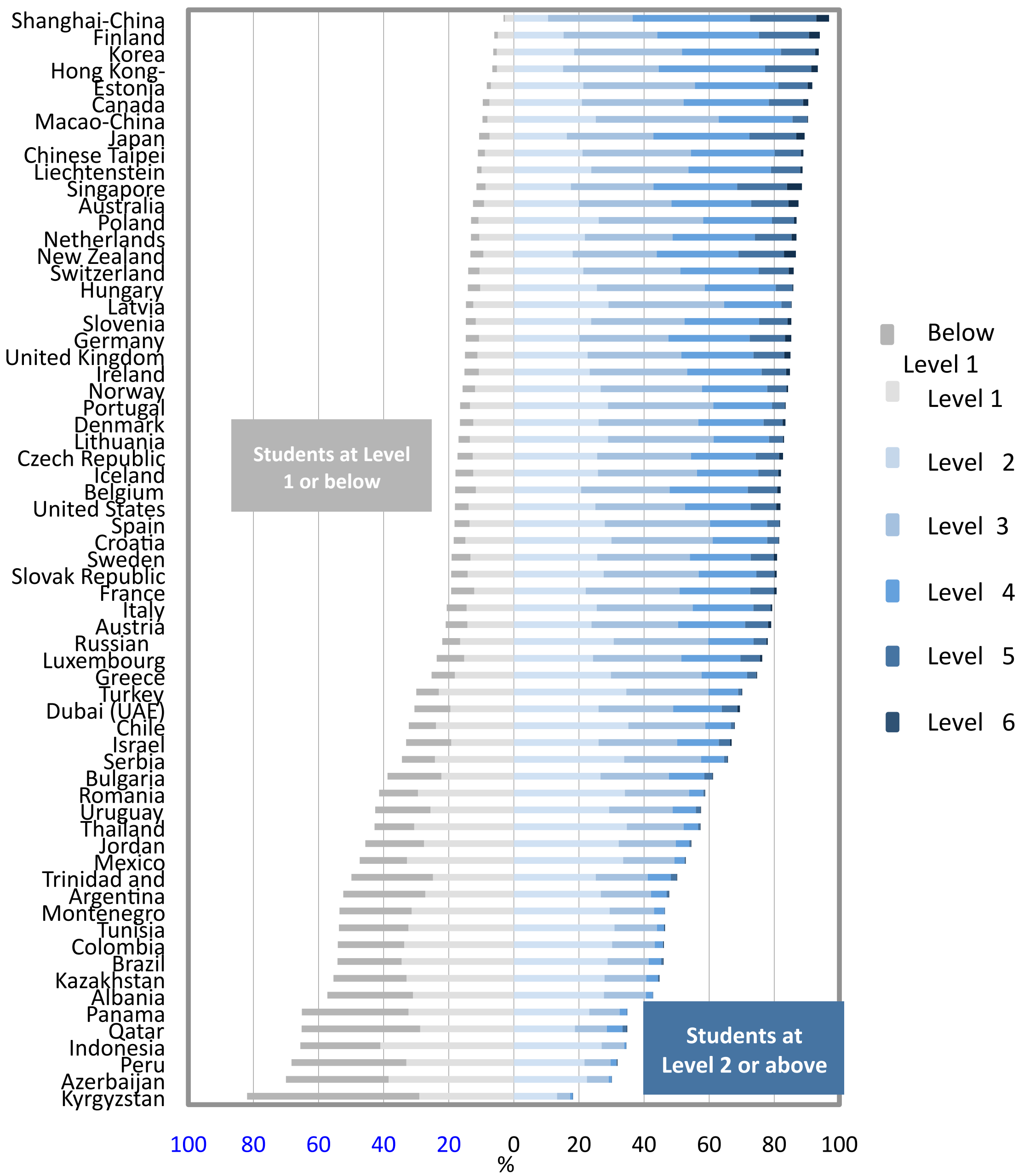
The ethnic and cultural make-up of many schools have changed. With the influx of immigrants to the US, schools are struggling to keep up with educating students whose primary language may not be English. The challenges associated with English language learners are opportunities for teachers and administrators to engage in discovery themselves-how do we continue providing quality education for all. Three years later after the 2006 PISA report, the US position had slipped to 30th (Table 3). Whereas numerous factors go into national and international exams, the message is clear and shows that US students are trending in a negative direction when it comes demonstrating scientific literacy. The 15-year old students tested would represent the vast majority of students in their 9th grade year of high school.

PISA (2010) defines scientific literacy:

> as an individual's scientific knowledge, and use of that knowledge, to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues; their understanding of the characteristic features of science as a form of human knowledge and enquiry; their awareness of how science and technology shape our material, intellectual and cultural environments; and their willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen. (p. 137)

Table 3

How Proficient are Students in Science on an International Scale?



(Programme for International Student Assessment, 2010)

Armed with this information, the education community must prepare to revolutionize what happens in American classrooms. Salmon (2000) wrote that we have "become increasingly concerned with the state of science education in the United States" and recognize the value that environmental science education has "always been a good way to make science come alive for young students" (p. 4-5). The "big three" sciences presented in all Texas high schools, biology, chemistry and physics, come together in the natural environment; the natural environment is the perfect venue for students to synthesize the learning that has occurred in the classroom. Under the guidance of a qualified teacher, students are able to explore, discover, and understand elements of the natural world. Salmon writes (2000) that the Independent Commission on Environmental Education has emphasized "teachers are the key to successful environmental education" (p. 7). "Commissioners are convinced that whether or not students really learn about the environment generally depends more on the teacher…" (Salmon, 2000, p. 7). According to NSES (1996), "the collective judgment of our people will determine how we manage shared resources-such as air, water, and national forest" (p. 11). The need for environmental science literacy is great. Educators themselves must be environmentally literate.

Reynolds (2010) writes that environmental literacy is "an understanding of the environmental, social, and economic dimensions of human-environment interactions, and the skills and ethics to translate this understanding into life choices that promote the sustainable flourishing of diverse human communities and the ecological systems within which they are embedded" (p. 18). The human-environment interactions are the critical components of my research. Human interaction with the environment must be pushed to deeper levels in schools.

Science knowledge is constantly being updated and changed and we can no longer allow the presentation of environmental science to solely be historical in nature.

The Call to Educate

After reviewing the recent literature on the need for increased literacy in environmental science, I am more convinced than ever of the importance of this research project. Researcher after researcher has identified the same need: society must be educated to minimize the adverse affects that humans are causing to the life sustaining systems in the biosphere. Americans have been called to action in the past. April 22, 1970 will be remembered by those alive during that time as a call to care for Earth. I make a similar call, but this time, not just to be concerned about Earth, but now, let us learn how to problem-solve the issues that human action has created and will continue to create.

Chapin et al. (2010) state:

> Human actions are having large and accelerating effects on the climate, environment and ecosystems of Earth, thereby degrading many ecosystem services. This unsustainable trajectory demands a dramatic change in human relationships with the environment and life-support system of the planet. (p. 241)

Power & Chapin (2010) report that current ecologists are working to minimize and reduce the stress placed on the life support systems of Earth. They say, "current collapses of local economies and natural ecosystems suggest that both must be reorganized and managed in ways that better sustain critical functions through a future of environmental instability and directional change" (Power & Chapin, 2010, p. 143). The best way to impede the degradation of human impact on the Earth is to educate them.

To solve environmental issues, the public must become more aware of how their interactions impact the local habitat. Jordan, Singer, Vaughan and Berkowitz (2009) state that "ecological literacy is necessary for understanding the natural world and human interaction with it and for making informed decisions about the conservation and management of resources" (p. 495). Jordan et al. (2009) further state that it is important to consider the rapid, developmental changes facing communities and that ecological literacy must be imbedded beginning as early as grade school and continue through adulthood. Jordan et al. (2009) contend that the time has come for ecological literacy, with up-to-date information because the body of knowledge is changing. They write, "an ecologically literate person exhibits awareness about local habitats, can link local issues to global concerns, and has an understanding of spatially independent concepts and issues" (p. 496). Jordan et al. (2009) takes the position that a complete framework to guide educators on what to convey is non-existent. They acknowledge the importance of the National Research Council Science Education Standards and the American Association for the Advancement of Science Atlas of Science Literacy as bodies of knowledge, but argue that the habits of mind associated with an ecological/environmental framework is lacking. Educators must be able to instill these habits of mind in their students.

The Role of Schools

Hurd (1958) wrote, "Breakthroughs in science lead to new horizons, and establish new areas for intellectual conquest, which in turn demand a plan of education to sustain the cycle of achievement. An education of this nature must have built into it some of the dynamic qualities that have given us the "scientific age" (p.14). The purpose of our schools is to prepare students for life outside the classroom.

At the foundation of this research lies the argument that schools must do more to educate students about the local environment. Schools fall short when it comes to educating students to recognize and solve environmental problems in their local communities i.e. the community in which the school exists. As pervasive as environmental science is in our actual existence, it is in its infancy as a science taught in schools. Environmental science in most cases is present as a chapter in a high school biology book or is an add-on to another science course. Students gain punctuated glimpses into the science of the environment in elementary and middle school years without meaningful connections drawing them together. Often times, environmental science is reduced to isolated vocabulary episodes. A student in Texas can graduate high school without ever taking a course dedicated to solely environmental science. Table 4 depicts the required and elective science courses that Texas students must fulfill to graduate from high school. Texas students have three diploma options: minimum high school plan (HSP), recommended HSP and distinguished HSP.

Table 4

Side-by-Side Science Graduation Comparison for Texas Students

2011-2012 Graduation Credit Requirements

Discipline	Minimum HSP	Recommended HSP	Distinguished Achievement Program*
Science ♦	**Two credits:** • Biology • Integrated Physics and Chemistry May substitute Chemistry or Physics for IPC but must use the other as academic elective credit	**Four credits:** • Biology, AP Biology, or IB Biology • Chemistry, AP Chemistry, or IB Chemistry • Physics, Principles of Technology, AP Physics, or IB Physics • The additional credit may be IPC and must be successfully completed prior to chemistry and physics. • The fourth credit may be selected from any of the following: ▪ Aquatic Science ▪ Astronomy ▪ Earth and Space Science ▪ Environmental Systems ▪ AP Biology ▪ AP Chemistry ▪ AP Physics B ▪ AP Physics C ▪ AP Environmental Science ▪ IB Biology ▪ IB Chemistry ▪ IB Physics ▪ IB Environmental Systems ▪ Scientific Research and Design (CTE) ▪ Anatomy and Physiology (CTE) ▪ Engineering Design and Problem Solving (CTE) ▪ Medical Microbiology (CTE) ▪ Pathophysiology (CTE) ▪ Advanced Animal Science (CTE) ▪ Advanced Biotechnology (CTE) ▪ Advanced Plant and Soil Science (CTE) ▪ Food Science (CTE) ▪ Forensic Science (CTE)	**Four credits:** • Biology, AP Biology, or IB Biology • Chemistry, AP Chemistry, or IB Chemistry • Physics, AP Physics, or IB Physics • After successful completion of a biology course, a chemistry course, and a physics course, the fourth credit may be selected from any of the following: ▪ Aquatic Science ▪ Astronomy ▪ Earth and Space Science ▪ Environmental Systems ▪ AP Biology ▪ AP Chemistry ▪ AP Physics B ▪ AP Physics C ▪ AP Environmental Science ▪ IB Biology ▪ IB Chemistry ▪ IB Physics ▪ IB Environmental Systems ▪ Scientific Research and Design (CTE) ▪ Anatomy and Physiology (CTE) ▪ Engineering Design and Problem Solving (CTE) ▪ Medical Microbiology (CTE) ▪ Pathophysiology (CTE) ▪ Advanced Animal Science (CTE) ▪ Advanced Biotechnology (CTE) ▪ Advanced Plant and Soil Science (CTE) ▪ Food Science (CTE) ▪ Forensic Science (CTE)

(TEA, 2012)

Pilgrim, Cullen, Smith, and Pretty (2008) argue that ecological knowledge becomes lost in wealthier countries. They believe that as societies adopt more modern lifestyles, people are less apt to be knowledgeable of how nature functions. The processes that they attribute this to are "urbanization, modernization of public services including education systems, and globalization of trade and belief systems" (p.1004). According to Pilgrim et al. (2007), the more advanced the society is, the less knowledge the populace has on how the world around them works.

The American Association for the Advancement of Science published *Science for All Americans* in 1991. The following excerpt is taken from Chapter 12: Habits of Mind:

> Throughout history, people have concerned themselves with the transmission of shared values, attitudes, and skills from one generation to the next. All three were taught long

> before formal schooling was invented. Even today, it is evident that family, religion, peers, books, news and entertainment media, and general life experiences are the chief influences shaping people's views of knowledge, learning, and other aspects of life. Science, mathematics, and technology—in the context of schooling—can also play a key role in the process, for they are built upon a distinctive set of values, they reflect and respond to the values of society generally, and they are increasingly influential in shaping shared cultural values. Thus, to the degree that schooling concerns itself with values and attitudes—a matter of great sensitivity in a society that prizes cultural diversity and individuality and is wary of ideology—it must take scientific values and attitudes into account when preparing young people for life beyond school.

This excerpt holds true today and provides guidance for what science education should and must do for society. The habits of mind are the critical factors that teachers help establish in students. The direct and indirect opportunities afforded the students by the teacher shape the values and attitudes instilled in the students. The curriculum is important, but it alone is insufficient to translate societal values. The educator is the lynch pin.

PISA (2010) states:

> The most impressive outcome of world-class education systems is perhaps that they deliver high-quality learning consistently across the entire education system, such that every student benefits from excellent learning opportunities. To achieve this, they invest educational resources where they can make the greatest difference, they attract the most talented teachers into the most challenging classrooms, and they establish effective spending choices that prioritize the quality of teachers. (OCED, 2010, p. 4)

Shortage of Quality Science Teachers

In 1983 the results from the work of the National Commission on Excellence in Education published a report entitled, A Nation at Risk. According to Lumpe (2008), "A Nation at Risk…pushed schools and governments to place an emphasis on standards, testing, and curriculum alignment, all in an effort to increase student achievement" (p. 313). This report ushered in a new era of governmental legislation that "looms large over every state, district, school building leader, educator, student" and continues to expand in present times (Lumpe, 2008, p. 313). The outcomes from this report energized the American education system by bringing to the forefront of the Nation a number of beliefs about and results of the our education system. "They {the public} even considered education more important than developing the best industrial system or the strongest military force, perhaps because they understood education as the cornerstone of both. They also held that education is 'extremely important' to one's future success, and that public education should be the top priority for additional Federal funds" (A Nation at Risk, 1983). The public expects our schools and teachers to educate the students. Because public schools are funded by tax dollars, states publish school and district report cards each year. These report cards inform the public how well schools are progressing. Subpar math and science scores continue to plague districts across the country.

The implications regarding teaching in the early 1980s are still with us today. Here is an excerpt regarding the findings on teachers.

According to *A Nation at Risk*:

> The shortage of teachers in mathematics and science is particularly severe. A 1981 survey of 45 States revealed shortages of mathematics teachers in 43 states, critical shortages of earth sciences teachers in 33 states, and of physics teachers everywhere. Half of the newly employed mathematics, science, and English teachers are not qualified to teach these subjects; fewer than one-third of U. S. high schools offer physics taught by qualified teachers. (p. 20)

More recently, in April 2007, NSTA reported that the fields of math and science continue to suffer from a lack of qualified teachers, indicating that the shortage of quality science teachers continues to plague the American education system. The highly specialized courses at the secondary level require greater content knowledge because of the highly content-specific science courses offered in high schools. It is imperative that educators are proficient in their content areas as well as appropriate methodologies to transfer this information to students. Lumpe (2008) surmises that even with a pre-packaged curriculum, research-based best practices, you cannot get around the problem of the teacher. Smith (2008) delves deeper into teacher quality by further emphasizing the critical role of the teacher.

Smith (2008) stated:

> The major weakness and, indeed, strength of the process model is that it rests upon the quality of teachers. If they are not up to much then there is no safety net in the form of prescribed curriculum materials. The approach is dependent upon the cultivation of

wisdom and meaning making in the classroom. If the teacher is not up to this then there will be severe limitations on what can happen educationally. (online retrieval)

Numerous school districts used critical need stipends to attract teachers to science and math. Science is deemed a critical need area in Texas. Critical need stipends were paid in addition to the base salary and reached as high as $3,500 in some districts. Currently, the majority of Texas districts are moving away from the critical need stipends and moving to performance pay incentives. Performance pay incentives are based on how well a particular teacher's students do on state assessments. Once implemented, teachers will receive bonuses based on their classroom observations and student performance.

According to TEA, in the 2010-2011 school year, 4,984,609 students were educated in Texas K-12 schools. The National Center for Education Statistics (2011) reports, "from 2008–09 through 2020–21, public elementary and secondary school enrollment is projected to increase from 49.3 to 52.7 million students" (p.1). Table 5 depicts the experience of math and science teachers in Texas from 2006 to 2010. The table illustrates a consistent turnover in the science-teaching workforce every ten years. This trend illustrates the need for insuring that a well-prepared workforce is continuously prepared to teach in public schools.

Market competitiveness tends to pull quality science teachers away from the teaching field. According to the Bureau of Labor Statistics in 2010, biological science teachers, made approximately $32,000 less than their counterparts in industry. The 2012 average salary for new teachers in Texas is $45,000. This is for an individual with zero years of teaching experience and a bachelor's degree. The climb up the teaching pay scale is very slow. As an example, one Texas school district pay scale states that an individual with a doctorate degree and 37 years of service would make approximately $74,000 annually.

Table 5

Texas Math and Science Teacher Experience from 2006 to 2010

Year	Number Employed	Average Experience	Percentage by Years of Experience					
			0-9	10-19	20-29	30-39	40-49	50-59
Mathematics								
2010	62,297	10.4	57.5	25.1	12.2	4.8	0.38	0.006
2009	59,276	10.5	57.1	24.7	12.9	5.0	0.33	0.007
2008	54,963	10.4	57.3	24.1	13.4	5.0	0.32	0.007
2007	52,400	10.6	56.2	24.3	14.3	4.9	0.28	0.004
2006	47,301	11.0	54.6	24.7	15.2	5.2	0.28	0.004
Science								
2010	54,595	10.1	58.9	24.4	12.0	4.4	0.32	0.007
2009	51,350	10.2	58.4	24.0	12.8	4.4	0.28	0.010
2008	47,463	10.1	58.9	23.1	13.3	4.5	0.26	0.006
2007	46,118	10.3	58.0	23.3	14.1	4.4	0.22	0.004
2006	41,292	10.6	56.4	23.8	14.9	4.6	0.23	0.005

(TEA, 2012)

The critical shortage of science teachers sometimes requires schools and school districts to hire individuals who are not yet certified but have a credentialing such as a permit or probationary certificate that allows them to teach for a limited time period. Table 6 shows the number of uncertified Texas secondary teachers from 2006 to 2010. The number of uncertified science teachers peaked in the 2008 fiscal year. Geographic location, pay, and working conditions are a few of the common reasons that would warrant the need for an uncertified teacher.

In 2009, the Texas Association of School Boards (TASB) expressed explicit concerns regarding the shortage of quality Texas science teachers. TASB reported “districts are only able to fill 20 percent of their teaching vacancies with fully qualified teachers” (2009). The board attests that approximately 35% of science teachers are teaching outside their field and predicts the shortage will continue to increase over the next five years (TASB, 2009).

Table 6

Percentage of Uncertified Texas Secondary Teachers from 2006 to 2010

Employment Subject Area	Teachers 2010	FTEs 2010	FTE Percent Uncertified 2006	2007	2008	2009	2010
SECONDARY (GRADES 9-12)							
BILINGUAL/ESL	128	53	13.6	9.0	16.6	9.4	15.0
CAREER AND TECHNICAL ED	17,457	11,163	10.8	11.2	12.4	11.5	10.8
COMPUTER SCIENCE	2,273	930	10.4	10.0	12.6	12.0	11.6
ENGLISH AS A SECOND LANGUAGE	2,643	1,080	8.8	8.4	9.8	6.7	6.3
ENGLISH LANGUAGE ARTS	19,267	13,194	9.5	9.3	10.7	8.1	6.9
FINE ARTS	9,305	6,475	8.7	7.8	8.5	7.7	6.5
LANGUAGES OTHER THAN ENGLISH	6,888	5,373	16.8	16.4	16.2	14.2	12.8
MATHEMATICS	14,824	11,374	11.0	11.7	13.1	11.3	10.9
PHYSICAL EDUCATION & HEALTH	19,464	9,365	8.4	8.2	9.2	7.9	6.7
SCIENCE	13,602	9,797	14.1	15.7	18.3	14.7	13.2
SELF-CONTAINED	99	40	57.1	60.7	43.8	50.0	38.2
SOCIAL STUDIES	15,469	10,477	9.4	8.9	10.2	8.2	6.7
SPECIAL EDUCATION	4,050	1,619	13.5	14.6	13.0	8.0	8.1
TOTAL	125,469	80,940	10.8	11.0	12.3	10.3	9.2

(TEA, 2012)

According to the National Science Education Standards, "The most important resource is professional teachers" that are knowledgeable of content and pedagogy (NRC, 1996, p. 218). Lumpe (2008) states, "If teaching is indeed the most critical factor in student learning, then teacher preparation and continuing professional development stands to play a huge role in impacting student achievement" (p. 315). Browstein, Allan, Hagevik, Shane, and Veal (2009) raise the importance of the *2003 NSTA Standards for Science Teacher Preparation*. They wrote that the standards were developed to ensure that all preservice teachers have the necessary knowledge, skills and abilities to teach science (Brownstein et al., 2009, p. 310). They state that the standards "provide a foundation for a performance assessment system through which preservice teachers must demonstrate the knowledge, skills and dispositions deemed important in the teaching of science" (Brownstein et al., 2009, p. 310).

Teacher Preparation in Environmental Science

McKeown-Ice (2000) wrote that little research is known regarding the environmental preparation of preservice teachers. "While many institutions of higher education are involved in environmental education, the extent of their involvement has not been documented, especially at the preservice level" (McKeown-Ice, 2000, p. 4). The Center for Education Research and Innovation of the Organisation for Economic Cooperation and Development conducted a study concerning environmental education in five countries; the study found that educator training was weakest in environmental education (McKeown-Ice, 2000, p. 4). McKeown-Ice's survey of 715 US preservice teacher development programs (higher education institutions) revealed:

1. Generally, environmental education in preservice teacher education programs in not institutionalized
2. Where it exists, implementation of the environmental education component in preservice education programs varies greatly across the US
3. Preservice teacher education programs are not systematically preparing future teachers to effectively teach about the environment

(McKeown-Ice, 2000, p. 10)

Harrell (2010) summarized a 1999 report that shows that 20% of all science teachers held neither a major nor a minor related to their teaching assignment. In Texas today, college hours and a degree are essential for the initial classroom-teaching certificate. However, once an educator is certified in a content area, the educator can add additional classroom certifications by taking an examination; no emphasis is placed on the college hours for additional certifications by examinations. According to TEA (2012), a teacher who holds a valid (provisional, professional, one-year or standard) Texas classroom teaching certificate and a bachelor's degree may add classroom certification areas by taking and passing the content exam for the area sought. More than one area can be added at a time for one fee. This is called additional certification by examination.

Given the specificity of knowledge required to teach many high school subjects, I opine that this will not be a widespread issue for upper-level, secondary teachers. I do find this troubling for Texas middle schools where some districts prefer teachers to have generalist certifications. The generalist certificate allows a teacher to teach science, math, social studies and English/language arts. This is a practice that gives schools and districts fiscal flexibility and does not appear to be what is educationally in the best interest of the student. Middle schools have transformed into content specific units that mirror the high school teaching structure; the practice of not having content teachers at the middle level puts high schools at a disadvantage when students arrive ill prepared. Numerous researchers have already stated the importance of having teachers that are steeped in their content knowledge as well as able to convey this information in a format that allows the students to grasp it. As Wellington and Osborne (2001) stated:

> As teachers of science, . . . our primary skills lie not in our ability to do science, or showing children how to do science, but in our ability to interpret and convey a complex and fascinating subject. We are, primarily, raconteurs of science, knowledge intermediaries between the scientific canon and its new acolytes. Such an emphasis

means that we must give prominence to the means and modes of representing scientific ideas, and explicitly to the teaching of how to read, how to write and how to talk science. (p. 138)

Teaching a Multidisciplinary Science

Environmental science is multidisciplinary in nature i.e. a combination of many subjects. Environmental science provides opportunities to engage multiple subjects with a common vision and purpose. Harrell (2010) states "The rationale for implementation of an integrated curriculum is to show how knowledge across disciplines in interrelated in a natural world, as compared to a program utilizing single-subject courses that narrow the learner's perspective and are less efficient in the learning process" (p. 146). By focusing the learning from various sciences in environmental science, students will have the opportunity to explore this knowledge through social contexts, scientific reasoning, and critical thinking (Harrell, 2010). NSTA, NSES, NRC, AAAS, and the Benchmarks for Science literacy all support an integrated, multidisciplinary approach to teaching science. We must move beyond the silos of subjects in schools and provide students with real-world practical applications, experiences and appropriate contexts. Whereas the *State Board for Educator Certification* (SBEC) has identified the courses that an educator certified in 8-12 life science is allowed to teach, the *Texas Essential Knowledge and Skills* (TEKS) govern the interconnectedness of the curriculum. Harrell (2010) argues, "teacher content knowledge is an important factor to consider with regard to effective implementation of an integrated curriculum and several studies have explored teacher knowledge as measured by completed coursework and teaching assignment" (p.148). Harrell also says that students were more likely to perform at higher levels when their teachers completed coursework in their areas of teaching. The rationale here is that teachers that have had rich experiences with the content will require more of their students.

Teachers that teach a multidisciplinary science, i.e. environmental science, must have the prerequisite background knowledge needed to digest the curriculum and engage the students in rigorous, relevant experiences. If teachers believe that they are not strong enough in a particular field of science, then they omit the content or do a poor job teaching it. Most colleges and universities are structured in single or double major systems. Harrell (2010) said that given the importance of teaching an interdisciplinary science, an educator cannot be ill-prepared to transfer the multitude of scientific literacy to students. This level of teaching requires an educator steeped in content knowledge as well as pedagogy.

The organization of secondary schools adds to the complexity of teaching a multidisciplinary subject. Most secondary schools still follow the grade and subject delineations when they were first introduced; students learn biology in the biology course; they learn chemistry in the chemistry course; and physics is learned in the physics course. All courses provide little cross-disciplinary teaching and further adds to the growing gaps in science literacy that currently exists. Disinger (2001) writes:

> Because environment-if considered at all-is usually an add-on to existing subjects, it must compete for time and space in the already crowded curricula, with few rigorously designed, effectively integrated teaching materials to facilitate meaningful inclusion. In any case, environmental topics now appear in science (and occasionally other) textbooks, most commonly as isolated chapters presenting litanies of environmental problems; these text materials are frequently designed to appeal to the pro-environmental proclivities of

> both teachers and students. A result is that environmental topics have not generally been taught in well-planned scope-and-sequence patterns; at best, they support the scope-and-sequence formats of the disciplines to which they are appended. (p. 6)

Pedagogical Content Knowledge

Pedagogy is the process of teaching. Content is the curriculum that is taught. When the two terms are combined, the result is pedagogical content knowledge or PCK. PCK is more expansive and requires greater teacher insight to employ than pedagogy and subject matter content knowledge separately. Hagevik et al. (2010) state, "Pedagogical content knowledge is defined as the knowledge base for teaching that distinguishes a secondary science teacher from a generic secondary teacher. The content-specific nature of a secondary science teacher is very different from a teacher who uses general pedagogical methods to deliver content" (p. 7). The science teacher must embrace specific methods of teaching science content that are considered best practices. Best practices are teaching strategies that allow students to grasp and comprehend the subject matter being taught. Best teaching practices account for the diverseness of students, the classroom space, and the topics being taught. The strongest teachers know that the nature of the science content and the learning styles of the students drive the instructional methods (direct and indirect) as well as the procedures and processes used for instruction. According to Hagevik et al. (2010), "If the characteristics of PCK are desired in an expert science teacher, then the acquisition of those characteristics are just as vital for beginning teachers. The goal for beginning science teachers is to develop foundational knowledge and skills that will help them develop PCK" (p. 9). Knowing science is a critical component to quality teaching in science. The most effective teachers are able to teach using the necessary pedagogical methods to relate the information to students in such a way that allows them to connect to the information being presented. The understanding and the ability to apply PCK distinguishes the teacher who understands the content deeply from the educator who can only teach in a perfunctory way (Hagevik et al., 2010, p. 9). For a teacher to teach a subject as complex as environmental science, they must have the ability to employ PCK. According to Hagevik et al. (2010), "Socially important science issues that are found and exemplified in the community are examples of science that preservice science teacher and students must understand" (p. 9). These are the issues that are relevant to an individual's immediate being. A person who understands local environmental issues can connect to large-scale environmental problems.

The No Child Left Behind Act (NCLB) brought a new wave of policy that impacted schools across the country. Any school, public, private, charter, receiving federal funds must comply with the "highly qualified teacher" parameters required in NCLB. According to NCLB, highly qualified, at the secondary level for a teacher new to the profession, means that an educator has met the certification requirements of the state and holds a high degree of competency in the areas taught as evidenced by college and/or graduate transcripts, advanced certification and/or credentialing. He, Levin and Li (2011) noted the increase in the federal government's role in regulating teacher quality since NCLB but recognizes that states still control teacher licensing processes (p. 157).

Need for Environmental Science Education

Wright (2005) defines environmental science as employing "the methods of sound science to provide the information needed by human societies to improve human welfare and to promote the health of the natural systems that sustain those societies" (p. 13). As far back as

1991, Kuzimak wrote that a broad base of Americans cared about the environment. Whereas an increased awareness of the environment may be evident, the wide-scale implementation of the practice of interacting with the environment remains relatively low. A disconnect occurs in schools when they fail to implement local environmental interaction; the problem-solving interaction between humans and environment must become more evident in classrooms to produce citizens that will make conscious environmental decisions.

According to Wright (2005):

> When a society fails to care for the environment that sustains it, when its population increases beyond the capacity of the land and water to provide adequate food for all, and when the disparity between haves and have-nots widens into a gulf of social injustice, the result is disaster. The civilization collapses. History is replete with the ruins of other civilizations, such as the Mayans, Greeks, Incas, and Romans that failed to recognize the constraints of their own environment. (p. 2)

Wright illustrates that a society that does not respect and understand how and what the environment provides for a civilization, is soon to go extinct. The environment returns back to equilibrium and the people lose.

Cakir, Irez and Dogan (2010) state:

> The need to promote a society of environmentally literate citizens is regarded as urgent in many countries and is accepted as one of the main goals of education. It is widely recognized that democratic societies in the new century necessarily need citizens who have an understanding and knowledge of the causes, potential consequences and possible

> cures of environmental problems thus enabling them to engage in critical dialogue about the political and moral dilemmas posed by global/local environmental issues and arrive at considered decisions. (p. 21)

Currently, sustainable development is gaining recognition as a concept that involves environmental, social, and economic consequences of human action and activities (Cakir et al.) "The sustainable and stable life on Earth depends on future generations developing the understanding necessary for making informed decisions about the environment" (Cakir, Irez, and Dogan, 2010, 22). Students today must have a solid scientific foundation and general knowledge from which they can draw to make reasonable decisions regarding local and global environmental issues.

McComas (2002) provides insight into the history, rationales, misconceptions and education standards of environmental science curricula. In his peeling back of the origins, he looks at contributions from early scholars and agriculturalists to the ecological sciences. McComas uses the terms environmental science, environmental education, and ecology education somewhat interchangeably. He does point out that ecology has been interwoven into other life sciences and does not exist on its own as a science in public schools today. McComas argues sternly for ecology to stand out on its own as it "provides students the opportunity to apply and synthesize much of what they have learned throughout a typical year of biology instruction" (p. 667). According to McComas, "ecology is a more sophisticated, higher level, and synthetic pursuit that involves almost all other domains in the life sciences" (p. 667). He asserts that the study of the environment demands, permits, and encourages students to apply what they have learned in addressing problems, in allocating resources, and in gaining a rich view of the interplay of science and society" (p. 667).

McComas believes that the National Science Education Standards are thoroughly adequate as a comprehensive presentation of environmental/ecological science. He says, "if this plan were followed, students would encounter these key concepts at increasingly higher levels of sophistication as they progress through school" (p. 672). I agree with McComas' assessment. Schools must get on board with this plan and ensure that students are exposed to the national standards through purposeful interactions regarding the environment; this interaction must come through local, tangible, meaningful environmental opportunities such as wastewater treatment, garbage disposal, air quality and water quality. Science teachers must embrace the criticality of environmental science and environmental literacy.

McComas (2003) delves into the depths of the traditional curriculum to elucidate an ideal environmental science curriculum for K-12 teachers. He first examines how ecology is represented in ten major high school biology textbooks. Interestingly enough, McComas discovered that roughly 10% of a high school text is devoted to ecology. Often, it is the last chapter in the book. The potential for it to be overlooked or omitted is great. He then examined the labs presented in the text. He found that the most common laboratory exercises "address population size, population interactions such as competition and predation, biodiversity and aspects of environmental harm caused by human action such as pollution" (p. 172). If the ecology chapter is being omitted or overlooked, a great chance exists that the student is not gaining any insight into ecology or environmental science.

McComas (2003) points to the North American Association for Environmental Education's (NAEE) *Guidelines for Excellence in Environmental Education (K-12)* as a curriculum basis in addition to the National Science Education Standards (NSES). He differentiates between the two by pointing out that the NAEE standards are more "comprehensive when it comes to action taking" whereas NSES provides the structure for the required knowledge (p. 175). He also notes the controversial nature of environmental science. Environmental science has the ability to draw people together as well as put them in opposition to one another. This is topic dependent. One thing is certain; people must be drawn in to explore their beliefs. Identifying the problem is half the battle. Creative problem solving and generating solutions is the critical second part. Currently, the vast environmental science curriculum focuses solely on identifying problems.

McComas (2003) attests that "ecology (environmental science) demands more from learners than almost any other branch of science while at the same time providing more in terms of strategies and perspectives" (p. 178). He ends by citing the difference between an uninformed environmentalist and an intelligent student: "An environmentalist who takes action without understanding the science behind his cause is just as uninformed as the student who scores high marks on the ecology test and fails to understand that there are rational causes worth fighting for" (p. 178).

Jenkins (2003) summarizes environmental education and the public's understanding of science by pointing out that average citizens lack of critical science understanding is more than the science being too hard to understand. His message is that students must be able to take their gained knowledge and engage in conversations with experts in the field to solidify what they know. This, he believes, will mold their understanding between social, personal and institutional factors that help formulate an individual's understanding of science. He calls for a new way of teaching science. Jenkins states "school science courses have traditionally encouraged the view that science is straight forward and non-controversial" (p.441). Jenkins wants environmental courses to draw students in to defend their beliefs; through this process, they will learn more about their belief and the beliefs of others. Teachers must require students to ground their beliefs in environmental truths.

Kennelly, Taylor, and Maxwell (2008) conducted a study of preservice secondary science teachers in Australia. Their research focused on a noted lack of environmental education preparation in colleges and universities for teacher educators. Preservice teachers were tested pre- and post- participating in a program designed to enhance confidence in teaching about the environment. The study found that participants had a greater understanding of environmental science after participating in the program; the program equipped teachers with pedagogical skills, resources, and strategies that would assist them in teaching their students. The participants felt more confident about teaching environmental issues once they had a thorough understanding themselves.

Texas Examinations of Educator Standards

The State Board for Educator Certification (SBEC) approves Texas educator standards that articulate what a beginning educator should know and be able to do in the classroom for student learning. The educator standards correlate directly and are derived from the state-required curriculum standards for students. The state-required student curriculum standards are called TEKS-Texas Essential Knowledge and Skills. The TEKS form the foundation of knowledge that is used to construct the Texas Examination for Educator Standards (TExES) testing framework.

TExES exams are organized into very broad content bands called domains. The life science 8-12 test, which is the focal point of this dissertation, is organized into six domains. Each domain consists of a number of competencies. A competency further breaks a domain into smaller, focused areas. Competencies are comprised of the competency statement and descriptive statements. The descriptive statements articulate what the beginning teachers should know and be able to do.

According to SBEC:

> As required by the Texas Education Code §21.048, successful performance on the educator certification examinations is required for the issuance of a Texas educator certificate. Each TExES test is a criterion-referenced examination designed to measure the knowledge and skills delineated in the corresponding TExES test framework. Each test framework is based on standards that were developed by Texas educators and other education stakeholders. (SBEC, 2012)

The TExES exam is a major component of the becoming a new teacher. Any person wishing to become a new teacher in Texas must have approved credentialing from SBEC by passing the subject matter content and the general pedagogy exams.

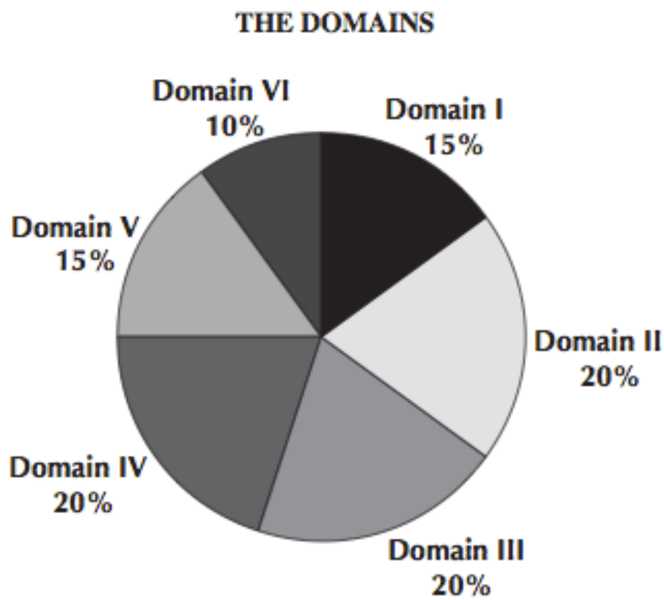
TExES 138 Life Science 8-12 Test Framework and Structure

According to the Texas Education Agency, the new TExES 138 life science 8-12 test was first administered in the fall of 2002 and replaced the ExCET Biology exam. Individuals holding the TExES 138 life science 8-12 certificate can teach all high school biology, environmental systems, AP environmental science, IB environmental systems, aquatic science, anatomy and physiology, medical microbiology, pathophysiology, and scientific research and design.

The life science 8-12 test is comprised of six domains and twenty competencies that articulate what the beginning teacher must know and be able to do upon entering the classroom. Therefore, it is imperative that new teachers walk into the classroom with the required, beginning knowledge and skills. The six domains are scientific inquiry and processes, cell structure and processes, heredity and evolution of life, diversity of life, interdependence of life and environmental systems, and science learning, instruction, and assessment. Figure 2 shows the composition of domains on the TExES 138 exam.

Figure 2

Exam Composition in Percentages by Domains



(ETS, 2011)

Domain V and VI are of interest in this research study. Are educators who have passed credentialing examinations ready to teach environmental science content to students? Examinees have recently exited an educator preparation program and should be at their respective peaks with the prerequisite content knowledge.

Texas Educator Certification Paths

Texas has four pathways to certification: Texas Educator Preparation Program (TEPP), Interstate/Country Reciprocity, additional certificate by examination and temporary teacher certificate. TEPP has two routes to certification: certification through a university-based program or through an alternative certification program. The five basic requirements for someone new to the teaching field to become a certified teacher are obtain a bachelor’s degree, complete a TEPP, pass the appropriate certification exam(s), submit a state application and get fingerprinted. These are non-sequential requirements.

Interstate/country reciprocity educators seeking certification in Texas must apply for a review of credentials by TEA. Educators who have been issued a standard certificate or credential from another state or country outside of the United States and its territories must apply for a review of their out-of-state/country credentials.

A teacher who holds a valid (provisional, professional, one-year or standard) Texas classroom teaching certificate and a bachelor's degree may add classroom certification areas by successfully completing the appropriate certification examination(s) for the area(s) sought. More than one area can be added at a time for a single fee. Although educators have this option, content area core teachers must meet the highly qualified parameters spelled out in NCLB.

All school districts receiving federal funds must ensure that core content teachers are highly qualified. Highly qualified means that the educator has received full teacher certification, has a bachelor’s degree with a concentration of courses in the content area, and has demonstrated subject matter competency in the academic subject in which they teach. All teachers of record who teach in a core content area must be highly qualified. Secondary teachers demonstrate competency in their core content area by passing the appropriate TExES exam and having an academic major or graduate degree or coursework equivalent to an undergraduate academic major i.e. twenty four semester hours, with twelve hours being upper level courses in the core academic subject area.

The *State Board for Educator Certification* approved the creation of the temporary teacher certificate (TTC) at its April 2, 2004, meeting. The TTC discussion will be omitted because there are no school districts participating in it at the time of this writing.

Summary

Several researchers have noted that the time has come for the public to become more knowledgeable of how human action affects the environment. For the public to become more informed about natural processes that occur in the environment and how humans impact those processes and affect other species, the population must be deliberately educated. According to Texas Compulsory Attendance laws, all students between ages 6 and 18 shall attend school. As presented in the research used for this project, the human population is growing as well as the number of children that will be attending schools. Without the comforts afforded by our environment, our chances of survival cease to exist.

As presented in this literature review, researchers have catalogued the importance of environmental science to the survival of the human race as well as other life forms. Curriculum frameworks exist and articulate what students should learn. The gateway to this learning lies in the transmission of knowledge from teacher to student. My research evaluates new life science teachers to determine if they demonstrated proficiency levels in knowledge and skill requirements to teach environmental literacy to students evidenced by their performance in domain V and VI of the TExES 138 exam.

Science is a complex subject. In many ways, it has its own language. The idea here is not for students to know everything there is to know about environmental science, but to set them on a path where they will be able to utilize the education that they have gained inside the classrooms to make informed, rational decisions outside the classroom. Davis, Petish and Smithey (2006) state that preservice teachers seem, for the most part, to lack adequate understandings of science content (p. 615). They acknowledge that new science teachers, presumably, are expected to do the same sorts of things as experienced teachers, with less proficiency (p. 609). According to Davis, Petish and Smithey:

> New science teachers are expected to develop deep conceptual understandings of learning goals while also conveying the nature of science by engaging students in authentic scientific inquiry-a very tall order. Teachers must devise experiences that will help students construct understandings of natural phenomena as well as assessments that demonstrate evidence of student learning to numerous constituencies. Science teachers are expected to help all of their students to succeed, respecting and drawing productively on students' diverse ideas, including those at odds with normative science ideas. Finally, they must situate their students' learning within the broader context of their school, neighborhood, town, or city, and the nation as a whole. (p. 609)

Environmental science is not exempt from the political/policy-making world and has been around more than a century. The oldest US environmental legislation is believed to be the Rivers and Harbors Act of 1899. Policy makers will continue to push environmental legislation and citizens must be informed when they support or reject those policies. Science teachers must plant environmental values and habits of mind in the students so that the students are able to contribute to and participate in the political and social decision-making processes concerning the environment.

Subotnik, Tai, Rickoff, and Almarode (2010) summarize that what we know now and what we will need to know in five years about specialized science, technology, and math is scaffolded. We take the learning and make it our own so that when new situations arise, we are able to process through them. They state, "It is clear that the world often turns to the United States to take the leadership role in science and technology, and it has been a role our nation has accepted and has little intention of ceding" (p. 7). To maintain this lead, we must work diligently to immerse our students in rigorous, relevant and recent science experiences. Subotnik et al. (2010) research focuses on students that seek specialized interest in STEM fields. According to a report published by the National Academies Press, *Rising Above the Gathering Storm,* "an effective way to increase student achievement in science and mathematics is to provide intensive learning experience for high-performing students" (p.131). This is important for identifying and producing environmental problem solvers, but we cannot forgo the importance of educating the masses.

Several researchers have noted that the time has come for the public to become more knowledgeable of how human action affects the environment. As presented in this literature review, researchers have catalogued environmental science in the national science education standards and what students should learn. The missing link, however, has been the ability level of the teacher. According to Kenyon, Davis and Hug (2011), "Preservice teachers struggle to learn to teach science effectively" (p. 2). My research assesses the level of proficiency in beginning life science teacher knowledge at the high school level and emphasizes that what teachers know as professional educators impacts what the students will learn and be able to do. Childs and McNicholl (2007) state, "The government standards for entering the teaching profession could imply that there is an expectation that all science teachers have high levels of knowledge" (p. 2).

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study is to assess whether or not Texas secondary life science educators, who became certified in the years 2003 to 2011, proficiency in environmental science (ES) content knowledge and beginning knowledge of how to teach and assess science learning. Additionally, this study will determine if a strong, positive correlation exists between performance on domain V (environmental science content knowledge) and domain VI (knowledge of how to teach and assess science learning).

The TExES 138 life science 8-12 exam results were analyzed in this study. This subject matter content exam allows educators to teach all life science high school courses. Whereas environmental science is the subject of this dissertation, Texas does not require high school students to take courses in environmental science to graduate. All high school students are required to take two science courses for a minimum credit diploma. The two science courses for the minimum diploma are biology and integrated physics and chemistry (Table 4, pg. 30). To graduate with a recommended or distinguished diploma, students must take four science courses, three of which are specified: biology, chemistry, and physics. The fourth science class is an elective and completely the student's independent decision.

Biology is the gateway course for high school science. All students must successfully pass biology before advancing to the next level of science. Biology has the environmental science *Texas Essential Knowledge and Skills* (TEKS) interwoven into its curriculum. Currently, Texas requires its school districts to provide at least 180 days of instruction to students. To receive credit for classes, high school students must be in attendance 90% of the days the class is offered. Teachers, new to the profession, are typically assigned introductory level courses like biology.

All educators in Texas are required to demonstrate their proficiency by taking a subject matter content exam. The subject matter content exam serves as a gateway that all individuals wishing to teach must successfully navigate. The intention of this research is to review the past nine years of the 8-12 life science educator exam results to identify educator proficiency trends in the environmental science and how to teach and assess for science learning strands. Educators have content curricular strengths and weaknesses. The content exam results show the educator their specific areas of strength and need based on domain and competency performance. Domains V and VI are the focus of this research and no competency performance information was provided. Individuals that have passed the content test will be eligible for employment in Texas school districts and, thus, impact learning in the classroom for years.

As state and national economies struggle and job loss soars in public and private sectors, the education system becomes flooded with applicants seeking stable, long-term jobs. Individuals from professional fields such as engineering, health professions, banking, real estate, as well as oil and gas look to the education work sector to support their financial needs. Simultaneously, colleges and universities are operating near maximum capacity, producing graduates ready to enter the work arena that may not be in a position to receive them. They, too, turn to education. All of these individuals must be vetted through an educator preparation program and the educator certification process. According to Brownstein, Allan, Exrailson, Hagevik, Shane, and Veal (2009), educator preparation programs "should provide evidence of a preservice teacher's ability to positively affect students' learning" (p. 409).

Rationale for the Study

Science education continues to take the national and international spotlight as a cause worthy of pursing and investing. Science is the systematic vehicle that allows humans to learn aspects of the natural world. In recent times, the large-scale, natural events have gained greater attention leaving many to ask questions like what caused this to happen or why did this occur. The wide-scale destruction on May 22, 2011 in Joplin, Missouri left many to question how could a tornado of this magnitude develop so quickly and decimate an entire city. The power of nature puts people in awe. Natural warning signs were evident. No one could anticipate or project, however, the amount of destruction. The National Weather Service issued a warning roughly twenty-four minutes before the storm struck. When the city fell silent again and people began to emerge, they saw the full power of natural phenomena up close. According to the National Oceanic and Atmospheric Service, the Joplin tornado was the deadliest single tornado since modern record keeping began in 1950 (2012).

Whereas nature is not always predictable, when natural events like this occur, they give us pause as well as stir us to learn more about Earth and the natural processes of Earth. As a public school administrator and science teacher, I am concerned about the decline in the environmental science knowledge base that is occurring. Consider a widely publicized and well-known exit interview conducted at a Harvard graduation in the 1980s. Graduates were asked to describe what causes the seasons. All interviewees responded that seasons are a result of how close or how far Earth is away from the sun. The graduates reported that when Earth is closer to the sun, it is summer; and when Earth is further from the sun, it is winter. This example from *A Private Universe* is one example that illustrates students are failing to learn science aspects and our education systems are allowing the students to matriculate without clear understandings of the natural world. The need for science literacy is real and a cause worthy of pursuing. Educators must prepare students to understand Earth and the natural systems of Earth. Our education system must answer the call to ensure that students gain the necessary knowledge and skills that will allow them to understand, apply, analyze, synthesize, and evaluate scientific information and Earth processes.

Texas education has a long, rich history. According to TEA (2012), "the first Texas public school law was enacted in 1840, setting aside land in every county to support public schools, and the state constitution of 1845 provided that one-tenth of the annual state tax revenue be set aside as a perpetual fund to support free public schools." According to TEA, Texas has 1,236 public school districts and charter schools, educating more than 4.8 million students. State funding for these schools comes from the permanent school fund that provides approximately $1 billion a year to school districts. (TEA, 2012)

The Texas Education Agency oversees primary and secondary education within the State. TEA's mission is to provide guidance, support, and resources to schools to ensure that students' educational needs are met (TEA, 2012). The State Board for Educator Certification (SBEC) is responsible for all aspects of educator preparation, certification and standards of conduct. SBEC was established in 1995. The governor appoints the eleven-member, voting board. Each member serves a six-year term. The board is comprised of four classroom teachers, one counselor, two administrators, and four citizens. Three non-voting members also serve: a dean of a college of education is appointed by the governor; the commissioner of education appoints a staff member from TEA; and a staff member of the Texas Higher Education Coordinating Board is appointed by the Commissioner of Higher Education. Given this level of support and infrastructure, it is imperative that Texas educators are well prepared to educate students.

Research Design

With regard to methodology, this study utilized quantitative, non-experimental research methods to analyze the TExES 138 life science 8-12 educator exam results and domain V and VI scores from the first nine-years of testing data. The exam consists of six content domains. A total scaled score of 240 or greater indicates that an examinee passed the exam. The maximum score on the exam is 300; a score of 240 on the exam equates to 80%. An individual can pass the exam and still exhibit weaknesses in particular content strands. The hypotheses ask whether a significant difference exists between the mean exam passing score and the mean scores in each domain. This relationship will be used to show strengths or weakness in the two domains i.e. do the domain scores tend to raise or lower an examinee's overall test score. If the domain performance is greater than the over all score, this can be considered an area of strength for the examinee. If the domain score is lower than the overall score, this can be considered an area of weakness for the examinee.

Domains V and VI are of interest in this research study. Domain V is the content strand focused on interdependence of life and environmental systems; domain VI is the content strand focused on science learning, instruction and assessment. The relationship between passing the exam and performance in domain V and VI is evaluated to determine if life science teachers certified during the time period exhibited strengths or weaknesses in the respective domains. Score reports show examinees the number of questions in each domain and competency compared to the number of correct responses (no such reports were provided to the researcher by TEA). The immediate feedback to the educators lets them know early where they should spend additional time and energy when entering the profession. Domain performance in this research study is used to show strengths or needs on a macro scale.

The research question for this study is:

> Did Texas secondary life science educators who became certified in the years 2003 to 2011 demonstrate proficiency in environmental science (ES) content knowledge and beginning knowledge of how to teach and assess science learning; and does a strong, positive correlation exist between performance on domain V (environmental science content knowledge) and domain VI (knowledge of how to teach science and assess for science learning) for individuals who passed the exam?

The null hypotheses are:

> H1: No significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2: No significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess for science learning.

The alternative hypotheses are:

H1a: A significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2a: A significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess for science learning.

The variables of interest are exam year, total score, domain V score and domain VI score. The number of examinees in each testing year varies. Each individual meeting exam access requirements are eligible to take the test. The exam scores were compared to the domain V and domain VI in each testing year, respectively. Additionally, domain V and VI were evaluated to determine if a strong, positive correlation exists. The exam passers each year comprise the sample. Descriptive statistics were performed to test the null and alternative hypothesis to determine if a significant difference exists.

Population Description

This research study encompasses summary data from all individuals that registered and took the TExES 138 life science 8-12 exam during the time period from September 1, 2002 through August 31, 2011. The sample extracted from each test year group is comprised of all the individuals who passed the exam. The individuals who passed the exam are of interest because they will be eligible to teach in Texas public schools.

During this nine-year period, 12,832 individual scores were recorded and registered with the State. Table 7 summarizes the TExES 138 exam results for the nine-year period. Those that passed the exam (total score of 240 or greater) and the corresponding percentages are reflected in the table. A notable statistic that caught my interest was the overall passing percentage each year. At no point did the number of individuals passing the exam exceed 50% for a particular year. This information is alarming considering that the individuals have recently graduated from a college/university or completed an educator preparation program in life science. The percentage of individuals gaining certificates each year remained fairly consistent except in the first testing year. The summary statistic for the time period shows approximately 41% of all examinees met the certification requirements during the course of this research period.

Table 7

TExES 138 8-12 Life Science Exam Statistics

Exam Year	Number that took the exam	Number that passed the exam	Percentage that passed the exam	Percentage that failed the exam
2002-2003	615	296	48.13	51.87
2003-2004	1274	523	41.05	58.95
2004-2005	1379	538	39.01	60.99
2005-2006	1552	609	39.24	60.76
2006-2007	1571	619	39.40	60.60
2007-2008	1597	655	41.01	58.99
2008-2009	1856	778	41.92	58.08
2009-2010	1682	715	42.51	57.49
2010-2011	1306	526	40.28	59.72
Total	*12832*	*5259*	*40.98*	*59.02*

(TEA, 2012)

No demographic data were provided on the examinees. All individuals registering to take the exam have met the Texas Education Agency (TEA) qualifications to gain access to the exam. To gain access to a certification exam, TEA requires that an individual participate in a Texas Educator Preparation Program (TEPP), seek access through Interstate/Country Reciprocity, or request additional certificate by examination. The focus of this research project is on the individuals who passed the exam with a total-scaled score of 240 or greater out of a maximum of

300 total points. The individuals that passed the exam will be eligible to teach in Texas secondary schools.

Table 8 reflects the initial math and science certificates issued in the 2008-2010 fiscal years. The number and percentage of TExES 138 life science 8-12 exams remained fairly consistent during the three years reflected. The life science exam is the second highest issued high school science exam, behind the science composite exam. During this three-year period, 1,274 educators received the life science certificate as their first or initial certificate. The numbers reflected in Table 7 and Table 8 do not coincide perfectly. The individuals represented in Table 8 are contained within the information presented in Table 7; the educators receiving their very first teaching certificate (Table 8) can be distinguished from those individuals that may be adding an additional certificate to teach in other fields. The information in Table 7 represents all individuals who took the TExES 138 life science 8-12 exam.

According to the Texas Association of School Boards, "A longtime shortage of math and science teachers is getting worse just as higher state graduation standards that require the completion of four years of math and four years of science are being phased in" (TASB, 2009). The gap in the number of science teachers needed in the state has widened dramatically since 2004. TASB states, "Things are even worse for districts in need of science teachers, especially high school science, where districts are only able to fill 20 percent of the teaching vacancies with fully qualified teachers" (2009).

Table 8

Initial Science Certificates Issued from 2008 to 2010.

Certification Field	Grade Level	Fiscal Year 2008 Number	Fiscal Year 2008 Percent	Fiscal Year 2009 Number	Fiscal Year 2009 Percent	Fiscal Year 2010 Number	Fiscal Year 2010 Percent
Mathematics							
Mathematics	4-8	819	40.3	830	39.6	1,128	43.4
Mathematics	8-12	1,010	49.7	1,061	50.6	1,264	48.7
Mathematics/Science	4-8	202	9.9	204	9.7	206	7.9
All Fields	All	2,031	100.0	2,095	100.0	2,598	100.0
Science							
Chemistry	8-12	89	4.6	91	4.9	82	4.1
Life Science	8-12	430	22.4	425	22.7	419	21.1
Physical Science	8-12	88	4.6	60	3.2	65	3.3
Physical Science/Math/Engineering	8-12	7	0.4	6	0.3	16	0.8
Physics/Mathematics	8-12	30	1.6	24	1.3	45	2.3
Science	4-8	608	31.7	601	32.2	625	31.4
Science - Composite	8-12	664	34.7	662	35.4	736	37.0
All Fields	All	1,916	100.0	1,869	100.0	1,988	100.0

(TEA, 2012)

In 2009, 125 approved institutions, organizations, and programs were able to certify an educator in the field of science. Certification programs are categorized as alternative, university post-baccalaureate, university undergraduate, and out of state (TEA, 2012). Table 9 summarizes the educator preparation pathway participants by gender and ethnicity. This information reflects all certification exams offered in Texas. In the 2009-2010 school year, roughly 2% of the individuals certified in Texas received the 8-12 life science certificate (526 divided by 28, 457).

Table 9

Texas Certification Program Data

Year	Total	Female		Male		Black/African American		White		Hispanic/Latino		Asian		American Indian/ Alaska Native		Other	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Alternative																	
2010	13,059	9,133	69.9	3,926	30.1	1,780	13.6	7,228	55.3	3,390	26.0	307	2.4	55	0.4	295	2.3
2009	13,413	9,700	72.3	3,713	27.7	1,927	14.4	7,142	53.2	3,602	26.9	297	2.2	52	0.4	262	2.0
2008	13,714	9,948	72.5	3,766	27.5	2,064	15.1	7,112	51.9	3,786	27.6	276	2.0	49	0.4	279	2.0
2007	12,199	8,880	72.8	3,319	27.2	1,760	14.4	6,450	52.9	3,314	27.2	307	2.5	48	0.4	191	1.6
2006	11,112	7,964	71.7	3,148	28.3	1,498	13.5	5,871	52.8	3,117	28.1	228	2.1	56	0.5	137	1.2
University Post-Baccalaureate																	
2010	1,766	1,352	76.6	414	23.4	179	10.1	1,211	68.6	270	15.3	67	3.8	5	0.3	34	1.9
2009	1,953	1,491	76.3	462	23.7	176	9.0	1,331	68.2	325	16.6	62	3.2	6	0.3	44	2.3
2008	2,283	1,772	77.6	511	22.4	218	9.5	1,482	64.9	448	19.6	64	2.8	11	0.5	40	1.8
2007	2,836	2,196	77.4	640	22.6	284	10.0	1,937	68.3	477	16.8	61	2.2	11	0.4	40	1.4
2006	3,324	2,515	75.7	809	24.3	320	9.6	2,163	65.1	652	19.6	89	2.7	15	0.5	46	1.4
University Undergraduate																	
2010	10,339	8,753	84.7	1,586	15.3	571	5.5	6,184	59.8	3,184	30.8	194	1.9	40	0.4	163	1.6
2009	10,541	8,964	85.0	1,577	15.0	561	5.3	6,459	61.3	3,094	29.4	166	1.6	31	0.3	169	1.6
2008	10,504	8,891	84.6	1,613	15.4	533	5.1	6,558	62.4	2,969	28.3	153	1.5	28	0.3	195	1.9
2007	10,241	8,757	85.5	1,484	14.5	536	5.2	6,416	62.7	2,886	28.2	150	1.5	40	0.4	147	1.4
2006	10,278	8,774	85.4	1,504	14.6	504	4.9	6,778	65.9	2,579	25.1	160	1.6	31	0.3	95	0.9
Out of State																	
2010	3,366	2,719	80.8	647	19.2	256	7.6	2,605	77.4	260	7.7	152	4.5	23	0.7	69	2.0
2009	3,715	2,981	80.2	734	19.8	343	9.2	2,790	75.1	323	8.7	139	3.7	33	0.9	73	2.0
2008	3,765	3,047	80.9	718	19.1	406	10.8	2,743	72.9	399	10.6	95	2.5	15	0.4	85	2.3
2007	3,909	3,171	81.1	738	18.9	423	10.8	2,882	73.7	353	9.0	113	2.9	26	0.7	83	2.1
2006	3,405	2,727	80.1	678	19.9	347	10.2	2,516	73.9	295	8.7	116	3.4	38	1.1	48	1.4
All Routes *																	
2010	28,457	21,896	76.9	6,561	23.1	2,778	9.8	17,179	60.4	7,091	24.9	717	2.5	123	0.4	561	2.0
2009	29,560	23,091	78.1	6,469	21.9	3,004	10.2	17,680	59.8	7,333	24.8	662	2.2	120	0.4	546	1.8
2008	30,134	23,550	78.2	6,584	21.8	3,214	10.7	17,795	59.1	7,584	25.2	585	1.9	103	0.3	595	2.0
2007	29,155	22,971	78.8	6,184	21.2	3,006	10.3	17,666	60.6	7,017	24.1	630	2.2	124	0.4	462	1.6
2006	28,174	22,023	78.2	6,151	21.8	2,681	9.5	17,363	61.6	6,647	23.6	594	2.1	140	0.5	328	1.2

(TEA, 2012)

Data Collection

An open records data request was submitted to the Texas Education Agency (TEA) requesting the individual test scores for the TExES 138 life science 8-12 exam coupled with performance scores in domains for each person that took the exam beginning in the September of 2002 (see appendix 1). The data were returned to the researcher electronically via an encrypted email from TEA and provided as comma separated values in an Excel spreadsheet. The data were organized by testing year. Each examinee's score was reported by the total exam score followed by the domain scores, I-VI, in chronological order. 12,832 individual scores were recorded in Texas during this time period. Fifty-two scores were recorded before September 1, 2002. These scores were not included in this research because it was the experimental period for the exam.

The TExES 138 life science 8-12 exam was introduced and first administered September 1, 2002. A testing year is from September 1st through August 31st. Examinees' results are grouped according to this time frame each year. The TExES 138 life science 8-12 exam replaced the ExCET Biology Secondary content exam.

TExES 138 Life Science 8-12 Exam Format

The TExES 138 life science 8-12 exam is developed and administered by *ETS*. *ETS* develops, administers and scores more than 50 million assessment tests annually in more than 180 countries, at more than 9,000 locations worldwide (ETS, 2011). All TExES exams are criterion-referenced examinations. They are designed to measure a candidate's knowledge in relation to an established criterion (knowledge of the TEKS) rather than comparing performance to other test takers. The life science 8-12 test is comprised of 90 multiple-choice questions, 80 of which are scored. Ten questions are field test items to be used on future exams and are indistinguishable from the scored items. Exam questions are sealed and not released. *ETS* provides sample questions to show examinees how competencies may be assessed, the format of the test questions, and the types of questions i.e. textual, graphs, diagrams, pictures, etc. Table 10 summarizes the percentage of the test and number of questions representative of each domain.

Table 10

Number of Questions by Domain

Domain	Test Percentage	Number of Questions
I	15	12
II	20	16
III	20	16
IV	20	16
V	15	12
VI	10	8

(TExES 2011)

The TExES 138 life science 8-12 exam was chosen for this study because the environmental science standards received the greatest coverage for educator preparedness of the certificates allowing an educator to teach biology. Biology is the gateway course for high school science and is required of all high school students in Texas (Table 4, p. 30). It is possible for students to graduate without taking additional science classes that expose them to *Texas Essential Knowledge and Skills* in environmental science.

Individuals holding the TExES 138 life science 8-12 certificate are able to teach the following high school courses that contain environmental science strands: biology, advanced placement biology, international baccalaureate biology, environmental systems, advanced placement environmental science, international baccalaureate environmental systems, and aquatic science. Educators must have 12 semester credit hours (on their transcript) in environmental science and/or ecology to teach environmental systems, advanced placement environmental science, and/or international baccalaureate environmental systems.

Statistical Methods Performed

Discussion in this analysis of data compares the overall exam scores to the domain V and VI scores to determine if a significant difference exists between the means. Data were obtained for the first nine-years of implementation of the TExES 138 life science 8-12 exam. Means will be tested for significance using the *t*-test. According to Ott and Longnecker (2001), the *t*-test procedures have been found to be accurate for statistical testing.

Domain V and VI scores for exam passers were analyzed using the *t*-test to determine if a significant difference exists between the mean exam score and the two domain mean scores respectively. A total exam score of 240 indicates that an individual passed the exam. Summary statistics were gathered for each testing year to identify trends in educator proficiency. R, a statistical computing program, was used to conduct the t-tests and produce the statistical graphs presented. Domain V and VI were selected for this portion of research because they communicate each individuals strengths and needs in the domains of interest. The overall score of 240 equates to 80% when compared to the maximum allowable points on the exam, 300.

This research study uses quantitative, non-experimental research methods to measure differences among means to determine if the differences are statistically significant. Statistical significance is based at the 95% confidence level ($\alpha = 0\ .05$). Significance of the test results will be identified by p-values compared to the selected significance level. If $p > 0.05$, we fail to reject the null hypotheses, i.e. no significant difference exists; if $p < 0.05$, we reject the null hypotheses, i.e. a significant difference exists.

Parametric tests were performed to confirm the normality of the data. The only data points removed were from the pilot year of exam administration. The pilot year was conducted prior to 2002. Tables and graphics to follow, show the data trends. T-tests were run to test for statistical significance.

The Texas Education Agency responded to an open records request by providing the data grouped by testing year. Initial analyses were run comparing individuals who passed the exam and those that did not pass the exam to determine if similarities and differences existed between the two groups and their performance in domain V and VI.

Variables of Interest

The full set of data contains nine variables and 12,884 records covering the years 2002 – 2011. Each record represents an individual's results from the TExES 138 life science exam during the time period. This test replaced the ExCET Biology exam and was in the development phase prior to September 2002; therefore, the data utilized in this study excludes these 52 records. By focusing on the individuals that passed the overall test, the number of individuals eligible to teach drops to 5,259 or 41%.

The variables of interest were test year, total test score, and domain V and VI scores. The examined data contained four variables and 5,259 records. Because of the large sample size, t-tests and correlations could be used to answer these questions without resorting to non-parametric measures, thus, allowing for higher power interpretation.

General Data Trends for all Test Takers

Trends were quickly identified that were statistically significant. In each testing year, the domain V scores of those who passed the test are significantly higher than those of people who did not pass the test. The Welch Two Sample t-test was used to evaluate this significance ($t = -87.7316$, $df = 12645.47$, $p < 0.0001$). This shows that those passing the test scored higher in domain V (significantly different) than those not passing the test. As expected, the educators passing the test had greater strengths than those who did not pass the overall test. On average, those who passed the TExES 138 test scored 36.5 points higher in the domain V than those that did not pass the exam. This means that individuals who passed the test have greater strengths in environmental science content when compared to those that did not pass the exam. This is a positive outcome in the data because the individuals that will be teaching have greater proficiency in the subject matter content than those that did not meet the testing standard. The difference in average scores for domain V ranged from 29.5 points (2010) to 49.1 (2004), meaning that test passers scored 29.5 to 49.1 points higher in domain V than those that did not pass the exam.

In each testing year, a statistically significant difference exists in the score on domain VI between those who passed the test and those who did not (Welch Two Sample t-test: $t = -71.8749$, $df = 12461.89$, $p < 0.0001$). This shows that those passing the test scored higher in domain VI (significantly different) than those not passing the test. As expected, the educators passing the test had greater strengths than those who did not pass the overall test. A positive spike was discovered in 2007 followed by a negative spike in 2008.

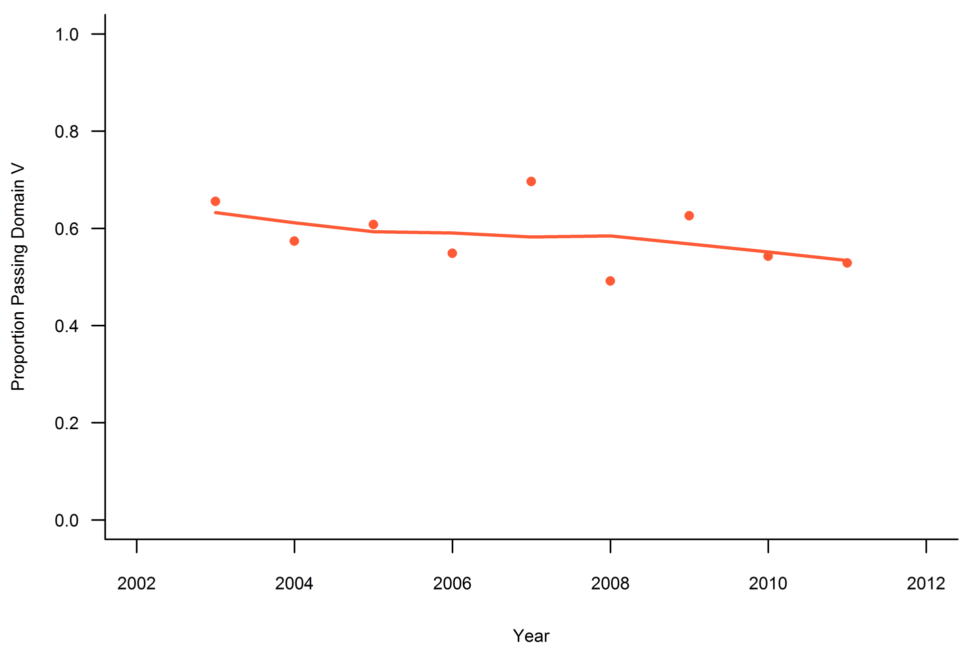
This assessment demonstrates that differences exist between the overall test passers and test failers in domains V and VI. From this point, I focused strictly on the individuals that passed the overall exam because they will be eligible to teach in Texas public schools. Additionally, this information communicates that the test failers are in need of remediation.

Domain V and VI Findings for those Passing the Exam

Regarding the proportion of people demonstrating minimum proficiency in domain V given that they passed the overall test: the plot (Figure 3) of the proportion examinees scoring at or above 240 in domain V does appear to indicate the trend that fewer are proficient in domain V as the years pass; this trend is not statistically significant at the usual 0.05 alpha level (effect= -0.0103; t= -1.261; p= 0.2477). Thus, we can conclude that no evidence exists of a trend in the proportion of people passing the domain V test, given that the person passed the full test. The maximum proficiency proportion occurred in 2007, when 69.6% of the test passers scored 240 or above on the domain V test. The minimum proportion took place in 2008, when 49.2% scored above 240 on domain V. (See Figure 3).

Figure 3

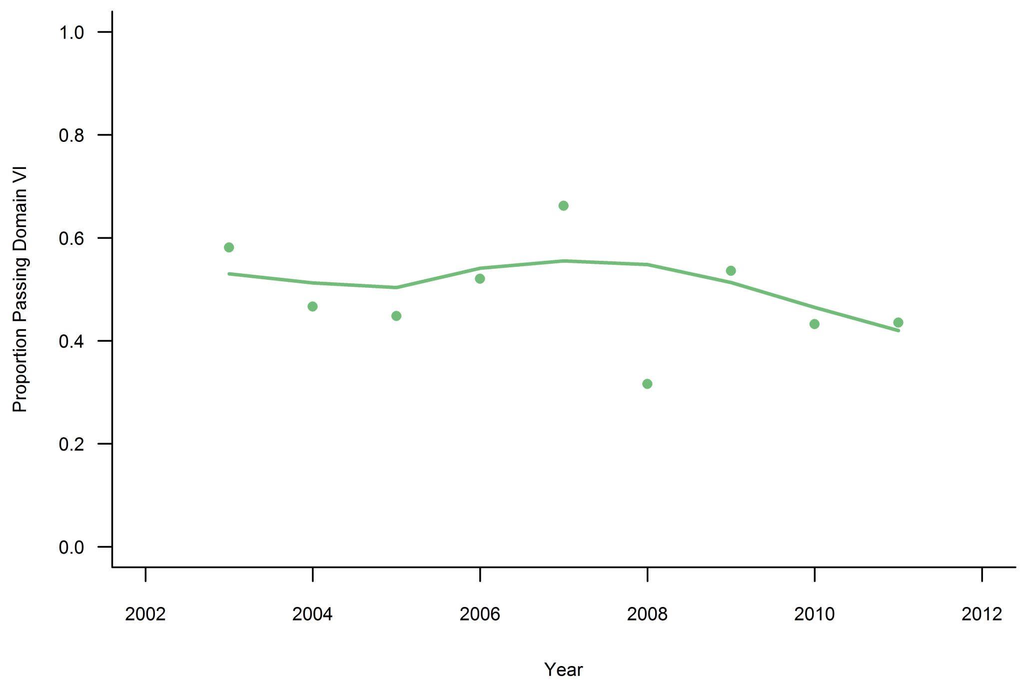
Proportion of Examinees Proficient in Domain V that Passed the Test



Regarding the proportion of people passing domain VI given that they passed the test: the plot (Figure 4) of the proportion passing domain VI does appear to indicate a trend that fewer people are proficient in domain VI as the years pass; this is not statistically significant at the 0.05 alpha level (effect=-0.0119; t=-0.913; p=0.3916). We can conclude that no evidence exists of a trend in the proportion of people passing domain VI, given that the person passed the full test. Similar to the domain V findings, the year with the maximum proportion passing domain VI was 2007 at 66.2%; the minimum year was 2008 with 31.6%. (See Figure 4).

Figure 4

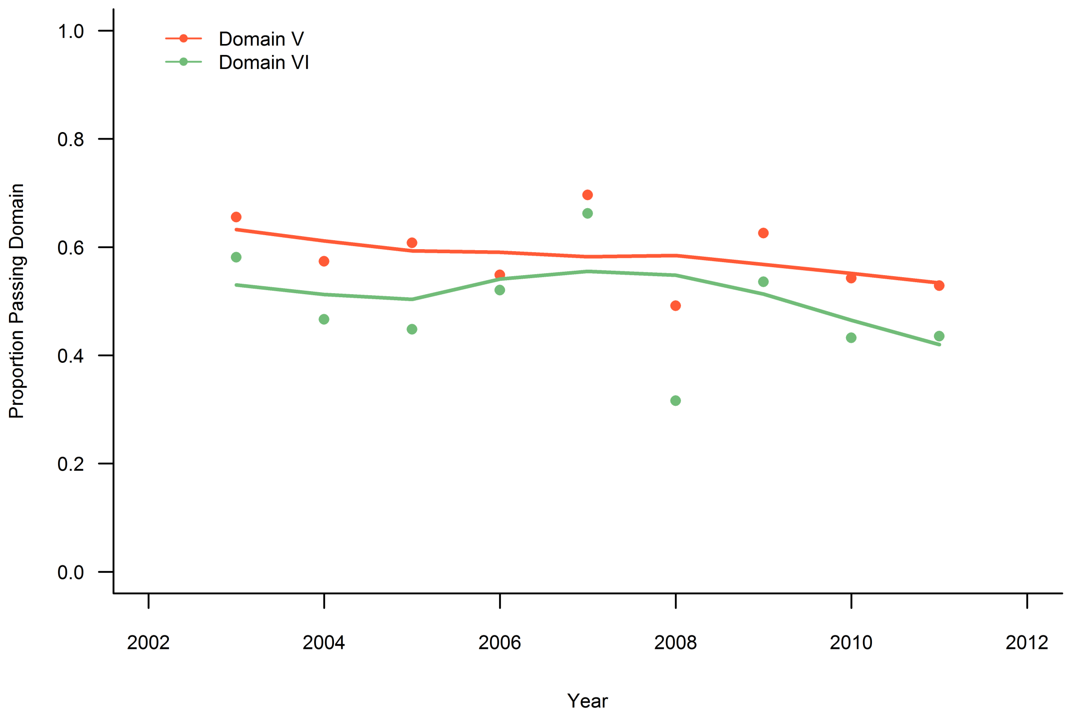
Proportion of Examinees Proficient Domain VI that Passed the Test



The proportion of test passers that demonstrated proficiency domain V was always higher than the proportion proficient domain VI during this nine-year period. This trend communicates that examinees were able to continuously demonstrate greater content curricular strengths in the environmental science strand over the how to teach science and assess science learning. As shown in Figure 5, when domain V performance graph is overlaid with domain VI performance, examinees consistently performed higher in domain V.

Figure 5

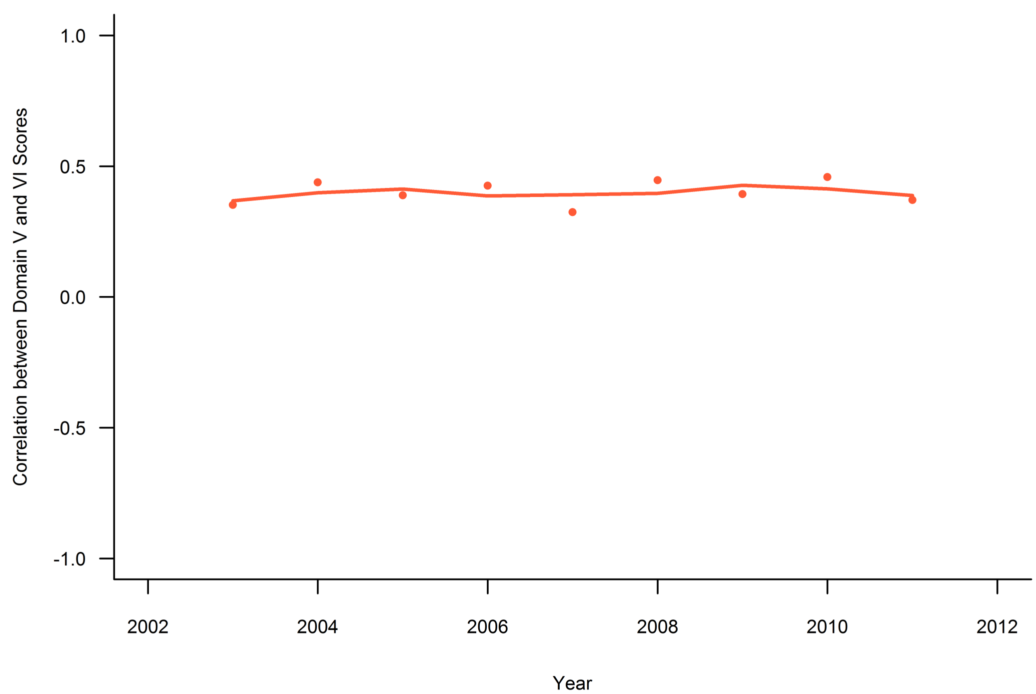
Comparison of Domain V and VI Pass Rates



The correlation between domain V and domain VI scores, given that they passed the test was very consistent throughout the time testing time period. (See Figure 6). Those who demonstrated proficiency in domain V, given that they passed the test, scored significantly higher on domain VI (25.1-point difference, on average). Similarly, those who demonstrated proficiency in domain VI also scored significantly higher on domain V than those who did not pass the overall exam (24.6-point difference, on average). Both of these findings are statistically significant at the 0.05 alpha level (p << 0.0001 in both cases). Furthermore, the average score on domain V was 1.3% higher than the score on domain VI; that is, test passers performed better in domain V than in domain VI.

Figure 6

Correlation between Domain V and VI Scores



When looking only at those who passed the test and demonstrated competency in domain V, the correlation between the domain V score and the domain VI score remains statistically significant (rho=0.409; t=24.785; $p \ll 0.0001$). The minimum correlation was rho=0.324 (2007); the maximum, 0.459 (2010). This correlation is important and shows that on average, educators who do well in both domains will have greater potential for impacting learning in the classroom. These educators have demonstrated their proficiency in the introductory content strands required of the beginning teacher. Furthermore, the annual correlation changed little in the time period of this study. The strength of correlation coefficient relates association between two variables; the closer the coefficient is to one, the stronger it is (Ott and Longnecker, 2001). A correlation of zero indicates that no relationship exists between the two variables.

Educators who perform well in domains V and VI may not struggle with content and are more likely to engage students in richer experiences because their understanding of the materials is greater. For example, an educator who struggles with a concept, like ecological succession, will be more inclined to give the students a quick overview of the concept and move on to the next subject without fully assessing whether the students have mastered the learning objective. The teacher has "covered" the concept in their mind but the students know no more than they did initially.

When looking at the difference in scores over time, a deficit pattern emerges. Each year, the domain V and VI scores are lower than the average pass score for all test passers. The negative number indicates that the total score for the exam is higher than the domain score. In each case, the p-value is less than 0.0001 in all cases. Thus, a significant difference does exist in each testing year between the mean test score and the mean domain V score. A significant difference exists in each testing year between the mean test score and the mean domain VI score. Figure 7 shows this the information in Table 11 graphically.

Table 11

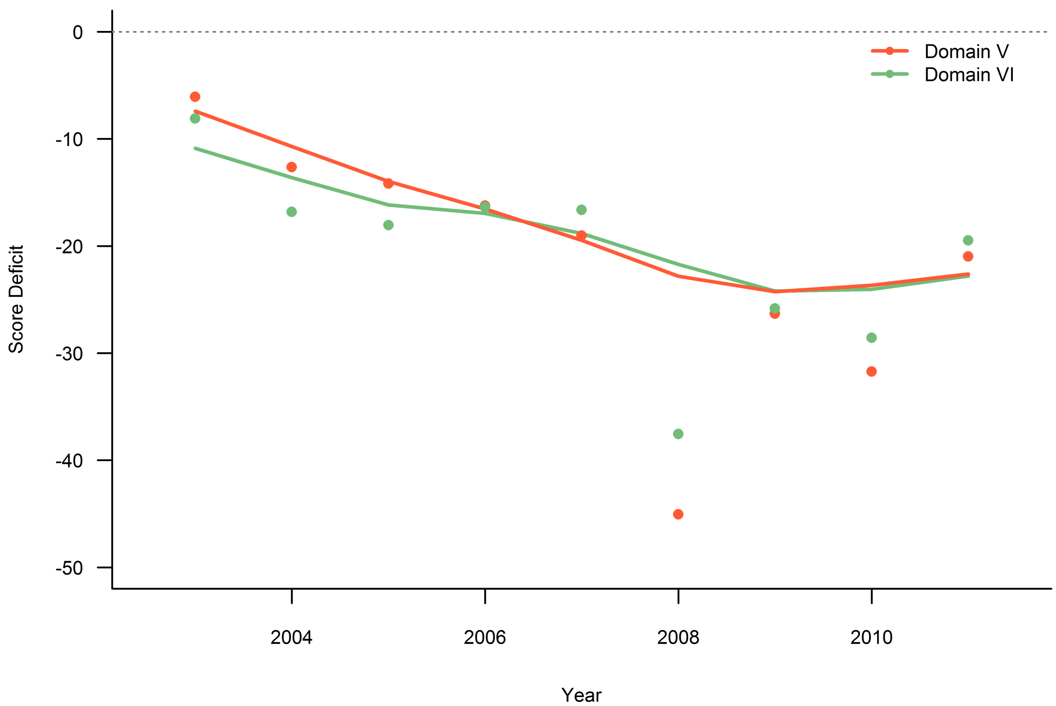
Table of Deficits for Domain against Total Score

Year	Domain V	Domain VI
2003	-6.066801	-8.089975
2004	-12.633107	-16.810649
2005	-14.176381	-18.059008
2006	-16.23936	-16.37133
2007	-19.033743	-16.619633
2008	-45.051193	-37.553742
2009	-26.325268	-25.830173
2010	-31.713762	-28.580655
2011	-20.97311	-19.474488
All	-13.5657	-18.87754

As seen in Figure 7, the Lowess curve shows the general performance trend in domains V and VI over time. The points reflected in Table 11 and graphed in Figure 7, show how far below the total test score examinees scored on average in the given domains. A steady decline in performance on domains V and VI, with a rise in 2007 and a large drop in 2008, has been observed and depicted in the graph. The zero line represents the overall exam score and shows how domain performance compares to the overall exam performance. During the time period 2003-2011, examinees consistently scored lower on domains V and VI than the other four domains on the test. This further communicates that test subjects have demonstrated, overall, a weakness in environmental science content knowledge and the knowledge of how to teach and assess students for science learning.

Figure 7

Lowess Curve: Annual Score Deficit for Domains V and VI



The tested hypotheses are:

Null:

H1: No significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2: No significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess student learning in science.

Alternative:

H1a: A significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2a: A significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess student learning in science.

At the 95% confidence level, we can safely reject H1: no significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge. (Table 12). A significant difference does exist between the mean scores of those passing the exam and the mean scores of domain V. Whereas the educator passed the content exam, they still demonstrate an instructional content area of need. On average, domain V scores were lower than the total exam scores during the nine-year period. Educators who passed the exam, on average, exhibit weakness in domain V. When examining average scores throughout the nine-year period, domain V average scores were consistently second to last out of the six content domains. Environmental science content is an area that certified life science educators struggled with consistently during the first nine-years of test administration.

Table 12

Test statistics for Total Score – Domain V Score

Year	Test Name	Test Statistic	Degrees of Freedom	p-value
all years	Paired t-test	59.2417	5258	<<0.0001
2003	Paired t-test	-6.066801	295	<<0.0001
2004	Paired t-test	-12.633107	522	<<0.0001
2005	Paired t-test	-14.176381	537	<<0.0001
2006	Paired t-test	-16.23963	608	<<0.0001
2007	Paired t-test	-19.033743	618	<<0.0001
2008	Paired t-test	-45.051193	654	<<0.0001
2009	Paired t-test	-26.325268	777	<<0.0001
2010	Paired t-test	-31.713762	714	<<0.0001
2011	Paired t-test	-20.97311	525	<<0.0001

At the 95% confidence level, we can safely reject H2: no significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach and assess science learning for students

(Table 13). A significant difference does exist between the mean scores of those passing the exam and the mean scores of domain VI. Whereas the educator passed the content exam, they still demonstrate an instructional content area of need. On average, domain VI scores were lower than the total exam scores during the nine-year period. Educators who passed the exam, on average, exhibit weakness in domain VI. When examining average scores throughout the nine-year period, domain VI average scores were consistently last out of the six content domains. Educators struggled consistently with how to teach science and assess student in science during the first nine-years of test administration.

Table 13

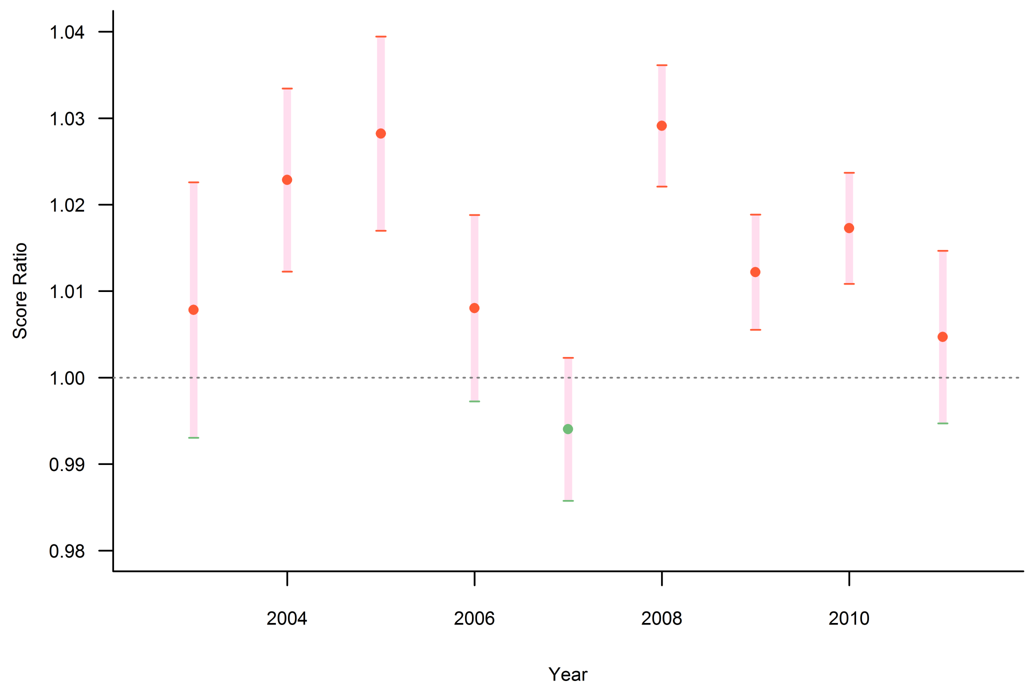
Test statistics for Total Score – Domain VI Score

Year	Test Name	Test Statistic	Degrees of Freedom	p-value
all years	Paired t-test	60.665	5258	<<0.0001
2003	Paired t-test	-8.089975	295	<<0.0001
2004	Paired t-test	-16.810649	522	<<0.0001
2005	Paired t-test	-18.059008	537	<<0.0001
2006	Paired t-test	-16.37133	608	<<0.0001
2007	Paired t-test	-16.619633	618	<<0.0001
2008	Paired t-test	-37.553742	654	<<0.0001
2009	Paired t-test	-25.830173	777	<<0.0001
2010	Paired t-test	-27.580655	714	<<0.0001
2011	Paired t-test	-19.474488	525	<<0.0001

One last analysis: when comparing the ratio of raw domain V scores to raw domain VI scores, the domain V scores tend to be higher. This difference in scores, domain V higher than domain VI, is statistically significant in years 2004, 2005, 2008, 2009, and 2010. This further emphasizes that examinees tend to do slightly better with environmental science content versus how to teach and assess student learning in science. At the 95% confidence level, I am confident that the scores are not statistically different in testing years: 2003, 2006, 2007, and 2011. The educators were able to demonstrate their proficiency fairly consistently in those years in the two domains of interest (See Figure 8). The ratio of the average domain V scores to the average domain VI scores is depicted in Figure 8. The points are the actual ratio. The bars indicate the usual 95% confidence interval. If the interval contains the 1.00 value, then no statistically significant difference exists between the two domain scores. If the bar does not contain the 1.00 value, then the conclusion is (at the alpha = 0.05 level, with 95% confidence) that a statistically significant difference occurs between the two domain scores.

Figure 8

Score Ratio Graph: Average Domain V Score to Average Domain VI Score



Summary

The research goal of this study was to evaluate Texas secondary life science educators, who became certified in the years 2003 to 2011, proficiency levels in environmental science (ES) content knowledge and beginning knowledge of how to teach science and assess science learning. Additionally, this study sought to determine if a strong, positive correlation exists between performance on domain V (environmental science content knowledge) and domain VI (knowledge of how to teach science and assess science learning).

This research study used quantitative, non-experimental research methods to measure differences among means to determine if the differences are statistically significant. Statistical significance was based at the 95% confidence level ($\alpha = 0 .05$). Significance of the test results was identified by p-values compared to the selected significance level. If $p > 0.05$, we fail to reject the null hypotheses, i.e. no significant difference exists; if $p < 0.05$, we reject the null hypotheses, i.e. a significant difference exists.

The evaluated research question is: did Texas secondary life science educators, who became certified in the years 2003 to 2011, demonstrate proficiency in environmental science (ES) content knowledge and beginning knowledge of how to teach science to students; and does a strong, positive correlation exist between performance on domain V (environmental science content knowledge) and domain VI (knowledge of how to teach science to students) for individuals who passed the exam?

The tested null and alternative hypotheses are:

H1: No significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2: No significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess student learning in science.

H1a: A significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2a: A significant difference exists between the TExES 138 life science exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess student learning in science.

The data used in this study were from the 12,832 examinees that took the TExES 138 life science 8-12 exam over a nine-year period. The results from the 5,259 individuals who passed the exam were utilized to test the hypotheses. The variables of interest were test year, total exam score, domain V score and domain VI score. Domains V and VI focus on environmental science content knowledge and how to teach and assess science learning respectively.

Initially, comparisons are made between the two large groups: those who passed the test and those who did not pass the test. I wanted to determine if differences existed in the variables of interest for the two groups. Once this was determined, I focused solely on the individuals who passed the exam to identify areas of strength and weakness.

The R-Statistical Computing Program was used to conduct all statistical tests and produce graphs. The t-test measure was selected for its statistical robustness. In both cases, the null hypotheses were rejected at the $\alpha = 0.05$ level, indicating that a significant difference exists between the exam mean scores and domain V mean scores as well as the exam mean scores and domain VI.

CHAPTER IV

FINDINGS

Introduction

This research project focused on the assessment of the overall question: did Texas secondary life science educators, who became certified in the years 2003 to 2011, demonstrate proficiency in environmental science (ES) content knowledge and beginning knowledge of how to teach science and assess science learning; and does a strong, positive correlation exist between performance on domain V (environmental science content knowledge) and domain VI (knowledge of how to teach science and assess science learning)?

This study examined educator exam results for the TExES 138 life science 8-12 exam. This subject matter content exam allows educators to teach all life science high school courses. Whereas environmental science is the subject of this dissertation, Texas does not require high school students to take courses in environmental science to graduate. All high school students are required to take a minimum of two science courses for the minimum credit diploma: biology and chemistry. To graduate with a recommended or distinguished diploma, students must take four science courses, three of which are specified by the Texas graduation plan: biology, chemistry, and physics. Biology is the gateway course for high school science. All students must successfully pass biology before advancing to the next level of science. Biology has the environmental science *Texas Essential Knowledge and Skills*. Teachers, new to the profession, are typically assigned introductory level courses like biology.

The TExES 138 life science 8-12 educator exam consists of six content domains. Domain I focuses on scientific inquiry and processes; domain II focuses on cell structure and processes; domain III pertains to heredity and the evolution of life; domain IV assesses the diversity of life; domain V covers the interdependence of life and environmental systems; and domain VI covers science learning, instruction and assessment. Performance in domains V and VI are of interest in this research study.

Data used for this study were extracted from the 12,832 individuals that registered and took the TExES 138 life science 8-12 exam. Individuals that passed the exam, 5,259 or 41% of the 12,832, became the population of interest and their results were used to conduct the study. These individuals were selected because they will be eligible to teach science courses that contain environmental science curricula in secondary schools. The four variables of interest were: test year, test score, domain V score, and domain VI score.

T-tests were used to analyze the difference in means; the exam mean scores were compared to domain mean scores. Domain V and VI scores for exam passers were analyzed to determine if a positive correlation exists between the two domains. A total exam score of 240 indicates that an individual passed the exam. A score of 240 in each domain was used to indicate that an individual performed at the 80% level (same level required to pass the exam). Summary statistics and statistical tests were gathered for each testing year to identify trends in educator proficiency.

The tested hypotheses are:

Null:

H1: No significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2: No significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess science learning.

Alternative:

H1a: A significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

H2a: A significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess science learning.

Results

The statistical tests for null hypotheses one and two resulted in p-values much less than 0.05. The null hypotheses can be rejected at the 95% confidence level and accept the alternative hypotheses. The accepted hypotheses are:

> H1a: A significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain V which assesses environmental science content knowledge.

> H2a: A significant difference exists between the TExES 138 life science 8-12 exam mean scores of educators passing the exam and the mean scores of domain VI which assesses how to teach science and assess science learning.

The significant difference between an examinee's total mean score and mean scores on domain V and VI can be interpreted as educators, as shown in this research, are weaker in those content domains. Performance in these two domains over the nine-year period was lower than the overall exam score. Examinees will potentially struggle with teaching environmental science content as well as struggle successfully teaching and assessing students for science learning. Examinees who passed the exam tended to score lower in domain V and lowest in domain VI each testing year.

These results are important to school districts, educator preparation programs, and the Texas Education Agency. Educators who have content weaknesses are granted access to classrooms to teach materials in which they are not yet proficient.

The correlation between domain V scores and domain VI scores is statistically significant and positive. This means that an individual who performed well in domain V also performed better in domain VI. The trend for this group of educators is a weak, positive correlation. A weak, positive correlation tells us that the educators who know their content will do a better job in transferring that knowledge to students. Together, domain V and VI represent environmental science pedagogical content knowledge.

As the overall results show, lower performance in domain V indicates that newly certified teachers have an area of need that must be strengthened. By strengthening domain V experiences for educators, educator preparation programs can ensure that their students get a deeper understanding and experience in environmental science at the onset of an educator's career. The same reasoning can be applied to domain VI that focuses on how to teach and assess student learning in science.

Conclusions

Texas educators certified through the TExES 138 life science 8-12 exam, in the years 2003-2011, results were evaluated in this study. It was determined that the difference in means between passing the test and mean scores in domains V and VI were statistically significant when compared to the mean exam scores in each testing year. On average, the educators certified during this time period demonstrated content areas where they may require additional support. The TExES exams communicate whether or not beginning teachers have the requisite knowledge and skills.

Additional research studies must be developed to determine the point in a new teacher's career where the domain deficiencies begin to subside or determine if they ever subside. School districts should implement professional development support and mentoring programs specifically designed to assist new, beginning teachers with content needs where initial deficiencies have been identified. By addressing the areas of need early in the educator's career, greater opportunities exist for the educator to strengthen their knowledge as well as provide students with deeper experiences with the content. The overall goal of this project is to raise awareness for environmental literacy and I argue that educators play a vital role in increasing environmental literacy. Additionally, further research is needed to determine the specific competencies in environmental science where educators need additional support. The same is true for domain VI.

Assumptions

This researcher makes the following assumptions regarding the data:

- No mistakes were made in transferring the data from the Excel spreadsheet to the database; from the database back to the Excel spreadsheet; from the Excel spreadsheet to the statistical program.
- The data raw data provided by the Texas Education Agency represents the TExES 138 life science 8-12 exam.
- Educators took the exam seriously and answered questions accurately based on their knowledge of content
- The proficiency standard in a domain score was 240.

- The TExES 138 life science 8-12 exam is an accurate measure of the environmental science *Texas Essential Knowledge and Skills*.

This study is meant to identify trends in environmental science proficiency of newly certified Texas life science educators. The study is aimed at improving environmental science literacy for all students in Texas. To improve student environmental science literacy, educator science content proficiency must be thoroughly understood. This study hopes to open the door for further exploration of the educator certification process so that Texas continues to set positive trends in education for the nation. This study does not consider educators who have been teaching for extensive periods of time. It only looks at trends of educators entering the field i.e. those taking their initial certification exam in life science. Once an educator passes a content exam, they do not have to take it again, ever, as long as they maintain their certification.

CHAPTER V

CONCLUSION

Overview

This quantitative research project assessed the overall question: did Texas secondary life science educators, who became certified in the years 2003 to 2011, demonstrate proficiency in environmental science content knowledge and beginning knowledge of how to teach science and how to assess science learning; and does a strong, positive correlation exist between performance on domain V (environmental science content knowledge) and domain VI (knowledge of how to teach science and assess science learning) for individuals who passed the exam?

Texas educators certified through the TExES 138 life science 8-12 exam, in the years 2003-2011, results were evaluated in this study. It was determined that the difference in means between passing the test and mean scores in domains V and VI were statistically significant when compared to the mean exam scores in each testing year. On average, the educators certified during this time period demonstrated content areas where they may require additional support. The TExES exams communicate whether or not beginning teachers have the requisite knowledge and skills.

The significant difference between an examinee's total mean score and mean scores on domains V and VI can be interpreted as educators, on average, are weaker in environmental science content and the knowledge of how to teach and assess science learning. Performance in these two domains over the nine-year period was consistently lower than the overall exam score.

Certified educators will potentially struggle with teaching environmental science content as well as struggle with successfully teaching and assessing students for science learning. Mean scores in domains V and VI were consistently in 5th and 6th place each testing year out of the six domains assessed on the exam. This indicates that the individuals certified during this time period have curricular areas where they need additional support.

The correlation between domain V scores and domain VI scores is statistically significant and positive. This means that an individual that performed well in domain V also performed better in domain VI. The relationship for this group of educators is a weak, positive correlation. Together, domain V and VI represent environmental science pedagogical content knowledge.

As the results show, lower performance in domain V indicates that newly certified teachers have an area of need that should be strengthened. By strengthening domain V for educators, educator preparation programs can ensure that students get a deeper understanding and experience in environmental science at the onset of an educator's career. The teachers will be able to improve students' understanding of the environment and raise environmental literacy levels.

The results show that domain VI is an area of need that should be strengthened. By strengthening domain VI for educators, educator preparation programs can ensure that their students get a deeper understanding and experience in science. The teachers will then be able to teach science with a higher degree of certainty and use teaching methods that will cause students to explore and learn science aspects more rigorously.

Abell, Park Rodgers, Hanuscin, Lee, & Gagnon (2009) state that "explicit attention to developing knowledge for teaching science teachers" is an important goal of teacher preparation programs (p. 78). "Knowing science is a necessary but not a sufficient condition for teaching. Science teachers must also have knowledge about science learners, curriculum, instructional strategies, and assessment through which they transform their science knowledge into effective teaching and learning" (Abell et al., 2009, p.79). Science teachers must know the curriculum as well as how to make the information palatable for students.

Summary

Environmental science literacy is a cause worthy of pursuing in educational institutions. It is important to have an environmentally literate populace. As the human population continues to rapidly grow, science classrooms need to have educators that are able to educate the masses as they matriculate through the systems. Schools have a substantial role ahead to eradicate science literacy deficiencies. As reported in this research, Texas still has a shortage of quality science educators. This translates into a strain on the educational system when teachers are not well trained in the subjects they teach. Of greater concern and pointed out in this research, individuals that have curricular weaknesses are able to gain entry into the classrooms. The certification process should be made more robust so that educators get the support they need early in their career.

The study assessed whether Texas secondary life science educators, certified from 2003 to 2011, demonstrated proficiency in environmental science content knowledge and the knowledge of how to teach science. A multitude of factors influence student learning; the educator is the single most important factor when compared to community, socioeconomic status, and home environment. An educator's preparedness is their knowledge of the subject matter content that they will in turn impart to students. An educator should have the prerequisite content knowledge and science teaching skills themselves before they are able to thoroughly share knowledge with the students.

Biology is the gateway high school science course and is required of all high school students in Texas to graduate (Table 4, p. 30). It is possible for students to graduate without taking additional science classes that exposes them to elements of environmental science. The TExES 138 life science exam was chosen for this study because the environmental science standards received the greatest coverage for educator preparedness of the certificates allowing an educator to teach biology.

As Texas legislators continue to mandate more rigorous testing and student accountability, the role of the Texas science teacher becomes increasingly important. The new side-by-side graduation plan, end of course exams and the new State of Texas Assessment of Academic Readiness (STAAR) exam all show students that must have excellent teachers to ensure they are ready to face the rigorous testing standards awaiting them in high schools. Beyond the high school environment, schools prepare students for life. By ensuring that every classroom has an educator that is vetted in content and pedagogy, Texans will know that their students are prepared to face future challenges. Colleges, universities, and employers are continuously communicating to high schools that they need students that are better prepared for the challenges that await them.

Conclusions

Environmental science researchers state the criticality of having an environmentally literate populace. Pace et al. (2010) argue that communicating to the public and policy makers about environmental issues is an important aspect of ecologists' careers. They recognize the rapid changes in the environment and the need to improve public understanding of science (p. 292). This call transcends directly into public schools; the people of Texas are entrusting schools to produce literate students necessary to sustain an excellent quality of life. Educators new to the field need to take their role seriously and perform the tasks as no other individual can.

To ensure that science teachers are prepared to teach students, educator preparation programs should equip future teachers with the knowledge and skills that will allow them to be successful in the classroom. Future teachers need curricular experiences that provide both macroscopic and microscopic understandings of environmental science and what it takes for students to learn science. Goodwin (2010) writes, “teacher preparation is a transition between what one has been in the past and will be in the future” (p 23). Future teachers will also need experiences in environmental science that allows them to continue developing their craft and create opportunities for students to learn. Our students deserve our very best teachers and teaching.

The Texas Academy of Science was established in 1892 and has been advocating for science education since that time. The current membership is composed of approximately 1,000 scientists and educators whose passion is advancing scientific knowledge. The Texas Academy of Science posted a position statement on science teacher certification:

> The current Texas teacher certification standards are too low to ensure adequately prepared science teachers. In a time when Texas is raising the academic standards for students, an even greater need exists for well-prepared teachers. Additionally, it is a time of science teacher shortage and growing need in our nation for graduates who have a stronger science background. Teachers who are well prepared are more likely to remain in the teaching profession and their students will have higher academic achievement. (TAS, 2012)

The role of the teacher is paramount in education and sets the stage for future discoveries and continued learning. Learner centered instruction will continue to be an effective method of teaching that engages both the teacher and the student in discovery (Park, Hewson, Lemberger, & Marion, 2010). Science teachers have a critical role to play as the rural countryside continues to erode away and morph into city suburbs. Earth does not depend on humans to carry out its necessary cycles and functions. Humans live at the mercy of Earth systems. Having an understanding of the basic tenets of environmental science can improve one's quality of life as well as the quality of life for other species.

Limitations

This study is limited to the educators' performance on the TExES 138 life science 8-12 exam. No college transcripts or professional trainings information is associated with this research data; it is not possible to ascertain how much environmental science preparation each individual received in their particular educator preparation program. This study is also limited in knowing the specific competencies where educators were weak.

This study examined raw test data for the nine-year period. No delineation was made between the types of educator preparation program through which an individual matriculated (university-undergraduate, university post-baccalaureate, alternative, or out of state). This research identified areas of weakness on a macro-scale did not conduct research into why those weaknesses exist.

This study is limited to the TExES 138 life science 8-12 exam. Further research will need to be conducted to determine if similar trends exist in the other secondary science certification exams.

Recommendations for Further Study

Secondary science teachers need greater preparation in environmental science content as well as greater understanding of how to teach science and assess science learning. It is recommended that Texas Educator Preparation programs review their life science vetting process in environmental science preparation and science pedagogy. The overall percentages of individuals that emerged in this study having passed the overall exam, domain V, and domain VI are low. How are individuals that have recently exited a life science preparation program only able to pass at a 40% rate each year? Under the current education structure in Texas, it is imperative that life science educators are well prepared to ensure that student learning is maximized and extended for the students. Educators should be comfortable with the content themselves to fully engage the students with the content.

It is recommended that the Texas Education Agency and the State Board for Educator Certification review its current certificate procedures. As illustrated in this research, individuals may completely fail a domain and be granted a certificate that allows them to teach the content strand. This process perpetuates literacy deficits when a teacher is weak in an area. The State should provide feedback to the certification venues to communicate weaknesses and strengths in their specific preparation programs. This feedback is a critical component to improving science literacy in schools. If the certification programs are able to provide improved instruction to the future teachers, they will be able to instruct their students at a much higher level. A similar trend may exist in other content areas.

The feedback from the State on how well the educator preparation programs are doing by subject test and domain may also assist in closing the critical need teacher shortage. The *National Science Teacher Association* stated that science continues to suffer from a lack of qualified teachers. The highly specialized courses at the secondary level require greater content knowledge because of the highly content-specific science courses offered in high schools. It is imperative that educators are proficient in their content areas as well as appropriate methodologies to transfer this information to students.

Educators should work to reduce the substantial deficit in the general environmental science knowledge of most citizens. Understanding the nature of the environment is critical. Individuals increase their chances of survival when they can recognize and understand the natural processes of Earth.

Results from this study

Results from this study provide critical information to life science educator preparation programs. These results show that educators are demonstrating consistent weakness in two domains after just exiting the preparation program.

Results from this study will show school districts that they need to review certification exam results so that professional development activities are aligned with areas of need for educators. Mentors are an excellent venue for supporting new teachers. The utilization of each individual's exam results will allow pairings based on need, not simply who is available to mentor. Tsui (2009) states that novice teachers should be paired with veteran teachers that have demonstrated mastery of pedagogical skills.

Educator preparation programs should utilize these results to improve the experiences and curriculum for individuals desiring to be teachers. If our teachers are better prepared, then the learning experiences of the students will be richer. Strawn, Fox, and Duck (2008) report, "Preparing skillful, knowledgeable teachers who meet the needs of diverse learners in today's classrooms is both a goal and a necessity for public schools" (p. 271).

REFERENCES

Abell, S. K., Park Rodgers, M. A., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the next generation of science teacher educators: A model for developing pck for teaching science teachers. *Journal of Science Teacher Education, 20*, 77-93. doi:10.1007/s10972-008-9115-6

Brownstein, E. M., Allan, E., Ezrailson, C. M., Hagevik, R. A., Shane, J. W., & Veal, W. R. (2009). Alignment of the 2003 nsta standards for science teacher preparation with the ncate assessment system. *Journal of Science Teacher Education, 20*, 403-413. doi:10.1007/s10972-009-9143-x

Brownstein, E. M., Allan, E., Hagevik, R., Shane, J., & Veal, W. (2009). Understanding and using the 2003 nsta science teacher preparation standards for ncate accreditation or state approval. *Journal of Science Teacher Education, 20,* 307-311. doi:10.1007/s10972-009-9139-6

Cabrera, D., Mandel, J. T., Andras, J. P., & Nydam, M. L. (2008). What is the crisis. Defining and prioritizing the world's most pressing problems. *Frontiers in Ecology and the Enviornment, 6*(9), 469-475. doi:10.1890/070185

Cakir, M., Irez, S., & Dogan, O. K. (2010). Understandings of current environmental issues: Turkish case study in six teacher education colleges. *Educational Studies, 36*(1), 21-33. doi:10.1080/03055690903148522

Chapin, F. S., Carpenter, S. R., Kofinas, G. P., Folke. C, Abel, N., Clark, W. C., … & Swanson, F. J. (2010). Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. *Trends in Ecology and Evolution, 25*(4), 241-249.

Childs, A., & McNicholl, J. (2007). Science teachers teaching outside subject specialism: Chllenges, strategies adopted and implications for initial teacher education. *Teacher Development, 11*(1), 1-20. doi:10.1080/13664530701194538

Dani, D. (2009). Scientific literacy and purposes for teaching science: A case study of Lebanese private school teachers. *International Journal of Environmental & Science Education, 4*(3), 289-299.

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research, 76*(4), 607-654.

Disinger, J. F. (2001). K-12 education and the environment: Perspectives, expectations, and practice. *The Journal of Environmental Education, 33*(1), 4-11.

ETS TExES. (2011). http://www.ets.texes.org

Fang, Z. (2005). Scientific literacy: A systemic functional linguistics perspective. *Science Education, 89*(2), 335-347.

Feinstein, N. (2011). Salvaging science literacy. *Science Education, 95*(1), 168-185.

Goodwin, A. L. (2010). Globalization and the preparation of quality teachers: Rethinking knowledge domains for teaching. *Teacher Education, 21*(1), 19-32. doi:10.1080/10476210903466901

Hagevik, R., Veal, W., Brownstein, E. M., Allan, E., Ezrailson, C., & Shane, J. (2010). Pedagogical content knowledge and the 2003 science teacher preparation standards for ncate accreditation or state approval. *Journal of Science Teacher Education, 21*, 7-12. doi:10.1007/s10972-009-9155-6

Harrell, P. E. (2010). Teaching an integrated science curriculum: Linking teacher knowledge and teaching assignments. *Issues in Teacher Education, 19*(1), 145-165.

He, Y., Levin, B. B., & Li, Y. (2011). Comparing the content and sources of the pedagogical beliefs of Chinese and American pre-service teachers. *Journal of Education for Teaching, 37*(2), 155-171. doi:10.1080/02607476.2011.558270

Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental & Science Education, 4*(3), 275-288.

Hurd, P. D. (1958). Science Literacy: Its meaning in American schools. *Educational Leadership, 16*(1), 13-16, 52.

Jenkins, E. W. (2003). Environmental education and the public understanding of science. *Frontiers in Ecology and the Environment, 1*(18), 437-443.

Jordan, R., Singer, F., Vaughan, J., & Berkowitz, A. (2009). What should every citizen know about ecology. *Frontiers in Ecology and the Environment, 7*(9), 495-500. doi:10.1890/070113

Kennelly, J., Taylor, N., & Maxwell, T. W. (2008). Addressing the challenge of preparing Australian pre-service primary teachers in environmental education: An evaluation of a dedicated unit. *Journal for Education for Sustainable Development, 2*(2), 141-156. doi:10.1177/097340820800200211

Kenyon, L., Davis, E. A., & Hug, B. (2011). Design approaches to support preservice teachers in scientific modeling. *Journal of Science Teacher Education, 22,* 1-21. doi:10.1007/s10972-010-9225-9

Kuzmiak, D. T. (1991). The American environmental movement. *The Geographical Journal, 157,* 265-278.

Laugksch, R. C. (2000). Scientific literacy: A conceptual overview. *Science Education, 84*(1), 71-94.

Lemke, J. (2001). Foreword. In J. Wellington & J. Osborne (Eds.), Language and literacy in science education (pp. iv – v). Philadelphia, PA: Open University Press.

Lumpe, A. T. (2008). No science teacher left behind. *Journal of Science Teacher Education, 19*(4), 313-315.

McComas, W. F. (2002). The ideal environmental science curriculum: I. history, rationales, misconceptions & standards. *The American Biology Teacher, 64*(9), 665-672.

McComas, W. F. (2003). The nature of the ideal environmental science curriculum: Advocates, textbooks, I conclusions (Part II of II). *The American Biology Teacher, 65*(3)*,* 171-178.

McKeown-Ice, R. (2000). Environmental education in the United States: A survey of preservice teacher education programs. *The Journal of Environmental Education, 32*(1), 4-11.

Membiela, P., DePalma, R., & Suárez Pazos, M. (2011). A sense of place in the science classroom. *Educational Studies, 37*(3), 361-364. doi:10.1080/03055698.2010.506340

Mora, C., Tittensor, D. P., Adl, S., Simpson, A. G. B., & Worm, B. (2011). How many species are there on earth and in the ocean? *PLoS Biology, 9*(8), 1-8. doi:10.1371/journal.pbio.1001127

NASA (2011). National Aeronautics and Space Administration. http://www.nasa.gov

National Center for Education Statistics. (2011). http://nces.ed.gov

National Oceanic and Atmospheric Administration. (2012). http://www.noaa.gov

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academy Press.

National Science Teachers Association (2011). http://www.nsta.org

OECD Programme for International Student Assessment. (2010). http://www.pisa.oecd.org

Ott, R. L., & Longnecker, M. (2001). *An introduction to statistical methods and data analysis* (5th ed.). Pacific Grove, CA: Duxbury.

Pace, M. L., Hampton, S. E., Limburg, K. E., Bennett, E. M., Cook, E. M., Davis, A. E. … Strayer, D. L. (2010). Communicating with the public: Opportunities and rewards for individual ecologists. *Frontiers in Ecology and the Environment, 8*(6), 292-298. doi:10.1890/090168

Park, H., Hewson, P. W., Lemberger, J., & Marion, R. D. (2010). The interactions of conceptions of teaching science and environmental factors to produce praxis in three novice teachers of science. *Research in Science Education, 40*, 717-741. doi:10.1007/s11165-009-9141-1

Parlo, A. T., & Butler, M. B. (2007). Impediments to environmental education instruction in the classroom: A post-workshop inquiry. *Journal of Environmental Science & Education, 2*(1), 32-37.

Pilgrim, S. E., Cullen, L. C., Smith, D. J., & Pretty, J. (2008). Ecological knowledge is lost in wealthier communities and countries. *Environmental Science & Technology, 42*(4), 1004-1009.

Population Reference Bureau. (2011). http://www.prb.org

Porteous, A. (2008). Dictionary of environmental science and technology (4th ed.). West Sussex, England: John Wiley & Sons, Ltd.

Power, M. E., & Chapin, F. S. (2010). Planetary stewardship: With an introduction from the editor-in-chief. *Bulletin of the Ecological Society of America, 91*(2), 143-175. doi: 10.1890/0012-9623-91.2.143

Putwain, D., Whiteley, H., & Caddick, L. (2011). Thematic versus subject-based curriculum delivery and achievement goals: Findings from a single-school study. *Educational Research, 53*(4), 387-398. doi:10.1080/00131881.2011.625149

Reynolds, H. L., Brondizio, E. S., Robinson, J. M., Karpa, D., & Gross, B. L. (2010). *Teaching environmental literacy across campus and across the curriculum.* Bloomington, IN: Indiana University Press.

Robinson, M., & Crowther, D. (2001). Environmental science literacy in science education, biology & chemistry majors. *The American Biology Teacher, 63*(1), 9-14.

Rutherford, F. J. (2005). The 2005 paul f-brandwein lecture: Is our past our future? Thoughts on the next 50 years of science education reform in the light of judgments on the past 50 years. *Journal of Science Education and Technology, 1*(4)*,* 367-386. doi:10.1007/s1095600580823

Rutherfod, F. J., & Ahlgren, A. (1991). *Science for all Americans.* New York, NY: Oxford University Press.

Ryan, J., Scott, A., & Walsh, M. (2010). Pedagogy in the multimodal classroom: An analysis of the challenges and opportunities for teachers. *Teachers and Teaching, 46*(4), 477-489. doi:10.1080/13540601003754871

Salmon, J. (2000). Are we building environmental literacy? *The Journal of Environmental Education, 31*(4), 4-10.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of new reform. *Harvard Educational Review, 57*, 1-22.

Smith, M. K. (2008). Curriculum theory and practice. The Encyclopedia of Informal Education. Retrieved December 27, 2011, from http://www.infed.org/biblio/b-curric.htm

State Board for Educator Certification (2012). http://www.sbec.state.tx.us

Strawn, C. A., Fox, R. K., & Duck, L. (2008). Preventing teacher failure: Six keys to success in moving beyond the "sink or swim" mentality. *The Clearing House: A Journal of Educational Strategies, 81*(6), 271-277. doi:10.3200/TCHS.81.6.271-277

Subotnik, R. F., Tai, R. H., Rickoff, R., & Alamarode, J. (2010). Specialized public high schools of science, mathematics, and technology and the stem pipeline: What do we know now and what will we know in 5 years? *Roeper Reivew, 32,* 7-16. doi:10.1080/02783190903386553

Texas Association of School Boards. (2012). Texas districts face acute shortage of secondary math and science teachers. http://www.tasb.org/services/hr_services/hrexchange/2009/March09/texas_districts_face.aspx

Texas Education Agency (2010). Guidance for the implementation of nclb highly qualified teacher requirements. http://www.tea.state.tx.us

Texas Education Agency (2011). http://www.tea.state.tx.us

TExES (2011). Preparation manual: 138 life science. Retrieved from http://texes.ets.org/prepManuals

Tsui, A. B. M. (2009). Distinctive qualities of expert teachers. *Teachers and Teaching, 15*(4), 421-439. doi:10.1080/13540600903057179

United States Department of Education. (1983). A nation at risk: The imperative for educational reform. Washington, DC.

Wellington, J., & Osborne, J. (2001). Language and literacy in science education. Philadelphia, PA: Open University Press.

Wright, R. T. (2005). *Environmental science: Toward a sustainable future* (9th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

United Nations Environment Program. (2010). http://www.unep.org

U.S. Department of Education, Office of Planning, Evaluation and Policy Development. (2010). *ESEA Blueprint for Reform*. Washington, D.C.: US Government Printing Office.

U. S. Environmental Protection Agency. (2008). *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2008.* Washington, D.C.: US Government Printing Office.

APPPENDICES

Appendix A

TExES 138 Life Science Exam Domains

TExES 138 Life Science Exam Domains

Domain I—Scientific Inquiry and Processes

Competency 001—The teacher understand how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment and technologies.

Competency 002—The teacher understands the nature of science, the process of scientific inquiry and the unifying concepts that are common to all sciences.

Competency 003—The teacher understands the history of science, how science impacts the daily lives of students and how science interacts with and influences personal and societal decisions.

Domain II—Cell Structure and Processes

Competency 004—The teacher understands the structure and function of biomolecules.

Competency 005—The teacher understands that cells are the basic structures of living things and have specialized parts that perform specific functions.

Competency 006—The teacher understands how cells carry out life processes.

Competency 007—The teacher understands how specialized cells, tissues, organs, organ systems and organisms grow and develop.

Domain III—Heredity and Evolution of Life

Competency 008—The teacher understands the structures and functions of nucleic acids in the mechanisms of genetics.

Competency 009—The teacher understands the continuity and variations of traits from one generation to the next.

Competency 010—The teacher understands the theory of biological evolution.

Competency 011—The teacher understands evidence for evolutionary change during Earth's history.

Domain IV—Diversity of Life

Competency 012—The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

Competency 013—The teacher understands that, at all levels of nature, living systems are found within other living systems, each with its own boundaries and limits.

Competency 014—The teacher understands the processes by which organisms maintain homeostasis.

Competency 015—The teacher understands the relationship between biology and behavior.

Domain V—Interdependence of life and environmental systems

Competency 016—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

Competency 017—The teacher understands the interdependence and interactions of living tings in terrestrial and aquatic ecosystems.

Competency 018—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

Domain VI—Science learning, instruction and assessment

Competency 019—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

Competency 020—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

Domain V and VI In-Depth

Domain V—Interdependence of life and environmental systems

Competency 016—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

The beginning teacher:

A. Analyzes types, sources and flow of energy through different trophic levels (e.g., producers, consumers, decomposers) and between organisms and the physical environment in aquatic and terrestrial ecosystems
B. Analyzes the flow of energy and the cycling of matter through biogeochemical cycles (e.g., carbon, water, oxygen, nitrogen, phosphorus) in aquatic and terrestrial ecosystems.

C. Understands the concept of limiting factors (e.g., ligh intensity, temperature, mineral availability) and the effects that they have on the productivity and complexity of different ecosystems (e.g., tropical forest vs. taiga, continental shelf vs. deep ocean).

D. Explains the relationship among abiotic characteristics of different biomes and the adaptations, variations, tolerances and roles of indigenous plants and animals in these biomes.

Competency 017—The teacher understands the interdependence and interactions of living tings in terrestrial and aquatic ecosystems.

The beginning teacher:

A. Understands the concepts of ecosystem, biome, community, habitat and niche.

B. Analyzes interactions of organisms, including humans, in the production and consumption of energy (e.g., food chains, food webs, food pyramids) in aquatic and terrestrial ecosystems.

C. Understands interspecific interactions in aquatic and terrestrial ecosystems (e.g., predator-prey relationships, competition, parasitism, commensalism, mutualism) and how they affect ecosystem structure.

D. Identifies indigenous plants and animals, assesses their roles in an ecosystem and describes their relationships in different types of environments (e.g., fresh water, continental shelf, deep ocean, forest, desert, plains, tundra).

E. Analyzes how the introduction, removal or reintroduction of an organism may alter the food chain, affect existing populations and influence natural selection in terrestrial and aquatic ecosystems.

F. Evaluates the importance of biodiversity in an ecosystem and identifies the changes that may occur if biodiversity is increased or reduced in an ecosystem.

G. Understands the types and process of ecosystem change over time in terrestrial and aquatic ecosystems (e.g., equilibrium, cyclical change, succession) and the effects of human activity on ecosystem change.

H. Explains the significance of plants in different types of terrestrial and aquatic ecosystems.

Competency 018—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

The beginning teacher:

A. Identifies basic characteristics of populations in an ecosystem (e.g., age pyramid, density, patterns of distribution).

B. Compares concepts of population dynamics, including exponential growth, logistic (i.e., limited) growth and cycling (e.g., boom-and-bust cycles).

C. Relates carrying capacity to population dynamics, including human population growth.

D. Analyzes the impact of density-dependent and density-independent factors (e.g., geographic locales, natural events, diseases, birth and death rates) on populations.

E. Compares *r*- and *K*-selected reproductive strategies (e.g., survivorship curves).

Domain VI—Science learning, instruction and assessment

Competency 019—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

The beginning teacher:

A. Knows research-based theories about how students develop scientific understanding and how developmental characteristics, prior knowledge, experience and attitudes of students influence science learning.

B. Understands the importance of respecting student diversity by planning activities that are inclusive and selecting and adapting science curricula, content, instructional materials and activities to meet the interests, knowledge, understanding, abilities possible career paths and experiences of all students, including English-language learners.

C. Knows how to plan and implement strategies to encourage student self-motivation and engagement in their own learning (e.g., linking inquiry-based investigations to students' prior knowledge, focusing inquiry-based instruction on issues relevant to students, developing instructional materials using situations from students; daily lives, fostering collaboration among students).

D. Knows how to use a variety of instructional strategies to ensure all students comprehend content-related texts, including how to locate, retrieve and retain information from a range of texts and technologies.

E. Understands the science teacher's role in developing the total school program by planning and implementing science instruction that incorporates school-wide objectives and statewide curriculum as defined in the Texas Essential Knowledge and Skills (TEKS).

F. Knows how to design and manage the learning environment (e.g., individual, small-group, whole-class settings) to focus and support student inquiries and to provide time, space and resources for all students to participate in field, laboratory, experimental and non-experimental scientific investigation.

G. Understands the rationale for using active learning and inquiry methods in science instruction and how to model scientific attitudes such as curiosity, openness to new ideas and skepticism.

H. Knows principles and procedures for designing and conducting an inquiry-based scientific investigation (e.g., making observations; generating questions; researching and reviewing current knowledge in light of existing evidence; choosing tools to gather and analyze evidence; proposing answers, explanations and predictions; and communicating and defending results).

I. Knows how to assist students with generating, refining, focusing and testing scientific questions and hypotheses.

J. Knows strategies for assisting students in learning to identify, refine and focus scientific ideas and questions guiding an inquiry-based scientific investigation; to develop, analyze and evaluate different explanations for a given scientific results; and to identify potential sources of error in an inquiry-based scientific investigation.

K. Understands how to implement inquiry strategies designed to promote the use of higher-level thinking skills, logical reasoning and scientific problem solving in order to move students from concrete to more abstract understanding.

L. Knows how to guide students in making systematic observations and measurements.

M. Knows how to sequence learning activities in a way that uncovers common misconceptions, allows students to build upon their prior knowledge and challenges them to expand their understanding of science.

Competency 020—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

The beginning teacher:

A. Knows how to use formal and informal assessments of student performance and products (e.g., projects, laboratory and field journals, rubrics, portfolios, student profiles, checklists) to evaluate student participation in and understanding of inquiry-based scientific investigations.

B. Understands the relationship between assessment and instruction in the science curriculum (e.g., designing assessments to match learning objectives, using assessment results to inform instructional practice).

C. Knows the importance of monitoring and assessing students' understanding of science concepts and skills on an ongoing basis by using a variety of appropriate assessment methods (e.g., performance assessment, self-assessment, peer assessment, formal/informal assessment).

D. Understands the purposes, characteristics and uses of various types of assessment in science, including formative and summative assessments, and the importance of limiting the use of an assessment to its intended purpose.

E. Understands strategies for assessing students' prior knowledge and misconceptions about science and how to use these assessments to develop effective ways to address these misconceptions.

F. Understands characteristics of assessments, such as reliability, validity and the absence of bias in order to evaluate assessment instruments and their results.

G. Understands the role of assessment as a learning experience for students and strategies for engaging students in meaningful self-assessment.

H. Recognizes the importance of selecting assessment instruments and methods that provide all students with adequate opportunities to demonstrate their achievements.

I. Recognizes the importance of clarifying teacher expectations by sharing evaluation criteria and assessment results with students.

Appendix B

Open Records Request

Public Information Request Form

Date: October 13, 2011

Requestor Full Name: Linus J. Guillory, Jr.

Organization: Oklahoma State University, PhD Dissertation Research

Street Address: 1907 Ganyard Dr.

City/State/Zip: Houston Tx. 77043

Telephone Number:

Cell Number: 713-249-4006

Fax Number:

Email Address: linus.guillory@gmail.com

If available, would you accept an electronic format of the responsive documents? ☒**Yes** ☐**No**

Detailed Description of your request: I am conducting research for my dissertation. I request the TExES exam scores (passers and failers) with total test performance, performance by domain and performance by competency for exams: 92, 136, 137, and 138, 140. I need the information starting from the start of the TExES exam in 2002 through 2009. An excel spreadsheet is preferred for this information. I do not need nor want names, only the individual scores with associated performance in domains and competencies grouped by testing year i.e. 9/1 to 8/31. Please feel free to call or email with clarification questions.

***NOTE:** Certain exceptions to disclosure exist under the Texas Open Records Act to protect against the disclosure of confidential or privileged information. If it appears that an exception to disclosure exists, an opinion will be sought from the Office of Attorney General regarding your request.

You may submit the form by mail, fax, e-mail or in person:
Attn: Public Information Request Texas Education Agency William B. Travis Building 1701 N. Congress Avenue Austin, TX 78701-1494 Tel: (512) 463-9734 Fax: (512) 463-9838 Email pir@tea.state.tx.us

Appendix C

List of Educator Preparation Programs Authorized by SBEC to Issue

Life Science (8-12) Certificates

1	A Career in Teaching-EPP (Corpus Christi)
2	A Career in Teaching-EPP (McAllen)
3	A+ Texas Teachers
4	Abilene Christian University
5	ACT-Central Texas - Temple
6	ACT-Houston
7	ACT-Houston at Dallas
8	ACT-Rio Grande Valley
9	ACT-San Antonio
10	Alamo College
11	Alternative Cert for Teachers NOW! (El Paso)
12	Alternative-South Texas Educator Program (A-STEP)
13	Alternative-South Texas Educator Program - Laredo (A-STEP)
14	Angelo State University
15	Austin College
16	Baylor University
17	Blinn College Teacher Education Alternative Certification Host (TEACH) Program
18	College of the Mainland COMPACT
19	Collin County Community College
20	Concordia University
21	Dallas Baptist University
22	Dallas Christian College
23	Dallas ISD
24	East Texas Baptist University

25	Education Career Alternatives Program (ECAP)
26	eTeach N Texas
27	Hardin-Simmons University
28	Harris County Department of Education
29	Houston Baptist University
30	Houston Community College System (ACP)
31	Houston ISD
32	Howard Payne University
33	Huston-Tillotson University
34	IteachTEXAS
35	Jarvis Christian College
36	Lamar State College - Orange ACE Pgm
37	Lamar University
38	LeTourneau University
39	Lone Star College - Kingwood
40	Lubbock Christian University
41	McLennan Community College
42	McMurry University
43	Midwestern State University
44	Our Lady of the Lake University
45	Pasadena ISD
46	Paul Quinn College
47	Prairie View A&M University
48	Quality ACT: Alternative Certified Tchrs
49	Region 01 Education Service Center

50	Region 02 Education Service Center
51	Region 03 Education Service Center
52	Region 04 Educator Certification Services
53	Region 05 Education Service Center
54	Region 06 Education Service Center
55	Region 07 Education Service Center
56	Region 10 Education Service Center
57	Region 11 Education Service Center
58	Region 12 Education Service Center
59	Region 13 Education Service Center
60	Region 14 Education Service Center
61	Region 18 Education Service Center
62	Region 20 Education Service Center
63	Rice University
64	Sam Houston State University
65	Schreiner University
66	South Texas College - Alternative Certification Program (STAC)
67	South Texas Transition to Teaching Alternative Certification Program
68	Southern Methodist University
69	Southwestern Adventist University
70	Southwestern Assemblies of God University
71	Southwestern University
72	St Edward's University
73	St Mary's University

74	Stephen F Austin State University
75	Steps to Teaching - ACP
76	Sul Ross State University - Alpine
77	Sul Ross State University - Uvalde/Rio Grande
78	Tarleton State University
79	TeacherBuilder.com
80	Teachers for the 21st Century
81	Texas A&M International University
82	Texas A&M University
83	Texas A&M University - Central Texas
84	Texas A&M University - Commerce
85	Texas A&M University - Corpus Christi
86	Texas A&M University - Kingsville
87	Texas A&M University - San Antonio
88	Texas A&M University - Texarkana
89	Texas Alternative Certification Program
90	Texas Alternative Certification Program at Austin
91	Texas Alternative Certification Program at Brownsville
92	Texas Alternative Certification Program at Houston
93	Texas Alternative Certification Program at San Antonio
94	Texas Christian University
95	Texas College
96	Texas Lutheran University
97	Texas Southern University
98	Texas State University-San Marcos

99	Texas Teaching Fellows (San Antonio)
100	Texas Tech University
101	Texas Wesleyan University
102	Texas Woman's University
103	TMATE - Killeen
104	TMATE - Metroplex
105	TMATE - TSU
106	TNTP Academy - Fort Worth
107	Training via E-Learning: An Alternative Certification Hybrid (T.E.A.C.H.)
108	Trinity University
109	University of Dallas
110	University of Houston
111	University of Houston-Clear Lake
112	University of Houston-Downtown
113	University of Mary Hardin-Baylor
114	University of North Texas
115	University of North Texas - Dallas
116	University of St Thomas
117	University of Texas - Arlington
118	University of Texas - Austin
119	University of Texas - Brownsville
120	University of Texas - Dallas
121	University of Texas - El Paso
122	University of Texas - Pan American
123	University of Texas - Permian Basin

124	University of Texas - San Antonio
125	University of Texas - Tyler
126	University of the Incarnate Word
127	Wayland Baptist University
128	Weatherford College
129	Web-Centric Alternative Certification Program
130	West Texas A&M University
131	Wiley College

Appendix D

Texas Administrative Code

Educator Preparation Curriculum

Texas Administrative Code

TITLE 19: EDUCATION

PART 7: STATE BOARD FOR EDUCATOR CERTIFICATION

CHAPTER 228: REQUIREMENTS FOR EDUCATOR PREPARATION PROGRAMS

SUBCHAPTER B: EDUCATOR PREPARATION CURRICULUM

(a) The educator standards adopted by the State Board for Educator Certification (SBEC) shall be the curricular basis for all educator preparation and, for each certificate, address the relevant Texas Essential Knowledge and Skills (TEKS).

(b) The curriculum for each educator preparation program shall rely on scientifically-based research to ensure teacher effectiveness and align to the TEKS. The following subject matter shall be included in the curriculum for candidates seeking initial certification:

(1) the specified requirements for reading instruction adopted by the SBEC for each certificate;

(2) the code of ethics and standard practices for Texas educators, pursuant to Chapter 247 of this title (relating to Educators' Code of Ethics);

(3) child development;

(4) motivation;

(5) learning theories;

(6) TEKS organization, structure, and skills;

(7) TEKS in the content areas;

(8) state assessment of students;

(9) curriculum development and lesson planning;

(10) classroom assessment for instruction/diagnosing learning needs;

(11) classroom management/developing a positive learning environment;

(12) special populations;

(13) parent conferences/communication skills;

(14) instructional technology;

(15) pedagogy/instructional strategies;

(16) differentiated instruction; and

(17) certification test preparation.

Appendix E

Texas Administrative Code

Assessment of Educators

Texas Administrative Code

TITLE 19: EDUCATION

PART 7: STATE BOARD FOR EDUCATOR CERTIFICATION

CHAPTER 230: PROFESSIONAL EDUCATOR PREPARATION AND CERTIFICATION

SUBCHAPTER B: ASSESSMENT OF EDUCATORS

RULE §230.5: Educator Assessment

(a) A candidate seeking admission to an approved educator preparation program for initial certification must be assessed for basic skills in reading, written communication, and mathematics.

(b) A candidate seeking certification as an educator must pass examinations required by the Texas Education Code (TEC), §21.048, and the State Board for Educator Certification (SBEC) in §233.1(e) of this title (relating to General Authority).

(c) A candidate seeking a standard certificate as an educator based on completion of an approved educator preparation program may take the appropriate certification examinations required by subsection (b) of this section at such time as the educator preparation program determines the candidate's readiness to take the examinations, or upon successful completion of the educator preparation program, whichever comes first.

(d) The holder of a Texas certificate effective before February 1, 1986, must pass examinations prescribed by the SBEC to be eligible for continued certification, unless the individual has passed the Texas Examination of Current Administrators and Teachers (TECAT).

(e) For an examination or other assessment required by law or under the provisions of this title, the SBEC approves the satisfactory level of performance required, a schedule of examination fees, and a plan for administering the examination.

(f) Scores from examinations required under this title must be made available to the examinee, the Texas Education Agency (TEA) staff, and, if appropriate, the educator preparation program from which the examinee will seek a recommendation for certification.

(g) A candidate seeking an exemption under the TEC, §21.048, must have a report submitted to the TEA staff by an audiologist licensed by the State of Texas, documenting that the candidate is hearing impaired as defined in the TEC, §21.048(d)(1). The report from the audiologist may not be dated more than one year from the date of application for the exemption.

(h) The following provisions concern test security and confidential integrity.

(1) An educator who participates in the development, design, construction, review, field testing, or validation of an examination shall not reveal or cause to be revealed the contents of the examination to any other person.

(2) An educator who administers an examination shall not:

(A) allow or cause an unauthorized person to view any part of the examination;

(B) copy, reproduce, or cause to be copied or reproduced any part of the examination;

(C) reveal or cause to be revealed the contents of the examination;

(D) correct, alter, or cause to be corrected or altered any response to a test item contained in the examination;

(E) provide assistance with any response to a test item contained in the examination or cause assistance to be provided; or

(F) deviate from the rules governing administration of the examination.

(3) An educator who violates subsection (b) or (c) of this section is subject to sanction in accordance with the provisions of the TEC, §21.041(b)(7), and Chapter 249 of this title (relating to Disciplinary Proceedings, Sanctions, and Contested Cases).

(4) An educator who is an examinee shall not:

(A) copy, reproduce, or cause to be copied or reproduced any test item contained in the examination;

(B) provide assistance with any response to a test item contained in the examination, or cause assistance to be provided;

(C) solicit or accept assistance with any response to a test item contained in the examination;

(D) deviate from the rules governing administration of the examination; or

(E) otherwise engage in conduct that amounts to cheating, deception, or fraud.

(5) An educator who violates this subsection is subject to:

(A) sanction in accordance with the provisions of the TEC, §21.041(b)(7), and Chapter 249 of this title;

(B) voiding of a score from an examination in which a violation specified in this subsection occurred; and

(C) disallowance and exclusion from future examinations either in perpetuity or for a period of time that serves the best interests of the education profession.

VITA

Linus Joseph Guillory, Jr.

Candidate for the Degree of

Doctor of Philosophy

Thesis: EDUCATOR PREPAREDNESS TO TEACH ENVIRONMENTAL SCIENCE IN SECONDARY SCHOOLS

Major Field: Environmental Science

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Environmental Science at Oklahoma State University, Stillwater, Oklahoma in May, 2012.

Completed the requirements for the Master of Education in Educational Administration at Prairie View A&M University, Prairie View, Texas in May, 2002.

Completed the requirements for the Bachelor of Arts in Biology at Texas A&M University, College Station, Texas in May, 1995.

Experience:

July 2008-Present	Assistant Principal Spring Woods Middle School Spring Branch ISD, Houston TX
June 2002-July 2008	NASA Education Projects: AESP & TFS NASA Johnson Space Center Oklahoma State University Stillwater, OK
August 1999-June 2002	Science Teacher-8th Grade Hoffman Middle School Aldine ISD, Houston TX

Professional Memberships:
ASCD, Association for Middle Level Education

Name: Linus Joseph Guillory, Jr. Date of Degree: May, 2012

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EDUCATOR PREPAREDNESS TO TEACH ENVIRONMENTAL SCIENCE IN SECONDARY SCHOOLS

Pages in Study: 137 Candidate for the Degree of Doctor of Philosophy

Major Field: Environmental Science

Scope and Method of Study: This study assesses the environmental proficiency of Texas life science educators certified from 2003 to 2011 by analyzing their TExES 138 8-12 exam results in domains V and VI. The sample consisted of all the individuals that took and passed the TExES 138 life science 8-12 exam. During this period, approximately 41% of the individuals who took the exam actually passed it. This study employed non-experimental, quantitative statistical methods to evaluate educators that passed the exam for proficiency in environmental science content knowledge and how to teach and assess science learning. Because this study focuses on improving environmental science literacy, the TExES 138 exam was selected. This exam contained a domain dedicated solely to environmental science and comprised a larger portion of the exam than other certification tests. Data were provided by the Texas Education Agency in response to an open records request. The variables of interest were year, total test score and scores in domains V and VI. Data were analyzed using t-tests.

Findings and Conclusions: Analysis of data revealed a significant difference in educator proficiency in environmental science content knowledge and how to teach and assess science learning at the 95% confidence level. Mean scores for the individuals that passed the exam are significantly different from mean scores in domains V and VI. The educators certified from 2003-2011 demonstrated weaknesses in the environmental science content and the content of how to teach and assess science learning. Educators certified during this time period may struggle with teaching environmental science and assessing student learning in science.

ADVISER'S APPROVAL: Dr. Kevin Allen