TEACHER PERCEPTIONS

OF FACTORS THAT AFFECT

TEACHING SPACE SCIENCE IN TEXAS

A Dissertation for the Degree

Doctor of Education

by

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Abstract

The purpose of this study was to describe the characteristics of teachers teaching space science associated subjects in Texas public schools, identify their perceived ability to teach these subjects, and to identify any impediments or enhancements to their ability to teach the subjects. The study was conducted through a mixed method design that included quantitative data from a survey and qualitative information obtained through a survey, interviews and classroom visitations. The survey methodology used primarily electronic delivery to 316 teachers, professors, and administrators from at least 106 Texas public school districts across the state. The results provided insights into the current condition of Texas space science education and challenges faced by the teachers in the areas of curriculum definition, textbook availability, access to subject matter expertise, technology use, and teacher training.

Many of the teachers reported common processes and encountered common challenges. Differences among the teachers were based on grade levels and subjects taught, years of experience, location, and information accessibility. Many participants in this study felt they were moderately knowledgeable and could provide adequate instruction in the space sciences fields, but that their instruction could be enhanced through access to more and better subject content information, technology, resources, and training. There were several key findings. Curricula were not perceived to be uniformly defined. While space science content was taught in most K-8 grades, teachers felt there was little continuity from one grade to the next. And, while an

abundance of technical content was available on the internet, teachers said that the lack of organization for ease of use and the apparent difficulty in finding suitable classroom activities that promote critical thinking skills requires attention. The development of required instructional resources identified in this study would be a step towards establishing a comprehensive curriculum for space science.

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Chapter I

Introduction

> Science is an adventure of the whole human race to learn to live in and perhaps to love the universe in which they are. To be a part of it is to understand, to understand oneself, to begin to feel that there is a capacity within man far beyond what he felt he had, of an infinite extension of human possibilities....
>
> I.I. Rabi, Nobel Laureate in Physics
>
> in *Understanding Physics*
>
> (Cassidy, Holton, & Rutherford, 2002, p.1)

For many years there has been concern about science education in our schools. The need for a scientifically literate society has never been greater at a time when science, technology, engineering and mathematics (STEM) permeates nearly every facet of modern life. The 2010 *Report to the President: Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future* states that "STEM education is most successful when students develop…excitement about STEM fields" and that "not only is there a lack of proficiency in STEM fields among American students; there is also a lack of interest in STEM fields" (White House, 2010, p. vi).

The Texas Education Agency (TEA) recognized the importance of the new knowledge coming from and about space, the universe, and the Earth and recognized the excitement and motivation that study of these new sciences could engender. So, beginning in the 2010-2011 school year the TEA introduced a new senior-level high school capstone course in Earth and space science in all Texas public high-schools. The course is prescribed in the TEA Texas Essential Knowledge and Skills (TEKS) requirements that define courses (Texas Education Agency, 2010, pp. 19TAC:112, C). The TEA cited that this subject could engage students, support science education, and develop 21st century workforce skills, and the state felt it was important to include the course in the curriculum. However, a study conducted during the inaugural year of the new capstone course identified issues in the course's introduction. Teachers said that because the new course is taught at the senior level, after students have completed their high-school matriculation standardized tests, the new course got little focus or monetary support (Kitmacher, 2010b). One TEA administrator said that the TEA would continue to focus its resources on the classic subjects of biology, chemistry and physics (Pickhard, 2010).

During the 2010 study, teachers and administrators both identified issues in implementing the new subject (Kitmacher, 2010b). In a 2013 interview for the current study, one science department chair said that every high school in her district introduced the new subject in 2010. But because of a lack of definitive curriculum, little or no support given for procuring required resources, and a lack of either trained teachers or teacher training programs, after two years the district would eliminate the course from its offerings during 2013-2014 (Teacher 308).

The TEKS identifies the need to use scientific processes in teaching. As shown in Appendix A, the TEKS identify by grade, and for high school, by course, the list of topics to be covered. The level of detail specifies the appearance and characteristics of objects in the sky and their effects on earth, the history of scientific thought, the contributions of scientists, space travel, space exploration, the interpretation of data from spacecraft, and the origins and evolution of the universe (Texas Education Agency, 2010). The current study showed that for some teachers this was an adequately defined curriculum and some even said that any additional definition would restrict their autonomy. Other teachers expressed discomfort in the uncertainty about the topics or level of detail to cover. Some expressed concern that there seemed to be little continuity in the content covered from one grade to the next.

What is the scope of space science? Where does space science end and astronomy begin? What is the scope of technology or history that should be covered in space science topics? Are there appropriate textbooks for the subject? Texas teachers surveyed in this study identified that these questions were issues in their teaching. The new high-school space science and astronomy course TEKS were written by two different committees, separately and without coordination. Committee members anticipated overlaps, gaps, and issues with respect to adequacy of resources.

As a study of issues related to space travel, space exploration, and scientific observations performed in space or from space, space science is a new field of science that began only with the first flights into space in the 1940s and 1950s. When our first probes visited the planets Venus and Mars in 1962 and 1965, respectively, they initiated a veritable cascade of new knowledge about the universe; it never let up.

Modern digital technology grew simultaneously and often as a direct response to space science; the two are inseparable. I became interested in space as a field of study at a young age and grew up with the space program. In 1965, when I was in the sixth grade, Mariner 4 became the first spacecraft to obtain and transmit images of a planet as it passed Mars. It was one of the earliest examples of true digital photography. A few years later, men orbited and then walked on the Moon by the end of the 1960s, when I was in high school. By the time I graduated from high school in 1972, there had been a great revolution in knowledge coming from space. Although still in its infancy, the first Applications Technology Satellite (ATS) was transmitting crop and oceanographic data and mapping the countryside (Kitmacher, 2009). Now, 45 years later, the TEKS identify that these should be a part of the subject of study in our schools. Yet a clear definition of what space science is and where the lines of demarcation between space science, space technology, earth science, or astronomy lie are not yet firmly in hand. Texas teachers have come face-to-face with this realization.

In 2012, the National Academies' National Research Council (NRC) report, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council, 2012), or '*Frameworks'*, recommended refocusing K-12 science education on three subject areas: physical sciences, life sciences, and earth and space sciences. *Frameworks* recognizes the relatively newfound richness of knowledge of the earth and space today as compared with prior eras and so calls for establishing earth and space science as a primary subject area for focus in high school and lower grades. The report specifically recognizes the significance of astronomy and space exploration. It also identifies the impact of newly-acquired knowledge of the universe prompts new thinking about the relevance between humanity, nature, and society.

Frameworks identifies a relatively small set of very large topics: the Earth's place, the evolution of the solar system, the galaxy, and the universe. However, *Frameworks* attempts to establish a vision for teaching and learning science, calling for content which crosscuts science and engineering, and for going beyond basic science into such multidisciplinary topics as history, applications and societal implications of technology. *Frameworks* calls for the establishment of more definitive standards, curriculum, and professional development resources (National Research Council, 2012).

Since 2011, Texas teachers have tried to introduce space sciences in the curriculum but the introduction has not been without its difficulties. On a national level, the NRC recommends that space sciences ought to be in all schools and all grade levels in the future. The Texas teacher's experience may serve to help guide the nation.

This study sought to describe the characteristics of teachers teaching space science associated subjects in Texas public schools, identify their perceived ability to teach these subjects, and identify any impediments or enhancements to their ability to teach the subjects. This study is seen as preparation for a next step, which would be to establish a definitive curriculum for the subject and a subsequent step to develop the required resources for the curriculum.

Based on these goals, this study identified challenges that Texas space science teachers have faced. The data to answer these questions were obtained when teachers were asked to complete a survey. Supplementary data were gathered from narrative statements made on the surveys, during interviews, and during class visitations. This study sought to identify teachers' perceptions about their abilities: whether their knowledge is adequate and current; whether they have had training or have availed themselves of professional development programs in the subject areas. Teachers were asked to compare the degree to which they perceive that curriculum and subject matter is defined for space sciences with respect to other sciences with which they are familiar. Teachers were also asked to provide their recommendations for mitigating any challenges they have experienced.

Purpose of the Study

The goal of this study was to identify the challenges and difficulties teachers have faced in teaching Texas courses containing space science themes. The purpose of this study was to gather perceptions from the teachers actively engaged in establishing and teaching the subjects. During the study, participants were asked to identify teacher professional development needs and course resource requirements. The study addressed the following research questions:

Research Questions

1. What are the characteristics of the population of teachers teaching space science associated subjects in Texas public schools?
2. Do teachers feel they are able to teach the space science related subjects?
3. What factors do teachers feel impede or enhance their ability to teach the space science associated subjects?

Summary

Space technology has given us fifty years of explosive growth in the space sciences. The advancement of technology during this time has demanded greater emphasis in education on the STEM fields of study. Ever more sophisticated information, communication and educational technologies have given rise to hope for faster and better learning, and yet in the U.S., educational success, particularly in STEM, has been elusive (U.S. Department of Education, Institute of Education Sciences. 2009).

In part because of their perceived motivational influence, the space sciences courses were introduced beginning in 2010 in Texas at the high school level. The introduction was not without difficulty, according to some study respondents. As reported by study respondents, the state, along with some regions and districts, have not supported the courses. Instead, the state and most district administrations focused on more traditional high school physical and life science courses. Also, many respondents reported that the curriculum is often undefined. Nationally, the National Academies, Board on Science Education, recommended in 2012 that space science become part of the core of science courses taught at all grade levels, in all schools. Owing to its rapid advances and the beauty of some of the images that come back showing vistas never before seen, space science could be exciting, motivational and even inspirational, but it has often not been part of the regular course of study in schools. Recent efforts, however, on a national level are prompting the incorporation of space science as a field of study. In spite of

recent progress, space science teachers have experienced challenges during the course introduction and implementation. This study sought to identify those challenges.

Chapter II

Literature Review

Introduction: The STEM Problem

Science, technology, engineering and mathematics permeates nearly every facet of modern life. Our economy is based on new high technology products and those high technology products require research and development (R & D); R & D is performed by educated scientists, engineers, mathematicians, and technologists. Encouraging students to pursue STEM studies will result in more, and greater, research and development.

For many years there has been concern about science education in our schools. In 1983, the U.S. Department of Education (DOE) chartered a panel to look at significant declines in SAT standardized test scores, which began in the late 1960s. The panel produced the report *A Nation at Risk* (U.S. Department of Education, 1983). It stated that U.S. preeminence in science and technological innovation was being surpassed by determined, well-educated, and strongly motivated competitors throughout the world. The report cautioned that:

> Our concern…goes well beyond matters such as industry and commerce. It also includes the intellectual, moral, and spiritual strengths of our people that knit together the very fabric of our society. The people of the United States need to know that individuals in our society who do not possess the levels of skill, literacy, and training essential to this new era will be effectively disenfranchised, not simply from the material rewards that accompany competent performance, but also from the chance to participate fully in our national life. A high level of

shared education is essential to a free, democratic society and to the fostering of a common culture, especially in a country that prides itself on pluralism and individual freedom. (p.10)

The 1983 study has repeatedly been reinforced in the ensuing three decades by the Hart-Rudman Commission on National Security in 1999, the Walker Commission on the Future of the U.S. Aerospace Industry in 2002, and the Aldridge Commission on the Implementation of the Vision for Space Exploration in 2004. Dozens of studies over the last quarter century, shown in Appendix B, have sought to characterize the STEM problem citing an impending shortage of workers in the STEM areas. A 2007 report from the National Academy of Sciences, Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* stated that:

> …the prosperity the United States enjoys today is due in no small part to investments the nation has made in research and development…over the last 50 years. Recently, however, corporate, government, and national scientific and technical leaders have expressed concern that pressures on the science and technology enterprise could seriously erode this past success and jeopardize future U.S. prosperity. (National Academy of Sciences, 2007, p. ix)

On February 4, 2010, Richard Stephens, a Senior Vice President with The Boeing Company, testified before the House Science and Technology Committee Subcommittee on Research and Science Education, saying that:

> …we are no longer a nation at risk; we are a nation falling further behind… retirements are increasing…the number of American workers with STEM degrees is declining... (Stephens, 2010)

Educators, scientists, entrepreneurs, and politicians all agree that developing scientific literacy in the populace is essential to our economy and our society. STEM literacy is required to solve challenges in the areas of energy, health, environmental protection, transportation, and national security. Scientific literacy includes technical content, together with its history, the evidence behind it, and the practical value of its application (National Science Teachers Association, 2005).

Standardized testing that compares students of different nations has shown that U.S. student performance in comparison with students in other nations is average to below average at the elementary school levels (Congress, 2012). Test scores grow progressively worse and performance relative to other countries declines in the secondary grades. Studies have shown a lack of fundamental knowledge in the science fields by U.S. students and adults. According to the Joint Economic Committee of the Congress of the United States, only about one-third of the bachelor's degrees earned in the U.S. are in STEM disciplines and half of those are students from outside the country (Congress, 2012). In China 53% and in Japan 63% of first university degrees are in STEM fields. The two largest suppliers of students earning advanced degrees in the United States are China's Tsinghua and Peking Universities (Friedman & Mandelbaum, 2011, p.232).

The *2009 National Assessment of Educational Progress* (NAEP) published by the National Center for Education Statistics (NCES), identifies five levels of achievement for standardized tests: Below Basic, Basic, Proficient, Goal, and Advanced. In 2009, only 72% of fourth-graders, 63% of eighth-graders, and 60% of twelfth-graders performed at or above the basic level in science (U.S. Department of Education, 2000). Only 34% of fourth-graders, 30% of eighth-graders, and 21% of twelfth-graders scored at the proficient level or above. The poor performance of U.S. science students and the low numbers of graduates with STEM degrees has been cited as a national crisis that is contributing to the decline of United States' position in the global economy.

The Organization for Economic Co-operation and Development (OECD), Program for International Student Assessment (PISA), assesses the preparation of students in industrial countries. The PISA tests focus on the student's ability to use their knowledge and skills to meet real-life challenges. This orientation reflects a change in the goals and objectives of curricula themselves, which are increasingly concerned with what students can do with what they learn at school and not merely with whether they have mastered specific curricular content. The goal would ideally be to focus on fundamental principles and relationships rather than on disparate facts or procedures. The NRC defines this as "deep learning" (Pellegrino & Hilton, 2012, p. 21).

Students are tested at the fourth and eighth grade levels every three years. In the 2011 PISA tests, the performance of U.S. students lagged behind students in many countries. In science literacy, U.S. students scored in the middle of the range. The longer American students are in school, the worse they perform compared to their international peers. (Organization for Economic Co-operation and Development, 2012). Of particular concern has been the competition posed by Chinese students. They did better in math, science, and reading than any of the other 65 tested countries. The concern going forward among educators is that China will apply the lessons learned in Shanghai to more and more Chinese cities in the future:

> The Chinese know how to duplicate and scale. If education is in the lead in Shanghai now, then in another decade they can improve test scores in 10 more Chinese cities and a decade after that they will improve education in 50 cities. (Resmovits, 2011)

Secretary of Education Arne Duncan issued a statement on December 7, 2010, in response to the 2009 PISA results, that "being average in reading and science-and below average in math-is not nearly good enough in a knowledge economy." After the 2011 PISA test results showed lower grade U.S. scores were improving, but showed eighth grade mathematics and science achievement had failed to improve, Duncan said he was:

> …particularly troubled by the stagnation in eighth grade science where scientific and technological literacy is so central to sustaining innovation and international competitiveness. Accelerating achievement in secondary-school and the need to close large and persistent achievement gaps in the upper grades is urgent... (Resmovits, 2011)

Space Science and Education

Space science is a study of issues related to space travel, space exploration, and scientific observations performed in space or from space (Harra & Mason, 2004). It is a new field of science begun only with the first flights into space in the 1940s and 1950s (Walter, 1992). As a course, it has not been a classic subject for K-12 education in most schools. There are related fields such as Earth science and astronomy, though neither of those have been a principal focus in pre-college education in the U.S. for a century (Krunemaker, 2008).

Space transformed science at a rapid pace as humanity sent machines and people there. In the fifty years since the beginning of the space age, we have experienced wonders and seen things previously beyond the imagination of even the most visionary of earlier eras. Space-science research has provided some of the most spectacular advances in modern science. We have gained a new perspective of our universe. Robotic explorers have visited all of the planets. Powerful telescopes such as the Hubble have revolutionized our knowledge of the universe. Satellites and space probes have defined the environments of Earth and space. The tools we developed to explore the cosmos are widely used to monitor our own world. A wide variety of reconnaissance satellites today routinely keep continuous watch on Earth's weather, land, oceans, disasters and people (Lowman, 2002). The broad range of activities comprising space science allows a view into the activities of scientific research and engineering. Many regard space as an environment that opens opportunities for new experiences, spiritual enrichment and jobs. The tools developed to study the distant universe have the potential for advancing education and science instruction (Sellers, 2007).

Inspiring students involves capturing their curiosity and imagination (Bottia, Stearns, Mickelson, Moller & Parker, 2012). The *National Science Education Standards* stressed that all citizens must experience and understand the natural world and the universe in order to become scientifically literate. The National Research Council (1996) has said that a key challenge for education today is engagement and scientific literacy. Many have suggested that space flight and space science can be a significant trigger for generating interest, curiosity, motivation, and inspiration for studying STEM subjects (Elliot, 1981; National STEM Centre, 2013).

The Texas Education Agency (TEA) felt that the stimulating effect of socially relevant, widely accessible new space-science information and the potential for positive influence was worth the establishment of new courses according to Dr. Irene Pickhardt (2011). The 2012 National Research Council report *A Framework for K-12 Science Education* calls for all students at all grade levels to study Earth and space science as a core discipline, together with physical and life sciences (National Research Council, 2012).

Frameworks focuses on a small set of space-science topics that cover a large territory: Earth's place; the evolution of the solar system; the galaxy; and the universe. *Frameworks* calls for going beyond the instruction of basic science, to also include addressing the engineering of how scientific knowledge is acquired, how science is utilized and how engineering, technology, science, and society are interconnected (p.210). *Frameworks* attempts to establish a vision for teaching and learning science, but asks for the establishment of standards that are more definitive, curriculum, and professional development resources in order to establish a much richer story and a broader range of ideas that will be taught more effectively than in the past. A curriculum for space science has not been adopted universally (National Research Council, 2012, p.241).

Space science has been defined inconsistently; the term's meaning changed over time as the science and the data it provided evolved. The purview of space science is very broad, covering a large number of inter-related though distinct subject areas. Space science sometimes is thought about as the collection of knowledge about our Earth and its place in the universe; or it may be thought of as the knowledge of space beyond our planet; or it can be thought of as science performed in outer space; or the study of everything in outer space. It overlaps with earth science and is sometimes confused with astronomy; in recent years, with the growth of knowledge from and about space, astronomy is sometimes defined as the subset of space science that focuses on observations made from Earth of objects and events beyond Earth (Harra & Mason, 2004).

The related field of Earth science refers to observations and processes in the world on which we live. By analogy, space science might be thought of as the collection of knowledge of the observations and processes in the universe including those of our planet. Earth science is arguably a special case in planetary science, a sub-element of space science; Earth being one of eight planets in the solar system and one of thousands of planets recently shown to be orbiting many of the stars of the galaxy.

Prior to the twentieth century the study of geology and astronomy were significant courses in the pre-college American curriculum and had been important subjects in schools going back to ancient times. However, by the early 1900s the subjects had been relegated to the status of electives (Orion, King, Krockover, & Adams, 1999). For a time, in the wake of Sputnik in the 1960s, the lack of knowledge about space was perceived to be a national security threat. This led to substantive curriculum reform and a renewed focus on science education in order to maintain U.S. military and technological advantage (DeBoer, 1991; Kennedy J., 1962; Mayer & Kumano, 1999).

The national attention to science education began the debate about science curriculum structure (Beane, 1993; DeBoer, 1991; Drake & Burns, 2004; George & Alexander, 2003; George, 1996a). There were attempts in the late 1960s and 1970s to establish new Earth science curricula with the Earth Science Curriculum Project (ESCP) and later the Crustal Evolution Education Project (CEEP); however neither had long-lasting impact (Orion, King, Krockover, & Adams, 1999). By the 1990s, there was another impetus to develop a more comprehensive Earth science curriculum as part of the Project 2061 science literacy project (Ault, 1994).

Space as an Observational Science

Science is a way of learning about the universe and man's place in it. In fact, science has given us a view of how our universe looks and functions. We have learned that the universe is not random; it moves in predictable ways. The images of the universe we have gained in the last century have been beautiful and amazing and the comprehensive nature of the level of understanding we have of the universe today is well ahead of what we understood a century ago. The acquisition of this new knowledge has certainly been one of the greatest achievements of humans (Ki-moon, 2012).

Experimentation and strict adherence to the scientific method is often not possible in observing natural, uncontrolled phenomena that is frequently the focus of the space scientist. The 'classic' sciences, physics, chemistry and biology represent the tools with which science is examined or understood. The natural sciences, including the study of Earth and space represent the phenomena or domains under study (Dodig-Crnkovic, 2003). The space scientist relies upon field-based evidence, interpretation, and narrative logic to describe phenomena (Frodeman, 1995; Turner, 2000, p51). The scientist makes a meticulous survey of observable phenomena and uses this as the basis for explaining physical processes of the past that led to current conditions. Space science often relies on observations of subjects in remote locations using remotely sensed digital imagery.

Earth and space sciences have been characterized as historical or observational sciences in contrast with the experimental physical sciences of physics or chemistry (Rusbult, 2004). The physical sciences have long sought to characterize only a narrow paradigm of experimental science using the scientific method (Dodick & Orion, 2003). The adoption of such restrictive principles fails to consider the historic interpretative nature of the observations that characterize Earth and space science. The implication is for an independent focus of study for these sciences in K-12 education. As observational sciences, Earth and space science complement the physical sciences and provide an alternative route to scientific literacy (Dodick, Dubowski, & Orion, 2000).

While not specifically experimental in nature, the observational sciences identify large collections of interconnected variables and emphasize systematic scientific methodology. This knowledge can fundamentally affect society. There are a number of examples from history; proof that Earth is spherical and not flat, or that Earth revolves around the sun. There are current scientific discussions that are ongoing such as the anthropogenic basis of global warming that may have serious implications as well. These are all revolutions in scientific thinking which influence our understanding of the human's place in the universe (Dodig-Crnkovic, 2003).

Human curiosity about the heavens has been a constant from well before the beginnings of recorded history. Early peoples observed, catalogued and recorded their observations of the sky and built great observatories to chart the paths of celestial objects. They could predict celestial events like lunar or solar eclipses, plan the coming of the seasons, and schedule crop plantings. They could maintain accurate calendars. Their observatories were a compass; their observations guided early explorers across the seas. The sky was linked to religion, agriculture, philosophy and science. All civilizations had an interest in and believed they understood their place in the universe. Early peoples envisioned a limited and orderly universe. As new instruments, like the telescope, became available, a myriad of new objects came into view and simplistic ideas of the universe were relegated to history. Galileo's first telescope in 1609 revolutionized our understanding of the universe (Bronowski, 1973). In the last 20 years, the Hubble space telescope revolutionized ideas about the universe once again with observations of the first planets beyond the solar system, dark matter, black holes, and the big bang (Devorkin & Smith, 2008).

At the beginning of the last millennium, we knew about six planets, including

Earth. The invention of the telescope, and the beginnings of scientific thought about orbits and planetary motion occurred in the 1600s. In the 300 years that followed, Uranus, Neptune and Pluto were added to the list of known planets. Discoveries like the concept that planets orbit the Sun and that Earth was not the center of the Universe increased scientific knowledge. There was little widely accepted knowledge of anything beyond the solar system. Many believed that galaxies, like the Andromeda, were nebulae or gas clouds within our own flattened disk of the Milky Way (Devorkin & Smith, 2008).

In the last century the study of Earth, the solar system and its planets, the structure and evolution of the universe, all ensued and in the later half of the century humanity move into space with machines and people. The growth in scientific knowledge was explosive. In the last twenty years, we went from not knowing whether planets even existed outside of our own solar system, to identifying distinguishing characteristics of some 2700 planets orbiting the nearest 2000 stars (Deming & Seager, 2009).

Reestablishing Earth and Space Science in the Schools

The NRC *Frameworks* report calls for refocusing science education on three subject areas: physical science, life science, and Earth and space science (ESS). The term ESS grew out of a recognition of the systems concept in science education in the 1990s. Prior to this time the subjects of earth science, geology, and astronomy commonly referred to the subjects that would come to compose ESS (Barstow, Geary, & Yazijian, 2001).

Peter Senge applied his engineering education to social systems modeling and said that learning was a dynamic process focused on interconnections between individual components (Senge, 1999). Two early 1990s reports sought to redevelop the science curricula in such an interconnected fashion. The *National Science Education Standards* (NSES) and *Blueprint for Change: Report from the National Conference on the Revolution in Earth and Space Science Education* recognized that a portion of Earth science referred to elements of the universe beyond Earth (National Research Council, 1996; Barstow, Geary, & Yazijian, 2001). At that time, Senge's systems approach was growing in acceptance and the *NSES* reframed "Earth science" into "Earth systems science", using the acronym 'ESS'; it acknowledged an integrated view of interacting systems within Earth together with systems outside of Earth (Lewis, 2008). In the report *Blueprint for Change: Report from the National Conference on the Revolution in Earth and Space Science Education,* the ESS acronym was adopted but modified to refer to Earth and space science (Barstow, Geary, & Yazijian, 2001). ESS was not a completely new subject since it was based in part on the old Earth science, though neither ESS nor Earth science were being taught in most schools or to most students by the late twentieth century (Barstow, Geary, & Yazijian, 2001).

Knowledge of soils, the Sun, Moon, tides, directions of the stars and other aspects of these subjects were taught in antiquity because the knowledge was a necessity for farm, nautical and rural life (Bishop, 1977). Though they had been taught, neither geology nor astronomy was recognized as natural sciences until the discoveries of Copernicus, Tycho, Kepler, Galileo and Newton in the 1600s. The progress in recognition could largely be attributed to theoretical skirmishes between the new scientific findings and the church (Bronowski, 1973).

Earth sciences gained in importance with the increased commercial significance of mineral mining during the industrial revolution. Physiography, one aspect of Earth science, also was important in nautical explorations. Both Earth sciences, primarily in the form of geography and physiographic education, and astronomy were taught widely in nineteenth century American secondary schools and they were required subjects for acceptance into universities like Harvard (Ornstein & Hunkins, 2004).

In 1892, a group of ten college and high school administrators met to set standards for college admission, then required because of the proliferation of public high schools across the U.S. They declared that science should occupy 25% of the high school syllabus. The "Committee of Ten" decided that physical geography would be taught in the 9th grade, biology in the 10th, chemistry in the 11th , and physics in the 12th grade (National Council of Education (NCE), 1892). These would be the requirements for college admission. Soon after, influenced by a report by the U.S. Bureau of Education, general science, a preparatory simplified chemistry and physics course, began to displace physical geography (Barstow, Geary, & Yazijian, 2001). “The rationale offered was that anyone can teach general science” (NCE, p. 122-123). General science or introductory physical science is still offered in lieu of Earth science in many U.S. schools today.

Between 1889 and 1890, 29.9% of students took geology. By 1927-28, the number taking Earth science or geology had dropped to 2.8% and by 1948-49, .4%

(Snyder, 1993, p. 50). By 1930, only 0.06% of secondary school students would take an astronomy class (Bishop, 1979).

In 1950, New York began to introduce Earth science as a special class for gifted ninth grade students. New York and Pennsylvania recognized Earth science in the state curriculum. Subsequently the course was adopted by hundreds of schools in those states (Ireton, 1997). In the wake of Sputnik, by 1965 more than 500,000 ninth grade students were enrolled in Earth science and a new inquiry-based Earth science text, the Earth Science Curriculum Project (ESCP) was recognized as a model of inquiry-based science education. However the increase in focus on Earth science education did not continue through the 1980's, and cutbacks in education resulting from the austere budgets of the Vietnam era and perhaps because of the lack of formally trained Earth science instructors. Perhaps the shortage of trained instructors resulted in a failure to persuade stakeholders that Earth science is a scientific discipline with equal status with biology, chemistry or physics (Ireton, 1997).

ESS continues to take a backseat to the more traditional physical and life sciences even in recent years (Dodick & Orion, 2003). Nationally at the high school level, only 7% of students take ESS while 88% take a biology course (Barstow, Geary, & Yazijian, 2001). Fifteen percent of science teachers are assigned to teach an ESS course. Of those few teachers, only 72% have certification in the subject field (Driscoll, Christensen, & Houlihan, 2004).

ESS frequently was taught at the middle-school level though fewer than 15% of students took the course (American Geological Institute, 2009). ESS often was used an alternative course for students designated to have little aptitude for the hard sciences like physics or chemistry. Astronomy did not even have the status that ESS enjoyed as a regular elective course in most schools; fewer than four percent of students ever had any astronomy instruction at any grade level prior to college (Krunemaker, 2008).

Deep Learning and Critical Thinking

In the 1950s and 1960s, space caught students' attention, engaged their interests and reliably fulfilled the promises of exploration, as envisioned in the science fiction of decades earlier. Space science provided new and unique perspectives of our world and of other worlds. Student interest in space built throughout the 1950s to a crescendo at the time of the first landing by a man on the Moon in 1969. For a time in the first decade or two after the beginning of the space age, real changes to the U.S. science curriculum were adopted, enrollment in science classes increased and standardized test scores grew higher (Launius, 2003).

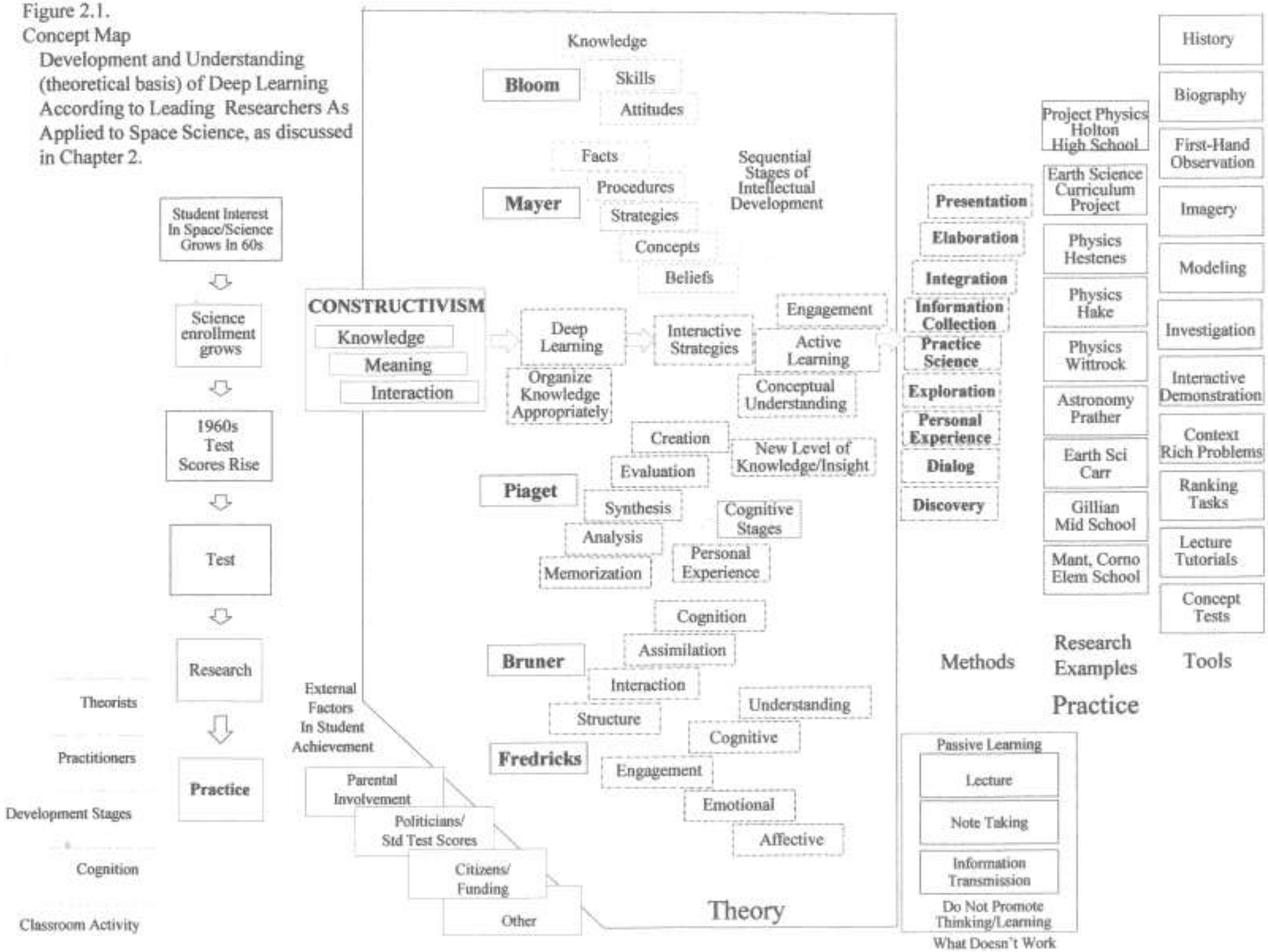
Several studies have looked at factors in student achievement. Some factors are external to the school system. They include parents who need to be more involved and more demanding; politicians who will push to raise educational standards rather than dumb them down in hopes of meeting standardized testing goals, and neighbors who are willing to invest in schools despite the fact that their children do not attend the schools. Also significant is the attentiveness and discipline of the students and whether the students are in school prepared to learn (Pickering, 1989).

Educational theorists have identified and documented sequential stages in intellectual development for at least fifty years, essentially coincident with the start of the space age. Bloom's committee established a hierarchy of learning types that affect the acquisition of skills, knowledge and attitudes (Bloom, 1956). In the Anderson, Krathwohl, Bloom, & Samuel (2001) update of Bloom's taxonomy of learning objectives, three principal characteristics are identified: (1) knowledge, facts or concepts; (2) skills, procedures or strategies; and (3) attitudes. Mayer (2011) identified an interconnected network of five types of knowledge required to instill deep learning: (1) facts defining the characteristics of elements in the universe; (2) concepts, schemas, or models; (3) procedures; (4) strategies; and (5) beliefs. Mayer suggested that the learner must organize these five types of knowledge appropriately if deep learning is to take place. Figure 3.1 identifies different functions of classroom learning and cognition according to several of the theorists.

Inhelder and Piaget (1958) described the process of forming a new "cognitive stage"; a new level of knowledge and insight gained by differentiating and integrating an element and its effects into a cognitive model. As the individual progresses from infancy through adolescence to adulthood, cognitive models and conceptual understanding progresses to new levels of sophistication. At the most basic level is memorization of declarative knowledge. The higher order domains require analysis, synthesis, evaluation, and creation. Bruner (1960/1977) wrote that the "teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer" (p.12). Interaction increases achievement because of the cognition by which information is obtained and assimilated.

Lectures and note taking have characterized traditional science education. Traditional instruction looked at students' minds as a tabula rasa, a blank slate, on which knowledge could be written (Mestre, 2005). Some students have a hard time absorbing the information that is presented, writing it into their notes, processing it, and remembering it. Lecturing transmits information but is a passive experience for the student that may not be effective in promoting thinking, or in engaging the student. Note taking focuses the student on capturing vocabulary and facts but not concepts. Under these circumstances, stress may be the most reliable method for ensuring that students absorb any information; the threat that the information may be on the exam. Students

Figure 2.1.
Concept Map
Development and Understanding (theoretical basis) of Deep Learning According to Leading Researchers As Applied to Space Science, as discussed in Chapter 2.



may find the lecture boring; they may have a difficult time focusing for as long as a typical hour-long class period (Lucas, 1999). "Lecture has often been described as the process of taking the information contained in the teacher's notes and transferring it into the student's notes without the information passing through the brains of either" (Johnson, Johnson, & Smith, 1991, p. 2). Often, faculty complains and students confirm, that content is "learned" for the exam and then promptly discarded.

In the 1980s, as SAT scores fell, criticism of educational methods grew and initiatives aimed at reforming academics were developed. Research increasingly focused on the application of constructivist philosophies; the idea that learning is constructed as the individual combines new information with existing knowledge and experience. The student develops a new plateau in understanding; as an interpretation or a new order is understood, it enables the student to acquire, comprehend, and test new knowledge (Matthews, 1998).

Constructivism argues that humans generate knowledge and meaning through interaction. Students learn best if their exercises are tied to their personal experience. Piaget (1950/1995) suggested that disequilibrium in the individual's cognitive structure motivates understanding and reasoning. From a cognitive perspective, physical interaction through dialog and discussion or through interactive exercises increases achievement because of the cognition by which information is obtained and assimilated.

Fredricks, Blumenfeld, & Paris (2004) defined engagement as a multidimensional concept. It broadly encompasses the components of emotional engagement and cognitive engagement. Emotional engagement is measured by the affective reactions such as interest or enjoyment reported by students. Cognitive engagement is measured by the students' interest in learning or understanding of the knowledge the study is intended to promote and the students' interest in continuing study in the future.

A growing congregation of disciples of interactive instructional strategies for the sciences has published guides for instructors, with the goal of turning passive students into active learners, engaging their minds, focusing on conceptual understanding, and providing tools for implementation and assessment. Rudolph, Prather, Brissenden, Consiglio, & Gonzaga (2010) used a multiple regression analysis to show that interactive engagement activities appear to benefit all students, regardless of their academic background, gender, ethnicity, or primary language. Interactive engagement leads to deeper levels of learning.

Applied to science, students should be encouraged to explore, to practice scientific skills, to make discoveries for themselves, and to engage in dialog about their findings. Students should develop knowledge and understanding of concepts that allow them to be able to investigate, develop and test ideas, elaborate on concepts and discuss their conceptual knowledge and its implications (National Research Council, 1996, p.173).

Sputnik, the first satellite, was launched by the Soviets in 1957. In its wake, concern about U.S. educational methods grew. Only about 20% of U.S. students were taking physics at the time and so in 1958 the National Science Foundation issued an urgent call for a new high school physics course. The course would be funded by the federal government. Gerald Holton of Harvard, already well known for his science history writings and his text *Introduction to Concepts and Theories in Physical Science*, recognized the need for a coherent story of the development of physics. The textbook that resulted was *Project Physics*. The book was different from the "pure Physics" books of the past. A primary emphasis of *Project Physics* was to permit all students, even those without an aptitude for mathematics, to gain confidence with science concepts, quantitative methods, and an understanding of the nature of science itself. *Project Physics* provided both the fundamental concepts of physics, the humanistic and intellectual contexts in which the concepts developed, the way intuitions about science had to be acquired by scientists and conveyed the sense of the nature of scientific thinking, as well as the equations required to analyze scientific problems and determine what scientific concepts really mean (Holton, 2003).

The *Project Physics* book used narrative text instead of equations to convey the meanings of laws and concepts. The fundamental scientific concepts were taught within the broader humanistic and historical contexts from which they arose. It related how principles of physics, such as thermodynamics, led to the industrial revolution and how an obscure formula, $E=mc^2$, led to nuclear reactors, atomic bombs, and new methods in medical diagnosis. The book included numerous illustrations and considerable effort went into the design and layout to make the book attractive. Interconnections between physics and other sciences were highlighted through the history of science and through the societal significance of scientific decisions. In addition to the textbook, an ancillary set of course resources were produced and distributed, including transparencies, film loops, teacher training films, documentaries, biographical lessons on famous scientists, worksheets, and a variety of books of readings. An instructor's handbook laid out integrated schedules and plans for the use of resources covering specific topics. Teacher training institutes were organized around the U.S. in six or eight week summer sessions. The numbers of students taking physics increased and the *Project Physics* text and course was being taught to 20% of all high school students in the U.S. *Project Physics* students did better on standardized external tests than students in other more traditional physics courses. One of the strengths of the *Project Physics* approach was a deeper understanding of the processes of scientific research, which led to better recall of content, an appreciation of what is known, and how and why it was known (Holton, 2003).

In the 1970s, federally funded science teacher training was severely reduced. The number of courses and texts fell back to narrower and more classical physical science training methods. Support for *Project Physics* teacher professional development ceased. Many of the ancillary educational resources were lost. Even so, *Project Physics* survived in many schools and in the 1990s, the *Project Physics* approach was endorsed by several national organizations, including the National Science Foundation (NSF), the Research Council of the National Academy of Sciences, and Project 2061 of the American Association for the Advancement of Science (AAAS). The increased focus on the teaching of science processes and away from rote learning continued (Gunstone, 1992).

One of the more publicized stories of the early adoption of research-based pedagogical strategies in science focused on Harvard physics professor Eric Mazur

(Mazur, 1997). Mazur had taught physics at Harvard since receiving his PhD in 1981. His students did well on tests and he received high evaluations at the end of courses. Another educator during this time, beginning in the mid-1980s, David Hestenes at Arizona State University developed a series of instruments, the Force Concept Inventory (FCI), which demonstrated that while physics students studying motion and Newton's laws could do well on end of course exams, their knowledge was superficial and their retention of knowledge was short-lived (Slater, Adams, Brissenden, & Duncan, 2001).

Mazur learned of Hestenes' findings and developed his own instrument for studying the gains in knowledge following instruction on the topic of electrical circuitry. Mazur found that his students could easily compute mathematical formulae associated with the subject but could not demonstrate an understanding of the fundamental concepts.

Richard Hake, a professor of physics at Indiana University, looked at class averages before and after introductory physics lessons (Hake, 1998). The averages of three separate instruments: the Mechanics Diagnostic Test (Halloun & Hestenes, 1985), the Force Concept Inventory (Hestenes, Wells, & Swackhamer, 1992), and the Mechanics Baseline Test (Hestenes & Wells, 1992) measured the performance of 6,542 students in sixty-two high school and college level classes across the United States. Hake compared the gains between traditional classes and those using interactive engagement strategies. He defined a traditional class as transmitting information via lecture, "cookbook" experiments, and problem based exams. He defined interactive classes as those that used in-class student-student and student-instructor dialog and information transfer to promote conceptual understanding. The 14 traditional classes averaged gains of .23 + .04 percent and the 48 interactive engagement classes averaged learning gains of .48 + .14 percent. The wide spread in the distribution of learning gains for interactive courses was explained by the effectiveness of different instructors' interactive engagement strategies and implementation. However, even the lowest gains by the interactive engagement classes achieved learning gains comparable to the best traditional classes (Hake, 1998). Hake explained the low gains in the traditional classes showed that students usually succeeded on course tests by memorizing short lists of facts and mimicking solution algorithms.

Hake's research focused on introductory physics (Hake, 1998). Researchers in physics (Wittrock, 1986; Duncan, 2006; Green, 2003), astronomy (Prather & Brissenden, 2009), and Earth science (Carr, Buchanan, Adkins-Heljeson, Mettille, & Sorensen, 1996), have all shown that students will more readily absorb and retain information when they are actively engaged in explaining and elaborating about the topic while learning. Several strategies have moved towards incorporation of active engagement.

In active engagement, typically the duration of the lecture is minimized and the emphasis is on interactive demonstration. Interactive lecture demonstrations strive to make in-class demonstration and discussion more than just a passive activity for students (Sokoloff & Thornton, 1997). Context rich problems (Heller, Keith, & Anderson, 1992; Heller & Hollabaugh, 1992) or ranking tasks (Hudgins, Prather, Grayson, & Smits, 2006) promote problem-solving skills and quantitative reasoning usually without requiring computation. Lecture tutorials are worksheets of carefully designed questions that require students to think about challenging subjects. In particular, lecture tutorials address concepts that students frequently find disconcerting or difficult. They are designed to help students confront erroneous concepts, and through well-designed questioning, guide students to thinking that is more scientific. Concept-tests are well-written multiple-choice questions that focus on concepts, which students have previously thought about, answered, and discussed in class. Frequently exam questions are based on the concept-tests, but with wording or parameters changed from the class discussion examples in order to ensure students understand the underlying concept. In class, instead of lengthy and continuous lecture, students talk with each other and teach each other, working through the lecture tutorial worksheets, ranking tasks and other learning tools; the instructor facilitates but tries to ensure students are thinking and developing their knowledge base without the instructor's constant intervention.

Hestenes, Hake and Mazur all conducted research focused on college level science classes and their studies resulted in the development of specific techniques and educational products such as workbooks of ranking tasks, concept tests, and interactive lecture demonstrations. Several other studies have looked at motivation and performance factors for students in earlier grade levels though techniques and products appear to be less universally applied. Gillian and Bennett (2013) used Program for International Student Assessment (PISA) data to study the relationships between classroom science teaching and learning activities and students' motivation towards science, enjoyment of science and future orientation towards science. They used the PISA data to establish a series of indices to define and measure interactivity.

The index of interaction measured the frequency with which four types of activities occurred during classroom science study: (1) students explain their ideas; (2) students voice opinions about the study topics; (3) debate or discussion occur in class; (4) students discuss topics amongst themselves. An index of hands-on activity measured by four factors: (1) time spent conducting investigations; (2) student design and development of how a scientific question could be investigated; (3) student development of conclusions from investigations they conducted; and (4) student conduct of investigations following teachers' prepared instructions. The index of student investigations was derived from three factors: (1) students are allowed to design their own investigations; (2) students may choose their own investigations from a provided set; and (3) students are asked to develop their own ideas and concepts and asked to conduct an investigation to test their idea. An index of applications in science was established based on the following four activities occurring during science class: (1) the teacher explains how a scientific concept can be applied in several situations; (2) whether the teacher explains how the science that is studied can be used to better understand the world; (3) whether the teacher explains how the science that is studies is relevant to the students' lives; and (4) whether the teacher explains how the science that is studies is relevant or important for society (Gillian & Bennett, 2013).

Gillian and Bennett (2013) looked at both the associations between student and school factors such as socio-economic status (SES) as well as teaching and learning activities. They found more positive feelings about engagement in better SES environments, when a student's parent had a career in a science or related field, and when the student reported they were interested in continuing their science studies. They also found a positive correlation between student enjoyment, interest and motivation to study science with increased scores for interaction, hands-on activities, and study of applications. Also of significant note, in school where there was a shortage of science teachers or where teachers had little education in science, students reported lower levels of interest in continuing studies and lower levels of enjoyment of scientific study.

The recommendation to introduce more cognitively engaging and interactive science lessons also resulted from a study of students at the elementary grade level. Challenging student cognition improved enthusiasm for science; it also inspired curiosity among 10 and 11 year olds. The students' enthusiasm was in turn directly related to improved educational performance and improved engagement and motivation (Mant, Wilson & Coates, 2007). Corno and Mandinach (1983) defined cognitive engagement as the student's effort to understand lessons. Teaching strategies that promote cognitive learning and thinking strategies are based on three factors: lesson content, active teaching and active learning. The teacher selects appropriate lesson content; active teaching requires the teacher to structure the lesson content so that students integrate information. In active learning the student is called on to use or apply the knowledge.

Tobin (1984), studying middle school grades six, seven and eight, found that achievement levels could be enhanced for all students by increasing engagement in tasks associated with learning. His studies showed that achievement and retention were related to the time each student engaged in planning, information collection as well as cognition. Students who participated in planning of their studies, and then in information collection tasks tended to obtain higher achievement scores. Practical, hands-on involvement in the learning process resulted in deeper and more lasting learning.

A critical aspect in order to establish a properly functional inquiry-based interactive science curriculum is planning. If done properly, an intensive process is required to design, develop, and enact the curriculum. Teachers have consistently identified time for collaboration, time to plan and time to reflect as an overarching limitation (Laurence, Kelley, Becker, Day, &. Marshall, 2006).

The curriculum must have certain key features such as the identified learning goals and structured activities that establish a scaffolding for student learning. Teachers require proper training in inquiry-based learning. Professional development is required to understand the proper methodology. “Teachers cannot simply move to inquiry approaches to instruction from recitation and direct instruction. They need to learn many new ideas about students, learning, curriculum, pedagogy, and assessment” (Marx, Blumenthal, Krajcik, Fishman, Soloway & Geier, 2004, p. 1066).

Framework, Standards and Curriculum

In 1989, the AAAS Project 2061 released the report *Science for All Americans* (American Association for the Advancement of Science, 1989). It called for an integrated science curriculum structure. In response, the framework for a curriculum was established in 1993, with its *Project 2061: Benchmarks for Science Literacy*

(Mulholland & Wallace, 2005; Monk & King, 1994). The framework recommended principles for effective science teaching, learning, and provided lists of recommended essential science content and concepts. It was a prescription for inquiry learning in science education.

The National Science Assessment Framework was developed through a steering committee established by the U.S. Department of Education. Their report, the *National Assessment of Educational Progress* (*NAEP*), assessed subject-matter achievement, instructional experiences, and school environment in grades 4, 8 and 12 (U.S. Department of Education, 2005, 2006). The report defined a framework for a science curriculum. The *Benchmarks* report marked a change from the traditional science framework. The more traditional curriculum structure was a topical curriculum in which students studied a single science discipline each year; individual topics were taught in specific courses and particular grades. The topical curriculum is also sometimes called a *siloed, discrete, subject-based* or *sequential* curriculum, as shown by the example taken from Serway & Jewett, p. vii (2012), shown in Figure 2.2 (Beane, 1993; DeBoer, 1991; National Academies, Board on Science Education, 2012).

The 1993 *Project 2061: Benchmarks for Science Literacy,* together with the 1996 *National Science Education Standards (NSES)* established an integrated curriculum structure in which concepts were introduced in the early grades and gradually expanded upon through later grades (National Research Council, 1996). A similar theme or subject area would be covered from a different aspect in multiple different subjects or disciplines as illustrated in Figure 2.3.

10 Rotation of a Rigid Object About a Fixed Axis 293
10.1 Angular Position, Velocity, and Acceleration 293
10.2 Analysis Model: Rigid Object Under Constant Angular Acceleration 296
10.3 Angular and Translational Quantities 298
10.4 Torque 300
10.5 Analysis Model: Rigid Object Under a Net Torque 302
10.6 Calculation of Moments of Inertia 307
10.7 Rotational Kinetic Energy 311
10.8 Energy Considerations in Rotational Motion 312
10.9 Rolling Motion of a Rigid Object 316

13 Universal Gravitation 388
13.1 Newton's Law of Universal Gravitation 389
13.2 Free-Fall Acceleration and the Gravitational Force 391
13.3 Analysis Model: Particle in a Field (Gravitational) 392
13.4 Kepler's Laws and the Motion of Planets 394
13.5 Gravitational Potential Energy 400
13.6 Energy Considerations in Planetary and Satellite Motion 402

Figure 2.2. Traditional Topical Curriculum Model (Serway & Jewett, 2012, p.vii.).

Between 2011 and 2012, the NRC released a series of drafts of *A Framework for K-12 Science Education* (National Research Council, 2012). The NRC *Frameworks* is the latest attempt to move towards a nationwide U.S. adoption of a single unified integrated curriculum approach to science education, though implementation will require mandating individual states and districts to change their curricula.

Frameworks identifies the concern that past efforts at curriculum reform focused too narrowly on specific concepts and processes in the traditional science disciplines and have not related science to the world from which they are derived. *Frameworks* calls for developing concepts that crosscut science and engineering and for instilling understanding of how engineering and science are practiced. *Frameworks* identifies the realization that humanity is an integral element of the environment in which it lives and it calls for the incorporation of multi-disciplinary historical, social, and cultural aspects in the natural science curriculum (National Academies, Board on Science Education, 2012, p.246).

Framework's vision is that students will acquire knowledge and skill in science and engineering through a carefully designed sequence of learning experiences (National Research Council, (2012). The NRC provided examples of how inquiry-based science teaching can be accomplished (National Research Council, 1998) but was an idealized standard of inquiry teaching that is only useful for establishing a benchmark. In the ideal lesson, the student notices a phenomenon, develops a question, and then carries out an extended investigation of that question and other questions that may develop. While

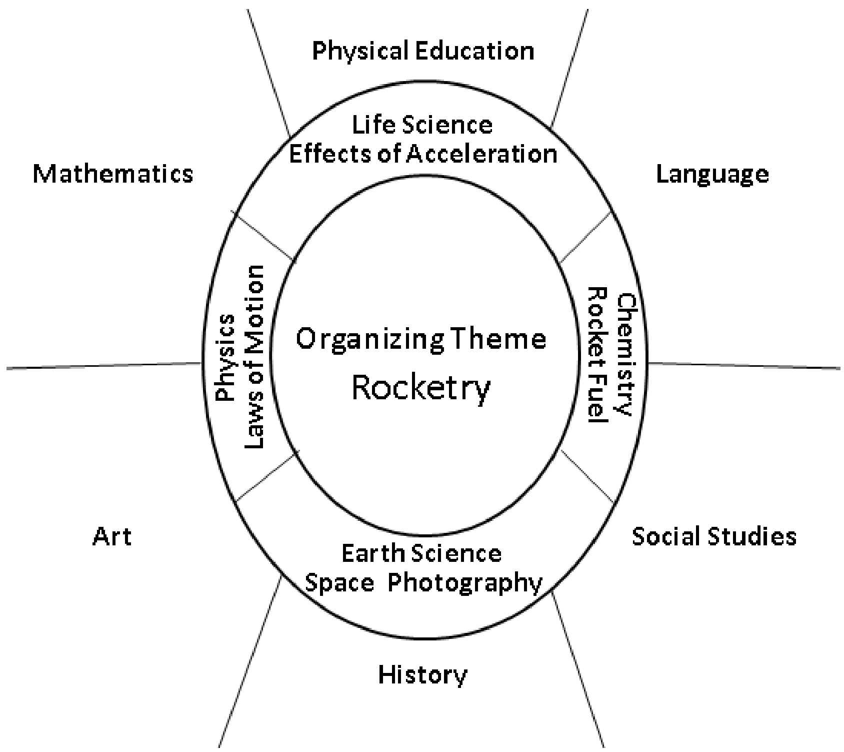


Figure 2.3. Integrated Curriculum Model.

such idealized examples are useful, they are generally too narrow to permit easy application to many classrooms in which resources are constrained. A range of examples specific to the subject content that apply scientific inquiry processes in the classroom would prove better than an individual example (Songer, Lee, & McDonald, 2003).

While the *Benchmarks* (AAAS, 1993), *NAEP* (U.S. Department of Education, Institute of Education Sciences, 2000) and even *Frameworks* (National Research Council, 2012) provide general guides, a more complete and detailed space science curriculum that would establish a set of courses and their individual syllabi at different grade levels has not yet been established. Educator workshops across the U.S. have been working towards identifying common themes or strands and establishing a more fully integrated framework for science education across all subject areas and all grade levels. The complexity this entailed has required years of concerted effort and has not been completed as of this writing.

Establishing a curriculum, particularly one integrated across subjects and grades, requires overcoming significant challenges in subject content and discipline definition together with teacher training and adequate resources. (Duschl, Schweingruber, & Shouse, 2007; Ellis, 2003; Hollweg & Hill, 2003). Teachers are often working independently and so the curriculum for these courses may be established in a topical and isolated fashion; ensuring rigorous, focused, and coherent content across subjects or across grades is difficult. Past investments by the state or school districts usually cover too many topics in too many small pieces with little integration of understanding (Alexander, 2003; Hollweg & Hill, 2003). Schools or teachers may resist the adoption of new curriculum (Olson, 2009).

Many state educational agencies, like the Texas Education Agency (2010), establish their own science frameworks such as the *Texas Essential Knowledge and Skills for Science (TEKS)*. Federal or state government standardized tests often determine the necessity for adherence to these frameworks. In many cases, funding for the lower organization in the administrative hierarchy depends upon achieving standardized test goals (Beaupré, Bloom-Nathan & Kaplan, 2002).

In addition to the financial and practical considerations that accompany the shift toward a more integrated curriculum there is some concern that the curriculum integration may not result in significant improvements in performance (Biological Sciences Curriculum Study, 2000; Duschl, Schweingruber, & Shouse, 2007; George, 1996a). The integrated structure has been a recommendation of constructionist theorists for at least half a century, though it has been neither widely implemented nor assessed (Beane, 1993). Some studies argue that an integrated curriculum structure improves retention of learned content and enhances conceptual understanding (Etim, 2005; National Research Council, 1996, 2010). Other studies suggest integrated curriculum structures improve student engagement (Bennett, Grasel, Parchmann, & Waddington, 2005; Krajcik, McNeill, & Reiser, 2007; Nathan, Tran, Atwood, Prevost, & Phelps, 2010). There have been, to date, no studies that confirm a relationship between standardized test scores and an integrated science curriculum (Drake & Burns, 2004).

Some counter the arguments for an integrated curriculum, claiming that the traditional topical structure of teaching individual subjects like physical sciences, life sciences and Earth sciences, each in a separate grade or year, provides for better conceptual understanding and retention while integration may result in less effective content or conceptual learning. Standardized test results have not demonstrated the efficacy of the traditional topical structure (DeBoer, 1991).

Curriculum integration revolves around making connections. Drake and Burns (2004) developed a model that provides a framework for delineating factors or dimensions that characterize the degree of integration of the curriculum. These include the degree to which organization of a subject and discipline surrounds a theme; the extent to which different disciplines are maintained or integrated; the extent to which a subject is based on standards; the approach used to deliver instruction; and the manner in which students organize their internal conception of a subject. The Drake and Burns model identifies four time periods or phases during which integration is characterized: planning, designing, implementing, and evaluating. The cognitive components of planning have been defined as: evaluating, prioritizing, formulating hypotheses, confirming, identifying, selecting, defining, noting patterns, and organizing (Yinger, 1980).

Some have suggested that a more optimal integrated curriculum can be established through community supported learning environments. Environmental structures such as activity theory (Engstrom, Miettinen, & Punamaki, 1999), legitimate peripheral participation (Lave & Wenger, 1991), communities of practice (Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989) and communities of learners (Brown & McIntyre, 1993) have all been applied to classrooms, endeavoring to construct optimal learning environments and curricula.

Teacher Education and Ability

Concerns about teacher ability, qualifications, and training increased after each of the national science education reports of the 1990s and recommendations for updated ESS teacher education professional development programs were made in the *NSES* (National Research Council, 1996). The less those higher-level standards define a subject's curriculum, the more reliance and responsibility rest with the individual teacher to define the course content. If the standards define the curriculum, could teachers be relied upon to implement it? In large measure this depends upon the teacher's ability and the support they receive (Wenglinsky & Silverstein, 2007).

The instructional process is a system. The purpose of the system is to bring about learning. The subject content, resources, teacher, and students are the components of the system. Learning objectives must be specified (Rothwell, 2008). Components interact to progress towards the desired objectives. Assessment measures the achievement of the learning objectives. Good instruction reinforces appropriate learner responses (Gagne, 1985). Many sources and inputs are critical to successfully establishing the instructional process (Moore, 2011). Inadequate learning means that modifications to the system parameters are required. All of the components must interact effectively (Dick, Carey, & Carey, 2005).

A wide variety of knowledge and support are required to ensure successful teaching. Shulman established a typology of teacher knowledge that includes knowledge of: (a) content, (b) general pedagogy, (c) curriculum, (d) pedagogical content, (e) learners and their characteristics, (f) educational contexts, and (g) ends, purposes and values of education (Shulman, 1987). The predominant process for establishing curriculum in science is a 4-step process: (a) generating a topic, (b) clarifying the science content, (c) developing activities associated with the topic, and (d) determining how to assess learning (Bybee & Scotter, 2007).

Some factors related to student performance are internal to the school system. Key factors may be the inadequate definition of the curriculum and lack of teacher preparedness because of inadequate training. Teachers in the sciences are frequently teaching outside of their certification field. Teacher professional development seeks to ensure that teachers are adequately prepared and have the requisite resources and knowledge (Wenglinsky & Silverstein, 2007).

Teacher Content Knowledge

As early as the beginning of the twentieth century, the National Society for the Study of Education (NSSE) critiqued science teacher training. Much of the criticism focused on inadequate scientific knowledge among science teachers. Such inadequacy resulted from insufficient college preparation (NSSE, 1932). Recommendations for adequate preparation of the teachers focused on required science content courses. This included preparation of Earth science teachers. Few teachers had accreditation in Earth science; only 19% of middle school science teachers had a geoscience degree. Thirty-nine percent had degrees in other science majors. Twenty-one percent of earth science teachers had elementary education certification and twenty-one percent had no teaching certification. Teachers seeking high school level certification should, the NSSE reported, divide their coursework between college science content courses and required education courses in sociology and psychology (NSSE, 1932). The committee strongly deemed science content knowledge to be of primary significance:

> It is impossible to teach any subject well without an adequate background of subject-matter training. Courses in methods and in other phases of education constitute a necessary part of the equipment of the teacher, but these courses should be considered always as additional to those required to provide a necessary background of subject matter; they should never be permitted as substitutes for subject matter (NSSE, p. 333).

The NSSE also recommended that all science teachers focus on science training in specific subjects: 12-16 credit hours in a specialization area: 18-24 credit hours in each of the primary sciences of physics, chemistry, and biology; and four credit hours each in several electives, including either geology or astronomy (NSSE, p.335).

The teacher should have knowledge of the scope, breadth, and depth of curricular possibilities. However, many teachers, and particularly science teachers at some grade levels, may have little if any preparation, education, or training for teaching science (Wenglinsky & Silverstein, 2007). If teachers have little training in a subject, and no training in interrelationships and processes, then they may be unable to convey concepts. This deficit in knowledge may lead to rote memorization of simple facts or definitions, rather than inquiry or scientific process. Research has increasingly focused on the application of constructivist philosophies to teaching and learning (Windschitl, 2013). The teacher is seen as one element of a complex developmental environment (Shulman, 1986).

According to Ball and McDiarmid (1990), content knowledge should be a primary area of emphasis in teacher preparedness. Training in content background is a key factor in the teacher's ability. Teachers require adequate training in content knowledge in order to prepare for teaching. Adequate training promotes the teaching of concepts and inquiry, rather than facts and procedures (Carlsen, 1991; Fennema & Franke, 1992).

Planning for course content is based on defining actions and behaviors that correlate to student outcomes (Clark, Gage, Marx, Peterson, Strayhook, & Winne, 1979; Peterson, Marx, & Clark, 1978). The role of teacher activity planning is a critical step in the design process; teacher activity planning is integral to establishing student classroom activity and emphasizing critical thinking skills. Studies have shown that teachers spend a significant amount of planning time establishing the classroom environment, developing the classroom activities, and obtaining the supporting resources (Clark & Yinger, 1987; Roskos & Neuman, 1995; Yinger, 1980). In addition, the National Research Council (1996) calls for teachers to have an appropriate understanding of the empirical, tentative, creative, inferential, and theory-laden nature of science in order to ensure scientific literacy (Lederman, Abd-EI-Khalick, Bell, & Schwartz, 2002).

Teaching Methodology

Understanding how best to *teach* new scientific content knowledge has often trailed the understanding of the scientific content itself. Recommendations to improve pedagogical strategies have included:

1. science methods that embrace authentic inquiry;
2. state-of-the-art technology and visualization resources;
3. exploration of formative assessment and how to modify instruction to meet students' learning needs;
4. awareness of common misconceptions and strategies to affect conceptual change;
5. establishment of scientific discourse communities to promote scientific literacy.

(Lieberman, 1992)

Properly teaching a science course requires the teacher to have extensive knowledge of teaching methodologies in addition to subject content knowledge. The teacher has to understand and apply how students learn in order to ensure that the classwork focuses on inquiry methods and the acquisition of conceptual knowledge.

Classroom activities should emphasize mastery of concepts through the scientific inquiry processes (Bybee & Scotter, 2007). Donovan and Bransford (2005) wrote that to make science relevant, it has to be current and based on extensive research that has been synthesized to the salient, significant concepts. They said that students learn science through familiarization with concepts, theories, and models and through an understanding of how knowledge is generated and justified.

A student’s understanding is adequate when it permits the students to engage in new inquiry. Learning occurs once new knowledge is absorbed and enables mastery of new processes or skills. Good instruction reinforces appropriate learner responses

(Gagne, 1985). Instruction provides stimuli, information and activities that organize and help to establish the students' internal mental processes. The significance of deep learning is the ability to transfer knowledge and skills and critical thinking ability to as yet undetermined purposes (Pellegrino & Hilton, 2012).

In order to ensure that Earth and space science teachers receive adequate training some departments offered the opportunity for their majors to gain teaching licensure in addition to their science degree. Other universities teamed education faculty together with science faculty to develop interdisciplinary science education teacher preparation programs (Lewis, 2008).

Resources in the ESS Classroom

From distances almost too incredible to contemplate, close-up observations of distant worlds have dazzled people. In King Henry VI, Shakespeare (1591) wrote that looking into the heavens a man wished his foot were equal to his eye; in this, Shakespeare communicates man’s innate desire to travel to the celestial bodies, rather than merely observing them. The enormity of space has awed man since the dawn of time. Today the grandeur of the views continues to awe us. In earlier eras of exploration, a few hardy sailors ventured out into the ocean. All others would wait behind for months or perhaps for years to hear what the sailors had discovered. This is no longer the case in the space age. Today, we all share in our explorations as they happen. When the Curiosity Mars rover descended to the surface of that planet on August 6, 2012, more than three million people watched it happen live on the internet (Kerr, 2012). The high technology of satellite communications, computers, and the internet enable an immediacy of discovery unrealized in earlier eras.

Now the same capabilities developed for space science are applied directly in communications, medicine, and environmental conservation. They meet many of the criteria for a broad based multidisciplinary course of study. For concepts that crosscut science and engineering, space science is integral with high technology. Space science includes vast quantities of information and new data has been streaming in continuously for a half century. Modern computer and internet technology permits ready accessibility to the information. *Frameworks* includes that "as the information archive grows and technology improves, our schools, teachers and students are living in an age of transition and even revolution" (National Research Council, 2012, p.172).

Multimedia

Attempts to incorporate multimedia learning tools in education go back to the mid-twentieth century. Harvard University psychologist Jerome S. Bruner, in his widely circulated report The Process of Education, called for a multi-disciplinary approach to curriculum design modeled on the planetarium. A planetarium is a theater for integrating three-dimensional views of the night sky with educational audio-video programming. The planetarium served as the centerpiece of a holistic, integrative instructional approach derived from the latest pedagogical theories. Bruner saw the planetarium as a means to deliver a virtual experience in space, enabling the comprehension and retention of scientific concepts and relationships and assimilating the principles of science (Bruner, 1960/1977; Marche, 2005).

Multimedia presentation can help to instill deeper learning. Multimedia combines images, pictures, video, and sound together with words; research has shown that students construct verbal and pictorial mental models and understand and retain information better than with text alone (Mayer, 2001). Science lends itself to computer and internet-based research, portrayal, modeling, and instruction. The internet facilitates the dissemination of current data. Computers and digital imagery have opened data management and communications pathways. They allow access to information without location constraints; data transport is at the speed of light and originals are reproduced without loss of quality. Computers enable archiving, searching, extraction, manipulation, and the graphical display of data. Models can illustrate the features of Earth, its atmosphere, the planets, and the universe, as well as how individual components interact (Gilbert & Ireton, 2003).

Computers and the Internet

Computers have found their way to uses in education (Burri, 2010); computers and technology have been described as an inseparable part of education (Pierson, 1999, 2001). Web sites can provide excellent resource materials whether in the form of raw data or exercises and curriculum content for internet-based classroom activities (Cunningham & Billinsley, 2005). Computers have been described as the hope for creating new learning environments (Carroll, 2000). Educators have been convinced, since technology’s outset, that computer technology would transform classroom education (Suppes & Searle, 1971; Dexter, Anderson, & Becker, 1999; Woodbridge, 2004).

The integration of computers in the public schools has been essentially continuous for some forty-five years. Every level of government, from district to federal, has invested in computer technology for school use. A U.S. Department of Education 2007 report suggested that total spending on computers during the 2003-2004 school year was nearly eight billion dollars (U.S. Department of Education, 2007). Fourteen million computers were available for classroom use in the nation's schools as of the 2005-2006 school year, which works out to one computer for every four students (U.S. Census Bureau, 2010). More money is now being spent on the technology tools for teachers and students than on virtually any other category of school spending other than personnel (Staples, Pugach, & Himes, 2005).

Despite the investment of dollars and time, research has repeatedly shown that the impact of computer technology on learning has been minimal. Some studies, like the Fuchs and Woessmann (2004) and Wenglinsky (1998), have even shown a negative relationship between computer use and learning. The U.S. Office of Technology Assessment (1995) identified that despite the widespread availability of personal computers and the internet, fewer than 15% of teachers were using computers for instruction (U.S. Office of Technology Assessment, 1995). In 1999, only 30% of teachers were using the computers available to them for educational purposes (Becker, 1999). *Teachers' Tools for the 21st Century: A Report on Teachers' Use of Technology (*NCES, 2000), reported that essentially all schools and teachers now had access to computer technology, but that fewer than 35% of teachers said they felt adequately prepared to use computers or the internet for instruction (U.S. Department of Education, 2000). Research tends to indicate that schools are funding technology without having a proactive, thoughtful, and integrated plan for its use.

Why has computer technology been slow to infiltrate the curriculum? Why have teachers been slow to adopt computers for instruction? Why have technology's effects on learning been marginal at best? Several researchers have explored this question. An extensive study, conducted from 2001 through 2003, the *Use, Support, and Effect of Instructional Technology* (USEIT), looked at 14,200 students, 4,400 classroom teachers, 122 campus principals and 120 school district administrators. The study identified factors affecting computer use, how computers were used and how learning was affected by computer use (O'Connor, Goldberg, Russell, Bebell, & O'Dwyer, 2004). Teachers identified access to computers, lack of practice, lack of familiarity with computers, and inadequate training in the use of computers as the most significant barriers.

Computer technology was integrated into the curriculum more effectively when teachers were appropriately trained in advance (Becker, 1999). This was consistent with findings that teachers often lacked the technical and professional training to integrate computer-based learning in the curriculum (Becker, 1999; O'Connor, Goldberg, Russell, Bebell, & O'Dwyer, 2004; Littrell, Zagumny, & Zagumny, 2005; Hew & Brush, 2006). The large-scale USEIT study found that, beyond the lack of technical expertise in the use of computers, a key obstacle to computer use in the classroom was the inability of teachers to deal with too large a quantity of potential computer-based curriculum resources and materials (O'Connor, Goldberg, Russell, Bebell, & O'Dwyer, 2004).

Several studies have looked at the integration of computer technology in the curriculum (Chan, Hong, Horng, Chang, & Chu, 2007; Rakes & Casey, 2002; Ertmer, Addison, Lane, Ross, & Woods, 1999). Sandholtz and Reilly (2004) recommended that teachers focus specifically on curriculum development and computer integration in the curriculum rather than on computer hardware and software technical issues. Teachers require training in the materials available for their specific subject area in order to help them to develop learning environments that make proper use of the computer technology and the resources that are available (Waddoups, Wentworth, & Earle, 2004). Staley (2004) argues that a teacher's focus should be on the activities in the classroom that are served by the technology rather than on the technology itself.

Computers were first adapted to facilitate the manipulation of large quantities of data. Later computers were adapted for basic skills. Students could write papers on their computers or they could get immediate feedback on math exercises. Computers today are far more sophisticated and powerful multimedia machines. Multimedia computer-based lessons can have a dramatic positive influence on knowledge scores over more traditional written instruction (Krishna, Balas, Konig, Graff, & Madsen, 2003). Several studies have shown that the improvement in learning outcomes will only happen with proper integration into the curriculum (Dillon & Gabbard, 1999; Mbarica et.al., 2001). A major obstacle has been the lack of interactivity (Nugent, 1982).

In addition to scientific literacy, the new twenty-first century definition first requires textual literacy or reading and writing ability. Additionally, students need a broadened technological literacy: the abilities and skills to understand words, sounds and images, to be able to manipulate and transform digital media, and to be able to distribute their productions pervasively. Students must expand upon the range of required communications competencies (P21, 2004; New Media Consortium, 2005; Brown, Bryan, & Brown, 2005; Jakes, 2006; Jenkins, K., Purushotma, Robison, & Weigel, 2008).

Summary

In the past, most science instructors used traditional lecture methods, outdated books, and laboratory exercises that had not been revised in decades. Dependence on those resources tended towards already established findings, single channel information transfer, little controversy, and silenced debate. Research showed that traditional science teaching negatively influenced student learning; most students' attitudes toward science were more negative at the completion of their courses than at the start of their courses (Hart, Mullhall, Berry, Loughran, & Gunstone, September, 2000; Tobias, 1992; Redish, Steinberg, & Saul, 1998).

Space science data offers the potential to overcome these negativities. Space science data is continuously streaming from its source, space itself. Every day, new vistas are observed and new information is transmitted. Computer technology offers opportunities for students and researchers to review, assess, and work with the data. One of the great motivational influences of this science is its novelty. Digital technology and internet-based communications enables students' access to information in new ways.

Structured interactions, interpretation and relevance to experience can engage students (Roschelle, Pea, Hoadley, Gordin, & Means, 2000, p.79). Learning becomes accessible through scientific inquiry, problem solving, reasoning, strategizing, hypothetical-deductive reasoning, synthesizing, giving and receiving feedback, and fostering the development of critical thinking skills (Linn, Davis, & Bell, 2004).

A logical, consistent, and coherent science curriculum framework is critical in order to achieve science literacy (Biological Sciences Curriculum Study, 2000; DeBoer, 1991; Duschl, Schweingruber, & Shouse, 2007; National Science Teachers Association, 2005; Schmidt, Houang, & Cogan, 2002). The astronomer, cosmologist, and educator Carl Sagan said in 1996, "…every kid starts out as a natural born scientist, and then we beat it out of them. A few trickle through the system with their wonder and enthusiasm for science intact…" (Head, 1996, p.119).

If it is to be successful, space science education requires a clear definition of the significant content. It requires definition of the appropriate pedagogical methods for communicating the information. It requires a curriculum framework that consists of well-defined concept and content standards, scope, sequence, and pedagogical techniques (National Research Council, 1996). Learning needs to focus on the ideas and skills that have the greatest scientific and educational significance. In short, it requires the investment of time and resources to define the curriculum and ensure that the appropriate sources and tools are available for the teachers. In addition to a well-defined curriculum and an availability of resources and tools, the instruction itself must be effective. The triadic relationship of curriculum, resources, and teaching is critical for successful space science education.

Chapter III

Methodology

Introduction

This study sought to identify the challenges and difficulties Texas teachers face in teaching courses that include space science themes. The purpose of the study was to gather perceptions from the teachers actively engaged in establishing and teaching the subjects. During the study, participants were asked to identify teacher course resource requirements. This chapter describes the research design, data gathering procedures, and data analysis process. The experiences of the Texas teachers who participated in this study may provide insights into challenges that teachers face in classrooms all across America now and in the years to come.

Nature of the Study

To analyze the challenges in teaching the space science subjects, a mixed methods analytical approach was chosen. Mixed methods were used to collect, analyze, integrate, and interpret the information collected in order to gain a deeper understanding of responses to the research questions. Quantitative or qualitative data and analysis alone would not have resulted in the thorough examination the study demands (Tashakkori & Teddlie, 1998).

This study was one in a series of studies conducted by the researcher; each of the studies was an examination of how space science is taught and the impact of that teaching (Kitmacher,2010b). Other study foci were spaceflight digital media

(Kitmacher, 2009); development of a space interest survey (Kitmacher, 2011b); STEM career selection and learning theory (Kitmacher, 2011a); and social psychology and space exploration (Kitmacher, 2010a). Kitmacher (2010b) was especially significant and served as a pilot for the current study. Kitmacher (2010b) formulated a brief survey to provide Texas astronomy and Earth and space science (ESS) teachers opportunities to assess the then newly introduced Texas space science and astronomy high school capstone courses during their inaugural school year. While some Likert-style questions were included in the survey, the respondents were also encouraged to provide open-ended narrative responses. In accordance with standard principles for instrument design, those responses to the earlier study served as psychometric models for the establishment and verification of questions that would ultimately be incorporated into the current study (Bradburn, Sudman & Wansink, B., 2004). Responses were categorized and expanded upon in order to create the range of questions and responses to be used in the survey for the current study. The process yielded the constructs used.

The intent of the survey was to gather statistically significant data. The data would serve to characterize the population of teachers of the space science associated subjects in Texas schools at all grade levels. They would also allow the identification of any correlations between the ability of teachers to teach the subjects with other factors. Much of the survey was organized around six constructs:

1. Curriculum establishment - Four Likert-style questions pertained to and were intended to represent how well curriculum was perceived to be established

for each of four subject areas: Earth Science, Earth and Space Science (ESS), Space Science, and Astronomy;

2. Experience - Thirteen questions, including one open-ended narrative question, pertained to experience as identified by the total number of years taught, individual subjects, and current teaching responsibilities;
3. Education - Three questions solicited responses regarding the respondents' educational backgrounds, including identification of college degree(s) earned and including the two parameters of level of degree and field of study: BA, BS, MA, MS, PhD, or other recent non-degree training; and, subject area of their degree(s) including physical science, life science, ESS-associated sciences, mathematics and non-sciences;
4. Community support - Ten Likert-style questions and two open-ended narrative questions pertained to community support. These questions asked the respondents to identify the degree of support provided by administration, local teachers, external or distant teachers, institutions of formal education, museums and institutions associated with informal education, local subject matter experts, the internet, and monetary or resource grants;
5. Resources used - Four multiple choice questions and two open-ended narrative questions pertained to resources used for different classes and asked the respondents to identify the degree to which they used textbooks, other written materials, worksheets, computers in the classroom for teacher use, computers in the classroom for student use, computers outside the

classroom for teacher use, computers outside the classroom for student use, digital media used on devices other than computers, and pre-recorded content; these data were collected for each individual course taught by the respondents.

The five constructs above were used as sources of descriptive statistical data and as independent variables factored into regressions/correlations. The final, sixth construct, was used as the dependent variable in regression/correlation analysis:

6. Ability – Four Likert-style questions asked for a self-appraisal by each respondent of their technical or subject content knowledge, currency of knowledge, knowledge of instructional methodology, and overall teaching ability and preparedness. An additional open-end question asked respondents to identify what might assist them in further developing these abilities.

In addition to the quantitative data collected through the survey, qualitative data augmented the study. The qualitative data was collected through a series of open-ended narrative responses in the survey as well as interviews and classroom observations.

Additional demographics and statistical data collected in the survey included date and time of submission, U.S. state, gender, number of classes and subjects currently being taught, and grade levels being taught. The identification of each respondent by name, school, district, and contact information was requested but identified as optional. Based on the optional data submitted, Texas Education Agency (TEA) school evaluation/rank, urban rank, and district size were identified.

The survey was worded in simple and straightforward language; the Kitmacher (2010b) study was instrumental in determining such language. This process ensured that terminology or vernacular would not be confusing to the target population. Potential wording or question issues were identified and corrected during a draft review process by independent reviewers.

Participants

Following certification of the survey by the University of Houston Committee for the Protection of Human Subjects, included in Appendix C, the survey was introduced at the 2012 Science Teachers Association of Texas (STAT) conference held in Corpus Christi, Texas. STAT embraced the research and encouraged teacher participation; a letter identifying their support for the study is included in Appendix E. A series of invitations, like that shown in Appendix F, was sent in emails. News lists were distributed during the first days of the conference by STAT, the TEA science coordinator, and the Texas Earth Science Teachers Association (TESTA). Immediately following the conference an invitation was distributed by the University of Texas McDonald Observatory education coordinator. These emails and news lists identified the availability of the survey, provided a link to the on-line survey, and invited all Texas teachers teaching space science associated subjects to participate. At the STAT conference, paper copies of the survey were also available. The survey is provided in Appendix G.

Because the STAT conference did not yield a statistically adequate number of responses, in February, 2013, a distribution list was compiled based on a TEA listing of coordinators for 1,265 public school districts in Texas. An email with a link to the survey was sent to every district's coordinator, inviting participants in their respective district to participate in the survey.

Current and past teachers of Earth science, space science, astronomy or associated subjects were invited to participate. Because *Frameworks* recommends space science instruction for all grade levels, and because the TEKS reflect that elements of space science are taught at every grade level, for this study teachers at every grade level were afforded the opportunity to participate in the survey.

Protection of Human Subjects

The study was conducted in accordance with the requirements of the Institutional Review Board (IRB) for the Protection of Human Subjects at the University of Houston. The survey and study comply, as well, with school district research requirements and protocols. The surveys and research procedure were reviewed and approved by the University of Houston's IRB and by those districts in which such approval was required. Data access, and in particular access to individually identifiable information, is restricted only to the researcher. Appendix C is the approval letter from the University of Houston Committee for Protection of Human Subjects and Appendix D is the letter of informed consent to participate in research.

Survey Form Software and Access

The survey software used was provided by the *Google Forms Survey* tool. This instrument permitted data collection through multiple layers of security that ensured that data would remain private. The survey web site was encrypted and access to the responses was limited by password. A copy of the survey text is provided in Appendix G.

Data Analysis

Submitted responses were coded into Excel and SPSS matrices for simple statistical descriptive analysis. Results are illustrated in Appendices H through N. In addition, regression/correlation analysis identified relationships between variables as shown in Appendices O through S. A total of 102 variables were identified. Effect size based on the R statistic, model strength based on the R^2 statistic, ANOVA and variable coefficient significance were computed. A *stepwise* linear regression method was used in most cases, in order to identify significant correlations, strengths of relationships, and significant predictor variables. In cases where *stepwise* yielded no results, then the less stringent *direct* computational method was used. SPSS output is provided in Appendices P through S. Computations were run for each individual independent variable against each of the dependent variable traits, and against the dependent variable overall average. Computations were also run for all respondents and then for respondents in each individual grade level.

Qualitative narrative data, including responses to survey questions and to interview questions, were consolidated by subject and by grade level. In several instances where responses were repetitive across grade level responses, numeric counts identified strength of responses both for individual responses and for comparison of one category of response against another. The most useful, constructive, explicatory, instructive or elucidatory responses were selected for incorporation in this report.

Summary

This study examined the instruction of space science classes and curricula in the K-12 grade levels in Texas public schools. In addition, the study investigated the characteristics of the population of teachers teaching space science associated subjects in Texas public schools. The project sought to answer the research questions through the development and use of a survey of Texas K-12 public school teachers and the analyses of statistical data that characterized the population as a whole as well as by the individual grade levels of elementary, middle, and high school.

In addition, the study sought to determine teachers' perceptions; specifically, perceptions regarding their ability to teach space science related subjects. This question was answered by statistically analyzing the construct of teacher ability. Teacher ability was measured by several contributory self-appraised factors:

1. content knowledge;
2. currency of knowledge;
3. knowledge of instructional methodology;
4. teaching preparedness.

These factors were considered as dependent variables correlated against several independent variable constructs:

1. perceptions about curriculum establishment;
2. classroom resources;
3. community support;
4. teaching experience;

5. education.

Finally, the study sought to identify any specific areas, such as textbook availability, computer and technology use, or resources on the internet, that teachers felt impeded or enhanced their ability to teach the space science associated subjects. This question was answered through qualitative analysis of narrative responses to the survey, together with select interviews and classroom observations.

Chapter IV

Findings

Introduction

The purpose of the study was to characterize the population of Texas public school teachers of subjects related to space science; to evaluate their perceptions concerning their ability to teach these subjects; and, to identify factors such as education, experience, resources and support infrastructure that they rely upon and that enable their teaching, or alternatively that constrain them. In this chapter, the researcher presented the data generated in the study.

Research Question Responses

Research Question 1

Research question 1: *what are the characteristics of the population of teachers teaching space science associated subjects in Texas public schools?*

This question was answered using descriptive statistics to characterize the population as a whole as well as the individual elementary, middle, and high-school grade levels teachers. Demographic information, together with a series of constructs, was used to characterize the population of teachers and the space science related subjects they teach:

1. teaching experience with respect to space science related subjects along with other science or mathematics fields;
2. teacher education pertinent to space science;

3. perceptions of curriculum establishment for space science related subjects;
4. classroom resources the teachers used for teaching space science related subjects;
5. community support the teachers depended upon in teaching space science related subjects;
6. teachers' perceptions of their own abilities to instruct space science.

Characteristics of Respondents

All data used to characterize the population of teachers came from the survey designed specifically for this research. That survey was first available at the 2012 Conference for the Advancement of Science Teaching (CAST); it was subsequently available on-line. All teachers who have taught space science related subjects in Texas public schools were invited to participate in this study. The invitations, an example of which is shown in Appendix F, were initially made through news lists and announcements at the 2012 CAST. Approximately 75 responses were received after CAST conference. Subsequently, 1,265 invitations were emailed to all of the Texas public school districts, addressed to the district/state coordinator for each district as listed on a Texas Education Agency website. This resulted in an additional 240 survey responses. Responses that were submitted by respondents who had not taught space science associated subjects in a Texas public school were eliminated from use in the study. In all, 303 responses representing at least 105 Texas school districts across the state were used in the analysis. Appendix U presents a list of all districts known to be represented.

Constructs

Data were collected for six individual constructs, each with respect to space science associated subjects. Each construct was composed of a series of factors or variables developed from the survey responses. Each construct was analyzed for the total population and for individual subpopulations by grade level.

Teaching Experience Construct

Two constructs, experience and education, were demographic in nature, establishing statistical information that characterized the background of the respondents. Three factors were used to measure the experience construct:

1. grade-level now teaching;
2. total years teaching experience;
3. years of experience teaching individual subjects.

The grade-level factor was used to separate survey responses for analysis by grade level. Nine Likert-style questions asked participants to rate their teaching experience on a five-point scale. Individual questions asked for experience in the subject areas of Earth science, Earth and space science, space science, astronomy, physical science (which included physics and chemistry), life science, technology/engineering, and mathematics; one question asked for total years teaching experience. The response scale for each question was divided into five options: 0-4 years, 5-8 years, 9-12 years, 13-16 years, and 17 years or more.

Table 4.1. Experience Construct.

A. Years of experience, all respondents.

Years experience	0-4	5-8	9-12	13-16	17 or more
Total	18	19	19	16	29
Earth Science	36	24	16	9	15
ESS	41	22	15	9	13
Space Science	44	21	15	8	12
Astronomy	56	19	9	5	10
Physical Science	36	23	16	10	15
Life Science	35	20	17	10	18
Technology/Engr	74	13	7	4	3
Mathematics	61	15	9	8	8

B. Years of experience, elementary.

Years experience	0-4	5-8	9-12	13-16	17 or more
Total	19	17	24	17	22
Earth Science	29	24	21	11	15
ESS	31	21	23	11	13
Space Science	33	23	20	12	13
Astronomy	53	20	12	8	8
Physical Science	39	19	20	10	13
Life Science	28	22	22	11	16
Technology/Engr	62	17	12	7	2
Mathematics	34	25	17	13	11

C. Years of experience, middle-school.

Years experience	0-4	5-8	9-12	13-16	17 or more
Total	20	20	19	13	27
Earth Science	36	28	13	7	16
ESS	40	26	12	7	15
Space Science	41	25	13	7	14
Astronomy	51	22	8	5	15
Physical Science	38	26	12	9	16
Life Science	37	22	16	10	16
Technology/Engr	83	11	1	1	3
Mathematics	81	8	4	3	5

D. Years of experience, high-school.

Years Experience	0-4	5-8	9-12	13-16	17 or more
Total	12	20	12	18	39
Earth Science	48	18	13	7	15
ESS	59	18	6	8	9
Space Science	67	10	10	6	8
Astronomy	68	15	6	3	8
Physical Science	31	26	15	12	17
Life Science	42	12	12	8	25
Technology/Engr	81	8	6	2	4
Mathematics	80	6	4	6	6

Note: All values are in percent of responses to individual questions. All values rounded to nearest whole percentage.

None of the selections were mutually exclusive or dependent on others so respondents could rate each of the subject areas independently or, alternatively, could choose not to respond to the question. The questions as relate to each subject area and the choices of length of experience were based upon data compiled in a pilot study (Kitmacher, 2010b).

The responses for each experience level and all subject areas are identified in Table 4.1 A-D. Histograms illustrating the experience construct results are provided in Appendix I.

Education Construct

The education construct was demographic in nature, establishing statistical information that characterized the background of the population of respondents. Three factors were used to measure the education construct:

1. degrees attained;
2. major fields of study;
3. most recent space science-related training.

Likert-style and open-ended questions asked respondents to identify their degree(s), major field(s) of study, and most recent training in ESS associated subjects. Respondents were free to identify multiple degrees, multiple fields of study and multiple types of recent training. Degree selections included the nominal categories of BA, BS, MA, MS, and PhD. Fields of study were ordered from least closely to most closely related to space science and were coded as (1) non-science, (2) life science, (3) physical science, and (4) natural sciences directly associated with ESS such as geology or astronomy. Most recent training included both not-for-credit, meaning workshops or professional development, and for-credit, meaning college courses. For-credit training was divided by how long ago it occurred. The choices were based upon the responses identified in a pilot study (Kitmacher, 2010b).

The responses for degrees, majors and recent training are identified in Tables 4.2 A-C. Histograms illustrating the education construct results are shown in Appendix J.

Table 4.2. Education Construct.

A. Degree(s) of teachers of ESS related subjects.

Education	All Respondents	Elementary	Middle-school	High-school
Degree: BA	16	17	17	16
Degree: BS	42	49	45	32
Degree: MA	20	23	18	18
Degree: MS	20	12	19	30
Degree: PhD or Dr.	2	0	1	4

B. Majors of teachers of ESS related subjects.

Education	All Respondents	Elementary	Middle-school	High-school
Non-science	52	77	42	27
Life Science	34	20	44	43
Physical Science	7	2	3	17
ESS and related	8	1	11	13

C. Most recent space science related training of teachers.

Education	All Respondents	Elementary	Middle-school	High-school
Never completed	55	54	59	47
Non-credit last 5 yrs	12	13	12	13
For-credit 7yrs +	5	10	5	2
For-credit 4-6 yrs	26	22	24	36
For-credit last 3 yrs	1	2	1	1

Note: All values are percent of responses to each selection. All values rounded to nearest whole percentage.

Resources Construct

Two constructs, resources and community, sought to have teachers identify the educational resources and community infrastructure they depended upon for teaching space science subjects. A series of Likert-style and open-ended narrative questions asked the teachers to identify the resources and the community elements they depend upon as well as those they need that are inaccessible.

Four questions asked teachers to identify those resources they regularly used to support or enable teaching their classes. The four questions addressed the different subject areas of Earth science, Earth and space science, space science and astronomy. Respondents were asked to identify whether they did or did not rely upon the following resources:

1. textbooks;
2. written content other than textbooks, such as magazines, books, or copied materials;
3. computers in the classroom used by the teacher ;
4. computers in the classroom used by the students;
5. computers outside the classroom used by the teacher;
6. computers outside the classroom used by the students;
7. digital media other than computers such as cell phones, smart phones, or tablets;
8. pre-recorded audio or video programs, visualizations, or simulations.

None of these selections were mutually exclusive or dependent on one another so that the respondents could select any, all or none of the choices. The choices were based upon the resources identified in a pilot study (Kitmacher, 2010b). The responses are identified by subject in Tables 4.3 A-C. Histograms illustrating the resources construct results are provided in Appendix K.

Community Support Construct

The community support construct sought to have teachers identify and establish a statistical characterization of the support upon which they rely for teaching space science. Eight Likert-style questions asked participants to rate on a four point scale from “do not depend upon” to “very dependent upon”. These selections referred to those entities in either their local or more extended communities that support or enable them to teach. The selections asked them to rate their dependence on:

1. their district or school administration;
2. teachers within their district;
3. teachers outside of their district;
4. colleges or other formal education institutions;
5. museums, professional organizations, or other informal education institutions;
6. subject matter experts in their community;
7. subject matter expertise found on the internet;
8. grants from government or corporations.

Table 4.3A: Resources Construct: Textbook and Written Materials

A. Written/printed resources used or not used;

Textbooks, non-textbook written content and worksheets.

	Earth Science		ESS		Space Science		Astronomy	
RESOURCE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE
All respondents, Written/Printed Materials								
Textbooks	52	48	51	49	49	51	50	50
Written, other	67	33	67	33	65	35	62	38
Worksheets	77	23	76	24	75	25	66	34
Elementary-school respondents, Written/Printed Materials								
Textbooks	45	55	46	54	43	57	42	58
Written, other	68	32	71	29	68	32	60	40
Worksheets	78	22	75	25	70	30	63	37
Middle-school respondents, Written/Printed Materials								
Textbooks	57	43	53	47	53	47	48	52
Written, other	67	33	66	34	65	35	60	40
Worksheets	76	24	78	22	79	21	68	32
High-school respondents, Written/Printed Materials								
Textbooks	56	44	58	42	53	47	65	35
Written, other	67	33	60	40	60	40	67	33
Worksheets	75	25	73	27	76	24	69	31

Note: all values are percent of responses to each selection; all values rounded to nearest whole percentage.

Table 4.3B: Resources Construct: Computers
Computer resources used or not used. Computers inside and outside of the classroom; computers for teacher use or for student use.

	Earth Science		ESS		Space Science		Astronomy	
RESOURCE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE
All respondents, Computers Inside and Outside of the Classroom								
Computers in Classroom for Teachers	89	11	90	10	88	12	87	13
Computers in Classroom for Students	54	46	57	43	53	47	54	46
Computers out of Classrm for Teachers	38	62	42	58	39	61	41	59
Computers out of Classrm for Students	36	64	37	63	35	65	36	64
Elementary-school respondents, Computers Inside and Outside of the Classroom								
Computers in Classroom for Teachers	92	8	91	9	89	11	82	18
Computers in Classroom for Students	58	42	61	39	53	47	56	44
Computers out of Classrm for Teachers	34	66	37	63	37	63	33	67
Computers out of Classrm for Students	37	63	36	64	36	64	33	67
Middle-school respondents, Computers Inside and Outside of the Classroom								
Computers in Classroom for Teachers	94	6	96	4	96	4	94	6
Computers in Classroom for Students	56	44	58	42	60	40	54	46
Computers out of Classrm for Teachers	45	55	44	56	42	58	43	57
Computers out of Classrm for Students	40	60	40	60	37	63	40	60

Note: all values are percent of responses to each selection; all values rounded to nearest whole percentage.

Table 4.3B: Resources Construct, continued.
High-school respondents, Computers Inside and Outside of the Classroom

	Earth Science		ESS		Space Science		Astronomy	
RESOURCE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE
Computers in Classroom for Teachers	75	25	81	19	71	29	83	17
Computers in Classroom for Students	42	58	50	50	38	62	50	50
Computers out of Classrm for Teachers	32	67	47	53	36	64	48	52
Computers out of Classrm for Students	27	73	35	65	31	59	33	67

Note: all values are percent of responses to each selection; all values rounded to nearest whole percentage.

Table 4.3C: Resources Construct: Digital and Recorded Media
Digital and Recorded Media resources used or not used.

	Earth Science		ESS		Space Science		Astronomy	
RESOURCE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE	USE	DON'T USE
All respondents, Digital and Recorded Media								
Digital Media	36	64	38	62	38	62	38	62
Pre-recorded	79	21	20	80	75	25	76	24
Elementary-school respondents, Digital and Recorded Media								
Digital Media	30	70	28	72	29	71	25	75
Pre-recorded	78	22	76	24	69	31	66	34
Middle-school respondents, Digital and Recorded Media								
Digital Media	38	62	45	55	46	54	46	54
Pre-recorded	80	20	85	15	81	19	81	19
High-school respondents, Digital and Recorded Media								
Digital Media	42	58	45	55	44	56	47	53
Pre-recorded	79	21	79	21	78	22	86	14

Note: All values are percent of responses to each selection. All values rounded to nearest whole percentage.

None of these selections were mutually exclusive or dependent on one another so that the respondents could rate each of these areas of support independently. The choices were based upon the community elements identified by teachers as those upon which they depended in a pilot study (Kitmacher, 2010b).

The responses rating dependence on each community support factor is identified by subject in Tables 4.4 A-D. Histograms illustrating the community support construct results are shown in Appendix L.

Curriculum Establishment Construct

Two constructs were psychometric in nature. These asked the respondents to characterize their perceptions about their teaching abilities. These constructs also asked teachers for their perceptions regarding the establishment of the curriculum with respect to space science. These constructs were established and statistically analyzed using a series of ordinal ratings.

Four Likert-style questions asked teachers whether they felt curriculum was adequately established to enable the teaching of their classes. The questions asked about curriculum establishment in the four subject areas of:

1. Earth science;
2. Earth and space science (ESS);
3. space science;
4. astronomy.

The respondents were asked to rank the curriculum for each subject area on a five-point scale from “minimally established” to “thorough and complete.” The specific subject areas and rankings were based on a pilot study (Kitmacher 2010b). The responses rating curriculum definition for each subject are presented in Table 4.5. Histograms illustrating the curriculum establishment results are shown in Appendix M.

Table 4.4: Community Support Construct.

A. For all teachers.

% Support from	Do not depend on	Depend on a little	Depend on somewhat	Very dependent upon
District/Administration	32	28	19	21
Local Teachers	26	23	35	16
Teachers Out of District	44	29	19	7
Colleges, Formal Ed	38	31	21	10
Museums, Informal Ed	35	38	19	9
Community Subject Experts	52	33	10	6
Internet	18	17	36	29
Gov't/Corporate Grants	66	24	7	3

B. For elementary-school teachers.

% Support from	Do not depend on	Depend on a little	Depend on somewhat	Very dependent upon
District/Administration	21	31	25	23
Local Teachers	16	27	38	17
Teachers Out of District	57	24	14	6
Colleges, Formal Ed	51	30	15	4
Museums, Informal Ed	37	41	14	8
Community Subject Experts	61	28	9	2
Internet	20	19	39	21
Gov't/Corporate Grants	69	22	7	3

Table 4.4: Community Support Construct, continued.

C. For middle-school teachers.

% Support from	Do not depend on	Depend on a little	Depend on somewhat	Very dependent upon
District/Administration	30	26	23	20
Local Teachers	20	23	35	21
Teachers Out of District	39	34	20	7
Colleges, Formal Ed	36	36	18	10
Museums, Informal Ed	38	35	19	8
Community Subject Experts	51	34	11	5
Internet	19	18	36	26
Gov't/Corporate Grants	66	25	8	1

Note: all values are percent of responses to each selection. All values rounded to nearest whole percentage.

D. For high-school teachers.

% Support from	Do not depend on	Depend on a little	Depend on somewhat	Very dependent upon
District/Administration	47	28	8	18
Local Teachers	41	20	31	8
Teachers Out of District	35	31	24	10
Colleges, Formal Ed	24	26	31	19
Museums, Informal Ed	30	36	24	10
Community Subject Experts	44	36	9	11
Internet	14	14	31	41
Gov't/Corporate Grants	64	24	7	4

Note: all values are percent of responses to each selection. All values rounded to nearest whole percentage.

Table 4.5. Teacher's Perceptions of Curriculum Definition.

	Earth Science Curriculum mean	ESS Curriculum mean	Space Science Curriculum mean	Astronomy Curriculum mean
All Respondents	3.32	3.05	2.74	2.45
Elementary	3.29	3.22	2.81	2.32
Middle-school	3.46	3.17	2.93	2.49
High-school	3.14	2.64	2.34	2.58

Curriculum Establishment Values:

1. Minimal definition of curriculum;
2. Moderate establishment of curriculum;
3. Thorough and complete definition of curriculum.

Research Question 2

Research Question 2: *do teachers feel they are able to teach the space science related subjects?*

This question was answered by statistically analyzing the construct of teacher ability. Teacher ability was measured by several contributory factors. These factors were considered as dependent variables and were correlated/regressed against five independent variable constructs:

1. feelings about curriculum establishment;
2. classroom resources;
3. community support;
4. teaching experience;
5. education.

Ability Construct

Teacher ability was measured by four contributory factors:

1. content knowledge;
2. currency of knowledge;
3. knowledge of instructional methodology;
4. teaching preparedness.

Four questions asked respondents to self-appraise their ability to instruct space science content. Respondents were asked to rank themselves on a five-point scale from inadequate and unable to thoroughly prepared and able. The specific questions and ranking choices were based on a pilot study (Kitmacher 2010b).

None of the survey selections were mutually exclusive or dependent on one another, so that the respondents could rate each of the factors independently. The percent of responses for each ability factor, by grade level, is identified in Tables 4.6.A-D. Histograms illustrating the ability construct results are shown in Appendix N.

Table 4.6. Ability Construct.

A. For all Texas teachers.

Ability	Inadequate	Minimally adequate	Moderately adequate	Somewhat adequate	Thoroughly adequate
Subject Content Knowledge	6	9	34	42	10
Currency of Knowledge	5	11	37	36	12
Instructional Methodology	4	14	32	39	11
Instructor Preparedness	5	10	38	36	11

B. For Texas elementary-school teachers.

Ability	Inadequate	Minimally adequate	Moderately adequate	Somewhat adequate	Thoroughly adequate
Subject Content Knowledge	7	12	32	37	12
Currency of Knowledge	6	11	38	34	11
Instructional Methodology	6	14	26	44	11
Instructor Preparedness	6	15	31	37	11

C. For Texas middle-school teachers.

Ability	Inadequate	Minimally adequate	Moderately adequate	Somewhat adequate	Thoroughly adequate
Subject Content Knowledge	4	4	38	47	7
Currency of Knowledge	4	9	35	41	11
Instructional Methodology	2	8	32	45	13
Instructor Preparedness	3	1	44	42	10

D. For Texas high-school teachers.

Ability	Inadequate	Minimally adequate	Moderately adequate	Somewhat adequate	Thoroughly adequate
Subject Content Knowledge	5	12	31	42	11
Currency of Knowledge	5	12	38	32	12
Instructional Methodology	5	20	41	26	9
Instructor Preparedness	5	15	40	28	12

Note: All values are percent of responses to each selection. All values rounded to nearest whole percentage.

Reliability

Cronbach's α was used to address the reliability of the survey response ratings that composed each construct (Beggs, 2013; UCLA Institute for Digital Research and Education, 2012). Cronbach's α was computed for each of the constructs: ability, resources, community support, curriculum establishment and experience. These results are presented in Table 4.7. The ability, curriculum establishment, resources, and experience construct scales all had very high reliabilities with α between .85 and .95. The community support construct scale had a lower, more moderate α of .683.

Table 4.7. Cronbach's α For All Constructs.

	All Respondents	Elementary	Middle-school	High-school
Ability	.910	.931	.886	.909
Curriculum	.875	.885	.893	.846
Resources	.867	.854	.850	.895
Community	.683	.693	.665	.715
Experience, all subjects	.921	.929	.933	.874
Experience, ESS subjects	.923	.937	.954	.871

Regression Analysis

In order to assess whether the ability of teachers to teach space science was correlated with individual factors, the four individual ability construct factors were considered as the dependent variables and were correlated/regressed against each of the variable construct factors developed in research question 1. In addition to the four ability factors being regressed individually, the four were also averaged and the average regressed against the independent variables. The demographic and psychometric factors that characterized the teachers and the resources and the community support on which they relied were treated as independent variables. One-way analysis of variance (ANOVA) was used to analyze the correlation between the construct parameters of the independent variables: experience, education, community support, curriculum and resources with the dependent variable, ability.

Several significant and highly significant relationships were identified. Appendices O-S, provide the statistical program regression data analysis including the model summary, analysis of variance (ANOVA) table and table of coefficients identifying statistically significant predictors. Each appendix provides the data for a single population. Appendix P provides regression analyses for all respondents. Analyses for elementary, middle, and high-school teachers are provided in Appendices Q, R and S, respectively. Analyses progress through each of the independent variable constructs and through each of the dependent variable factors in sequence. Tables 4.8 A-E provide a summary of the significant and highly significant relationships established through the statistical analysis of multiple regressions.

Table 4.8.A. Statistically Significant Correlations. Data tables for these regressions are included in Appendices P, Q, R and S.
Correlations Between Ability and Experience.

Statistically Significant Correlations

Dependent Variable: **Ability**

Independent Variables	Ability Average Elem 1	Ability Average Midl 1	Ability Average High 1	Ability Average All 1	Subject Content Knowledge Elem 2	Subject Content Knowledge Midl 2	Subject Content Knowledge High 2	Subject Content Knowledge All 2	Knowledge Currency Elem 3	Knowledge Currency Midl 3	Knowledge Currency High 3	Knowledge Currency All 3	Instructional Methodology Elem 4	Instructional Methodology Midl 4	Instructional Methodology High 4	Instructional Methodology All 4	Instructor Preparedness Elem 5	Instructor Preparedness Midl 5	Instructor Preparedness High 5	Instructor Preparedness All 5
A. EXPERIENCE, Years Teaching																				
Total		○			○				●				●				●			
Earth Science		○			○															
ESS		○		●	○	●	●	●						●				●		
Space Science		○			○				●	○		●	●			●				●
Astronomy		○	●	●	○				●		●	●	●		●				●	●
Physical Science		○			○					●							●			
Life Science		○	○	●	○			●			●	●		●		●		●	●	●
Tech/Engineering		○			○				●				●				●			
Mathematics		○			○															

● highly significant, sig ≤ .01 ○ significant, sig ≤ .05

Table 4.8.B. Statistically Significant Correlations. Data tables for these regressions are included in Appendices P, Q, R and S.
Correlations Between Ability and Education.

Statistically Significant Correlations

Dependent Variable: **Ability**

Independent Variables	Ability Average Elem 1	Ability Average Midl 1	Ability Average High 1	Ability Average All 1	Subject Content Knowledge Elem 2	Subject Content Knowledge Midl 2	Subject Content Knowledge High 2	Subject Content Knowledge All 2	Knowledge Currency Elem 3	Knowledge Currency Midl 3	Knowledge Currency High 3	Knowledge Currency All 3	Instructional Methodology Elem 4	Instructional Methodology Midl 4	Instructional Methodology High 4	Instructional Methodology All 4	Instructor Preparedness Elem 5	Instructor Preparedness Midl 5	Instructor Preparedness High 5	Instructor Preparedness All 5
B. EDUCATION																				
Highest Degree Earned							○													
Major						●	○	●												
Education Degree			○				○								●					
Most Recent Training				○		●	○	●												
Not for Credit Training	●				●	●	○	●	●				●				●			

● highly significant, sig ≤ .01 ○ significant, sig ≤ .05

Table 4.8.C. Statistically Significant Correlations. Data tables for these regressions are included in Appendices P, Q, R and S.
Correlations Between Ability and Resources.

Dependent Variable: **Ability**

Independent Variable E. RESOURCES		Ability Average				Subject Content Knowledge				Knowledge Currency				Instructional Methodology				Instructor Preparedness			
		Elem 1	Midl 1	High 1	All 1	Elem 2	Midl 2	High 2	All 2	Elem 3	Midl 3	High 3	All 3	Elem 4	Midl 4	High 4	All 4	Elem 5	Midl 5	High 5	All 5
Earth Science	Textbook																				
	Written Content																				
	Worksheets																				
	Computers in Classrm/Teachers																				
	Computers in Classrm/Students																				
	Computers Outside Classrm/Teachers																				
	Computers Outside Classroom/Students																				
	Digital Media												●								
	Prerecorded programs							●		●			●								
ESS	Textbook																				
	Written Content																				
	Worksheets																				
	Computers in Classrm/Teachers																				
	Computers in Classrm/Students																				
	Computers Outside Classrm/Teachers									●				●			●				
	Computers Outside Classroom/Students																				
	Digital Media																				
	Prerecorded programs			●	●																
Space Science	Textbook							●													
	Written Content																				
	Worksheets	●				●				●				●				●			
	Computers in Classrm/Teachers	●				●				●			●	●				●			●
	Computers in Classrm/Students				●												●				
	Computers Outside Classrm/Teachers	●			●	●			●				●				●	●			●
	Computers Outside Classroom/Students																				
	Digital Media																				
	Prerecorded programs								●												
Astronomy	Textbook																				
	Written Content																				
	Worksheets																				
	Computers in Classrm/Teachers											●								●	
	Computers in Classrm/Students																				
	Computers Outside Classrm/Teachers																	●			
	Computers Outside Classroom/Students																				
	Digital Media			●	●			●	●		●	●	●				●			●	●
	Prerecorded programs	●									○	○		●		●					

● highly significant, sig ≤ .01 ○ significant, sig ≤ .05

Table 4.8.D. Statistically Significant Correlations. Data tables for these regressions are included in Appendices P, Q, R and S.
Correlations Between Ability and Community Support.

Statistically Significant Correlations — Dependent Variable: **Ability**

Independent Variables	Ability Average Elem 1	Ability Average Midl 1	Ability Average High 1	Ability Average All 1	Subject Content Knowledge Elem 2	Subject Content Knowledge Midl 2	Subject Content Knowledge High 2	Subject Content Knowledge All 2	Knowledge Currency Elem 3	Knowledge Currency Midl 3	Knowledge Currency High 3	Knowledge Currency All 3	Instructional Methodology Elem 4	Instructional Methodology Midl 4	Instructional Methodology High 4	Instructional Methodology All 4	Instructor Preparedness Elem 5	Instructor Preparedness Midl 5	Instructor Preparedness High 5	Instructor Preparedness All 5
COMMUNITY SUPPORT																				
District/Administration	●				●				●				●				●	○		
Local Teachers																				
Distant Teachers			●				●				○								○	
Colleges(formal ed)			●				●	●												
Museums(informal ed)				●																
Local Subject Matter Experts													●							
Internet	●				●				●				●				●			
Grants (gov't or corp)	●		●		●				●				●				●			

● highly significant, sig ≤ .01 ○ significant, sig ≤ .05

Table 4.8.E. Statistically Significant Correlations. Data tables for these regressions are included in Appendices P, Q, R and S
Correlations Between Ability and Curriculum.

Statistically Significant Correlations — Dependent Variable: **Ability**

Independent Variables	Ability Average Elem 1	Ability Average Midl 1	Ability Average High 1	Ability Average All 1	Subject Content Knowledge Elem 2	Subject Content Knowledge Midl 2	Subject Content Knowledge High 2	Subject Content Knowledge All 2	Knowledge Currency Elem 3	Knowledge Currency Midl 3	Knowledge Currency High 3	Knowledge Currency All 3	Instructional Methodology Elem 4	Instructional Methodology Midl 4	Instructional Methodology High 4	Instructional Methodology All 4	Instructor Preparedness Elem 5	Instructor Preparedness Midl 5	Instructor Preparedness High 5	Instructor Preparedness All 5
CURRICULUM																				
Earth Science						●		●						○				○		
ESS	●		●	●	●				●		●		●		●	●	●		●	
Space Science		●								●		●	●				●			●
Astronomy							●	●												

● highly significant, sig ≤ .01 ○ significant, sig ≤ .05

Research Question 3

Research Question 3: *what areas do teachers feel impede or enhance their ability to teach the space science associated subjects?*

This question was answered through qualitative analysis of narrative responses to the survey, augmented with interviews and classroom observations. Five questions were posed in the on-line survey. Teachers were able to respond with narrative, open-ended, unlimited length responses. These questions were:

1. Can you provide additional information on resources, including books, AV or computer programs that you depend upon in these classes?
2. Can you identify resources you need for these classes but do not have access to?
3. Can you identify organizations, institutions, people, or places you depend upon for your classes?
4. Are there institutions, people, or places you would like to have access to but don't?
5. If you had an opportunity to enhance your knowledge in earth, space science, or astronomy, what would you focus on?

Several additional questions were posed to teachers during interviews and class visitations. Those questions are provided in Appendix T.

Teacher Education

Several teachers wrote about needing professional guidance and training. In their narrative comments, many identified their lack of familiarity with the subjects they taught. Some comments pertained to better and more current knowledge of subject content and others focused more on the optimal curricula:

> "…I would focus on enhancing students' understanding of the wonder and scale of the universe! …" (Teacher 134, middle-school)
>
> "…how [earth and space] correlate with each other…why we need to know how the Earth works and how the solar system works…why are these important to sixth graders? …" (Teacher 161, middle-school)
>
> "…the combined space sciences and earth science in an approach to be able to teach a high-school leveled class on this…" (Teacher 163, high-school)
>
> "…curriculum development -- what should be taught? More knowledge of the subject…" (Teacher 240, high-school)
>
> "…STEM integration into the existing Texas science standards (TEKS) (grades 6-8) - how to include more MEANINGFUL math & engineering integration while still meeting the TEKS..." (Teacher 181, middle-school)
>
> "…a teacher's manual should outline the topics and curriculum and there ought to be professional development for the first two or three years the teacher is teaching the subject…" (Teacher 289, high-school)

Other teachers focused on instructional methodology and making teaching more effective:

"…ways to effectively communicate this knowledge to students…" (Teacher 133, middle-school)

"we need training to build the needed background but what we teach needs to provide rigor, rigor, rigor" (Teacher 51, elementary-school)

Curriculum

Despite the fact that curriculum was not specifically identified in any of the narrative questions, many teachers commented on the level of establishment of the curriculum in their narrative responses. Their comments covered a range of feelings and perspectives:

"…my district provides a curriculum…we are required to follow the curriculum..." (Teacher 108, elementary-school)

"…the district has a scope and sequence for science…" (Teacher 29, elementary-school)

"…our district has people in charge of the science curriculum…" (Teacher 56, elementary-school)

Some wrote of a need to integrate the curriculum across grades:

"…in a cohesive curriculum a student should have been introduced to a concept one year and the next year come back to it to learn about it in greater depth…to expand understanding…" (Teacher 168, middle-school)

Several middle-school teachers cited the topical items identified in the TEKS as the definition of the curriculum for their science classes. However, several identified issues with reliance on the TEKS:

> “…the TEKS are not particularly clear…” (Teacher 161, middle-school)
>
> “…STEM really requires integration into the existing Texas science standards (TEKS)…” (Teacher 181, middle-school)
>
> “[we] have received little guidance, beyond the written TEKS, of just how we should go about introducing these courses” (Teacher 206, high-school)
>
> “…TEKS give an outline so I know the curriculum is correct, but sometimes I think what we write might be a little over their heads…” (Teacher 167, middle-school)

Often cited in reference to establishment of a curriculum for earth or space sciences was CSCOPE (not an acronym). The Texas Education Agency describes CSCOPE as “a curriculum management system created by Texas Education Service Centers with assistance from content experts”. It was being used in “875 public school districts educating 34 percent of the state's total student population” (Texas Education Agency, 2013).

A significant number of teachers responding to the survey, six percent, cited CSCOPE as having a role in establishing the curriculum they used. Several of the teachers wrote that:

> “…CSCOPE [was important because] …it provided lessons including labs, demonstrations, and vocabulary…” (Teacher 53, elementary-school)
>
> “…C-Scope has labs involving intent research, worksheets and building modules…” (Teacher 140, middle-school)

…time [is] allocated in the curriculum framework through the CSCOPE yearly sequence and TEKS requirements. But we have so much to cover that we touch everything so lightly. What is needed is the integration of Earth and space into a project based curriculum… (Teacher 149, middle-school)

"…as of now, I follow CSCOPE, but not to its entirety. I am the only one in the school who does…" (Teacher 178, middle-school)

Several teachers described that the CSCOPE content was of 'limited value:'

…they tell us we don't have to use the CSCOPE lessons, just follow the year, scope and sequence, but I have no other resources that I have been given…besides my CSCOPE curriculum…CSCOPE gives VERY little background information for the teacher…. (Teacher 73, elementary-school)

However, not all teachers were of the opinion that they needed help from the administration with respect to curriculum. A high-school teacher wrote:

Actually no, I don't need any more guidance. One of things I enjoyed most about teaching Earth and Space Science was the autonomy. I had the TEKS, which is very broad, but it was entirely up to me how to teach them. There was no curriculum, no textbook I was expected to follow, no district exam, and no other teachers really that I had to be in step with. I was the only one teaching this in the district. It was okay if this awesome project idea I came up with took two weeks - we could take the time. I'm afraid that with more help or guidance would come more oversight. (Teacher 280, high-school)

Resources

The open-ended survey questions were particularly focused on the resources teachers used for teaching their classes. The teachers were asked to identify resources upon which they rely and resources which they need but are unavailable to them. This focus on the resources upon which teachers rely resulted from a pilot study (Kitmacher, 2010b); as the study was conducted, many teachers indicated that there were problems associated with finding and using appropriate resources.. In interviews, authors of earth and space science (ESS) TEKS as the study was conducted, many teachers indicated that there were problems associated with finding and using appropriate resources.

Some teachers identified the need to gain access to primary sources with which their students could take part in actual scientific research:

> "I need university data sets-original data, and research questions, to help get students more involved in learning and doing the practice of true science."
> (Teacher 264, high-school)

However, it was more common for teachers to identify their need to access basic informational content.

Textbooks

In many courses, textbooks form the basis of the curriculum and syllabus. Members of the committee who wrote the high-school ESS TEKS discussed in the months prior to its implementation that there was little source material and no textbooks available for the course (Henning, 2011; Odell, 2011). Therefore, new instructional materials would need to be developed. At the time the high-school course was first introduced teachers reported ‘there was little out there’ (Kitmacher, 2010b). Some similar comments were made in the current study. A teacher for one of the state’s largest urban school districts wrote:

> “…we need additional resources and materials for the space science course…” (Teacher 278, high-school)

One high-school teacher in a Houston suburb said that when he began to teach the earth and space science course:

> …I have nothing; I’ve taught physics in past years and the curriculum is a regimen; it is well defined, it follows the textbook; the text provides exercises for the students and the lab is equipped for activities. But in ESS there is no text, and no one has told me what I need to teach; there are no activities provided; there is no laboratory. The curriculum is wide open. All I do is search on the internet to try and identify material to cover. I have become familiar with websites like NASA, Google Earth, Google Mars, Google Moon, etc., but I would like some training in how to use them. I do not know what activities are possible with them. What should I do with them? … (Teacher 307, high-school)

In the large urban district nearby, a science instructor in one of the district’s 56 high-schools wrote that:

> …we really need additional resources and materials for the ESS course. Since the course is not assessed by the state on a standardized test, we receive a lot less attention than the long time standards of biology, chemistry or physics; there are

fewer resources devoted to this course. We really need an integrated plan of content, lesson ideas, information and activities that can be covered in the classroom with limited supplies and a very low budget for purchasing anything. It makes doing hands-on activities very difficult. I need a well-defined curriculum that includes textbooks and workbooks and that is as cohesive and streamlined as our math or reading textbook adoptions with resources imbedded… (Teacher 308, high-school)

Even for those teachers who do have textbooks, many reported that the texts were unsuitable. Fifteen percent of the elementary-school teachers identified problems with the textbook:

"…we need new and current text books…" (Teachers 20, 98, elementary-school)

"…we need new textbooks that are aligned with the TEKS…" (Teacher 91, elementary-school)

"…a new textbook would be nice seeing as how the one we currently have is 13 years old…" (Teacher 20, elementary-school)

Some reported having textbooks but not using them:

"…they are so dated I don't bother even checking them out from the book room…" (Teacher 102, elementary-school)

"…occasionally I use the textbook…" (Teacher 27, elementary-school)

"…there are textbooks posted on line that are better than mine…" (Teacher 52, elementary-school)

"…I depend upon my textbook because that is all that I have…" (Teacher 40, elementary-school)

The problems were not exclusively at the elementary-school level. Ten percent of middle-school teachers reported that the texts they were expected to use were out of date:

"…our textbooks are so outdated…" (Teacher 102, middle-school)

"…textbooks are limited due to their age and the rapid advancement of the science…" (Teacher 120, middle-school)

Several commented that textbooks they were using were not appropriate for the grade levels they taught. At the high-school level teachers reported using textbooks borrowed from the eighth grade. Astronomy had been taught in middle-school based on TEKS requirements that were applicable more than ten years earlier in the 1990s. This meant the books were dated as well as written for the wrong grade level:

"…our text is very old and not in depth enough to meet the standards I am expected to teach at the depth and rigor I need to teach it…" (Teacher 173, high-school)

"…the only textbook for astronomy that was on the adoption list was at a sixth grade level so it was not appropriate for an upper level elective…" (Teacher 258, high-school)

One teacher reported that his class's astronomy text had been written in Finnish and translated to un-natural English:

"…it is a difficult read for most of the high-school students…" (Teacher 309, high-school)

Several teachers suggested that textbooks could be very useful if they were well integrated with other resources, if they were widely available and up to date:

"…what's needed are on-line interactive textbooks…" (Teacher 223, high-school)

"…textbooks with embedded internet based resources…" (Teacher 275, high-school)

"…New textbooks…with interactive software with visuals…" (Teacher 91, elementary-school)

"…a free on-line textbook for Astronomy-free because my district won't pay for one; on-line because then I know my students would have access to it anytime…" (Teacher 259, high-school)

Written and Printed Resources Other Than Textbooks

Teachers wrote about seeking and using a wide variety of source materials. Several teachers wrote of a desire to provide integrated science lessons to their students and they wrote about the challenges they faced of finding sources for the appropriate materials and resources; they wrote that a system for delivering an integrated lesson should provide:

"…hands-on activity which allows the student to observe phenomena…" (Teacher 206, middle-school)

"…activities weekly or biweekly…" (Teacher 227, high-school)

"…[a means for] the students [to] view explanatory videos, and follow and fill out activity or worksheets…" (Teacher 258, high-school)

"…interactive resources; resources that stimulate critical thinking interactively, not just in a way that makes the question/problem difficult, but serves to stimulate the mind and teach students to think that way BEFORE they answer questions…" (Teacher 105, middle-school)

"…they read an explanation in a text in order to build depth and rigor…" (Teacher 73, elementary-school)

"…student texts should provide additional content beyond what is planned to be covered; homework assignments are needed…" (Teacher 86, middle-school)

"…there ought to be a library of recorded programs and simulations..." (Teacher 52, elementary-school)

"…recorded programs need to be short enough to fit into the class…" (Teachers 226, 248, high-school)

"…we need to provide recorded programs [together] with related activities, discussion points and worksheets…" (Teacher 275, high-school)

While many wrote about needing a particular set or variety of resources, others wrote of having essentially nothing at all. At the elementary-school level teachers wrote:

"…I have nothing; we have no science materials…" (Teacher 94, elementary-school)

"…I have access to the necessary materials, but it takes a great deal of time and effort to hunt, gather, and adapt it to my student's needs…" (Teacher 29, 102, elementary-school)

"…I have to search for resources that are appropriate for my grade level and that are current and that meet the TEKS…" (Teacher 104, elementary-school)

"…I depend only on myself to gather information and resources to teach the TEKS…" (Teacher 29, elementary-school)

"…I do many of these things on my own with very little assistance from the school, due to funding or personnel…" (Teacher 10, elementary-school)

Eight percent of teachers cited seeking assistance from other teachers to help design or borrow hands-on activities for use in class. Middle-school teachers specifically wrote of spending considerable time seeking current and up-to-date material:

"…I need new research and data to show evolving understanding of space…" (Teacher 120, middle-school)

High-school teachers faced similar problems though often times magnified over challenges of the lower-grade levels. The lower grades teach an integrated course of sciences that focuses on space science and extraterrestrial topics for only several weeks. At the high-school level the ESS and astronomy courses continue for the entire school year. One high-school instructor wrote that like in the lower grades teachers in the high-school are looking for:

"…full up lessons that have student activities for critical thinking and problem solving; I need activities and worksheets; workbooks for students to take home for homework assignments, review and studying…" (Teacher 239, high-school)

Twenty percent of elementary, middle and high-school level respondents identified the need for interactive, hands-on resources and activities that can be manipulated:

"…I need more hands-on materials, 2D [digital] models and 3D [physical] models, and equipment to demonstrate space science concepts such as rotation, revolution, apparent movement of the sun…" (Teacher 8, elementary-school)

"…the kids don't get enough hands on…" (Teacher 25, elementary-school)

"…I utilize as many manipulatives as I can find or create…" (Teacher 30, elementary-school)

"…a solar system model with accurate sizes of the sun and planets or paper models that can be glued into journals..." (Teacher 67, elementary-school)

"…anything that will help the kids identify and learn material better…" (Teacher 23, elementary-school)

Several teachers at all of the grade levels said their students maintain journals of their activities, observations, readings and papers and these become the de facto text and an interactive resource. Teachers commented:

> “…this is our main resource--activities, lab, interactive reviews, on-line testing, vocabulary cards…I use an interactive notebook to try to keep everything together…” Teacher 59, elementary-school)
>
> “..we use our science notebook to take notes and really create our own textbook as we are going through the year…” Teacher 102, middle-school)
>
> “…tactile and active learning. Projects, models, long term activities, investigative notebooks, etc. that challenge the students (I often feel like the more tactile the activity the more juvenile it feels)…” (Teacher 245, high-school)

Teachers at all grade levels felt it was important to have materials in hand and that viewing on computers was not adequate:

> …it is nice to show on a SmartBoard or computer, but when the students are able to touch and manipulate they get the ideas better. I have lithographs from NASA from the 90's and the kids love looking at them and reading them. We need more real data, satellite images, pictures, posters, books, and magazines… (Teacher 184, middle-school)

Computers and Technology

Although many teachers reported searching for more hands-on manipulative and printed materials, often having to build libraries of books and other resources on their own and at their own expense, many said they were ultimately reliant on computers and the internet. Based on the Kitmacher (2010B) study, computer availability comes in four forms: computers inside and outside of the classroom, and computers for teachers and for students.

Most teachers have computers for their own use inside the classroom, including for driving displays for the class, but there are inadequate numbers of computers for student use. Ten percent of elementary teachers cited too few computers for student use during class-time.

> "…computers are not usually at hand in the science lab so the students cannot do research immediately for subjects that are being covered during class time..." (Teacher 41, elementary-school)

Several teachers identified issues with computer and internet usability:

> "…the internet is very slow to connect so we don't get to use it very often…" (Teacher 33, elementary-school)

> "…our school is small, in a remote community and has poor internet connections and so cannot stream video or audio…" (Teacher 135, middle-school)

> "…we need high speed internet - much of what I plan depends on use of Google Sky and Earth and without high speed internet we really cannot depend on the connection…" (Teacher 199, middle-school)

> "…web access is problematic; the district blocks a lot of sites with educational filters…" (Teacher 224, high-school)

Ten percent of middle-school teachers wrote about inadequate, old or nonexistent computers and technology available for students. One wrote:

> "…we have an iPad lab, but there are only 30 iPads for a school of 1100 students…" (Teacher 116, middle-school)

Others identified needs for “new computers”, for “more computers”, or for “any sort of computers or technology for students to use”:

> “…more digital access is needed for the students...” (Teacher 116, middle-school)
>
> “…the students need access to on-line resources. It is important to provide them with science content and just as important to train them in the use of the computer and internet resources...” (Teacher 45, middle-school)

A high-school teacher reported that:

> …my students have no reference except for the notes I give them for my presentations. If they would like to look up something that is not in my notes, they have no resources; we have no computers or internet access… (Teacher 242, high-school)

Several teachers reported that they depend on the internet and on a Promethean board, and several said that:

> “…the classroom projector is essential…” (Teacher 257, high-school)

Many reported that they need more computers for students and software for the few computers they have.

Internet and Computer Applications

Many teachers wrote about the significance of content they accessed from the internet. One elementary teacher wrote that they used a science update from a National Aeronautics and Space Administration (NASA) website almost every day. Others accessed lessons and lesson plans that other teachers and schools made available on-line. Approximately ten percent identified that they use news lists to find other teachers to help design or borrow hands on activities. Approximately 20% of elementary teachers wrote that they used video content from websites like YouTube. Other elementary teachers reported:

> "…needed are additional interactive websites for kids; on-line available programs for students; topographic maps and satellite images; computer programs like Google Sky, Starwalk and Starry Night to better teach space and astronomy…" (Teacher 25, elementary-school)
>
> "…needed are websites that 'simulate' processes…" (Teacher 38, elementary-school)

The second most cited single source of space science information was the Discovery Education Curriculum Center and Discovery United Streaming Video website. These were identified by 35% of elementary teachers, 27% of middle-school and nine percent of high-school teachers. This website is principally a subscription service and provides a wide range of media based interactive texts and curricular resources. A middle-school teacher wrote:

> "…its a great resource for students because its student appropriate, videos are updated regularly, and there are a lot of science videos or segments we can use…" (Teacher 138, middle-school)

An elementary-school teacher said that access was not available all of the time:

> …my district subscribed to Discovery Education and I have been able to use videos from their site, but that is not on a regular basis; students read and find

information from an expository text and then look at other on-line media materials… (Teacher 40, elementary-school)

Several teachers said that budget constraints limited access to such subscription services and that services were sometimes lost as a result of budget cutbacks:

"…unfortunately United Streaming has been taken off our list for science tools this year…" (Teacher 124, middle-school)

"…our best resources would be on-line, but everything seems to have such an exorbitant cost that we can't afford to use them…" (Teacher 75, elementary-school)

Ten percent of middle-school teachers wrote of spending considerable amounts of time in:

'…exhaustive internet searches for content…' (Teacher 46, elementary; 104, 170, 206, middle-school; 244, 261, 271, 298, high-school)

Several specifically cited seeking current and up to date material:

"…I depend on the internet for current issues and the latest modern discoveries…" (Teacher 267, high-school)

"…I want current Internet information-not information that dates back to the 1990's…" (Teacher 295, high-school)

"…I would like to see…particularly the topics that are often in the news and that are rapidly changing; this is the stuff that students love but it changes rapidly so I'm not always up to date…" (Teacher 280, high-school)

‘…I need new research and data to show evolving understanding of space…’ (Teacher 20, 23, 52, 82, 104, elementary; 115, 120, 124, 165, 184, 202, 206, middle-school; 244, 252, 295, high-school)

Some did a daily weather and geophysical science ‘update’ that would review major weather systems and earthquakes. One teacher wrote that:

“…it would be nice to have virtual programs to review space program events, space weather, or to report on constellations and events in the night sky…” (Teacher 178, middle-school)

High-school teachers wrote:

…space related websites are the key to making my class successful. I use a lot of materials from NASA, NOAA, a number of sites associated with New York public schools (http://www.learnearthscience.com/ etc.), as well as just about any on-line site from which I can get materials or ideas… (Teacher 245, high-school)

Several teachers identified that while information was widely available on the internet selecting information that promoted active thinking and engagement was more problematic:

“…I get many resources on-line from other teachers and from college notes posted on-line…” (Teacher 258, high-school)

“…I find it difficult to find any resources that promote serious critical thinking (i.e. not just a web quest of how many moons Saturn has)…” (Teacher 206, high-school)

"…space and astronomy-most stuff I can find is either too easy or too hard, I am not familiar enough to ramp it up or explain the difficult concepts…" (Teacher 299, high-school)

"…I would like to see a deeper conceptual study of the basic principles; also-how to best approach these incredibly brain-bending topics so students can understand the difficult concepts abstractly…" (Teacher 280, high-school)

…I depend on the internet a great deal. I feel there are few lessons available, however, that are high-school level so I spend a great deal of time adapting existing lessons to high-school classes or creating my own by compiling the information and resources… (Teacher 259, high-school)

Several comments stressed the quantity of content that was available on the internet and the difficulty finding what was needed:

"…space has a multitude of resources in my opinion; there is no shortage of them. I cannot use all that I have and that is available…" (Teacher 168, high-school)

"…content from the internet is critical for my class though it is poorly organized and difficult to find what I need when I need it…" (Teacher 239, high-school)

…what would be helpful is a well maintained index of resources that other teachers have found useful. There are dozens of various places like this on-line that have a handful of good resources. Within our district, we have dozens of resources like this for every subject, separated by unit. But we don't have it for earth and space science, as it is taught by at most two teachers in any one school at any given time… (Teacher 280, high-school)

"…Digital Library for Earth Science Education (DLESE) is a great resource but it is so big these days that it is hard to keep up and sift through everything…" (referring to the NSF and National Center for Atmospheric Research Library) (Teacher 223, high-school)

Many suggested that:

"…it would be nice to network with teachers who have experience in the four science content areas outlined of earth, ESS, space and astronomy..." (Teacher 289, high-school)

Approximately half of the respondents said they would be interested in participating in an on-line community or network to share teaching resources.

Community Support

In many instances, it was hard to distinguish between internet-based resources and internet-based community support. At all grade levels, the primary resource was identified to be the internet. The single most widely cited source of information and support was NASA. NASA was cited as being relied upon by 15 and 20 percent of elementary and high-school teachers, respectively. Middle-school teachers cited their dependence on NASA information sources in approximately 45 percent of their responses:

“…I rely heavily on education and public outreach resources associated with NASA's active missions, including the Great Observatories, Heliophysics and Solar System missions, Earth Systems missions, Kepler, etc. I use archived data as well…” (Teacher 248, high-school)

“…NASA's website has always been a valuable resource for me when discussing earth and space science topics… they have satellite images and activity ideas straight to full lesson plans…” (Teacher 200, middle-school)

“…virtual tours of NASA or locations for earth science that do not require special equipment…” (Teacher 14, elementary-school)

“…we need more NASA…” (Teacher 247, high-school)

However another comment received:

“…NASA is not as available as before…” (Teacher 207, middle-school)

Many suggested that field trips to NASA locations or visits by NASA speakers would be desirable but that because of difficulties in arranging these, setting up visiting speakers by teleconference or by Skype could be beneficial.

In the case of elementary and middle-school teachers, after the internet they tended to rely next upon local support in the form of other teachers and their district or school administration:

“…just my administration…” (Teacher 19, elementary-school)

‘…my co-teachers, as needed...’ (Teachers 24, 50, 51, 79, 91, elementary-school; Teachers 157, 162, 164, 182, middle-school

"…I usually get help from my science team lead on curriculum…" (Teachers 200, 217, high-school)

"… [district] ISD science experts are a huge resource…" (Teacher 225, high-school)

"…the district science specialist… is where to turn if you need academic help, ideas or finding supplies…" (Teacher 41, elementary-school)

"…my science department…" (Teacher 118, middle-school)

"… [our] PTO is awesome at helping supply speakers ..." (Teacher 41, elementary-school)

In the case of the high-school teachers, after the internet, they relied most upon colleges and institutions of formal education. Although a number of colleges and universities, individual college departments, and professors were identified as primary resources, the most prevalent citation of university support was the Rice University STEM Scopes, mentioned in approximately ten percent of elementary, middle and high-school teacher responses. One teacher wrote that:

"…these are interactive/simulated activities, vocabulary is interactive, and reading/writing materials are integrated through the content being taught. This is our main resource for activities, labs, interactive reviews, simulated activities, on-line testing, and vocabulary cards…" (Teacher 59, elementary)

"…the vocabulary is interactive, and reading/writing materials are integrated through the content being taught. All of these are web-based…" (Teacher 38, elementary)

The STEM Scopes are available through a subscription license but only for a select set of grades and topics. To date, material specifically for high-school ESS, earth science or astronomy was not available according to the Rice University STEM Scopes website (Rice University).

Other groups, whether museums, subject matter experts, or teachers outside of their districts come in a somewhat more distant 3rd place when providing support to the teachers at all of the grade levels. Field trips to museums, the NASA space center, observatories, planetaria, and other locations were cited by many to be desirable but as often as not were precluded by travel requirements and expense:

> "…would love to take my students to Space Center in Clear Lake, but distance and cost make that impossible. Also do not have the funds to visit other museums that are closer…" (Teacher 8, elementary-school)
>
> "…field trips to sites that would increase the excitement for science. When students get to experience something first hand, then it sticks with them and they come back to the classroom excited to learn more…" (Teacher 41, elementary-school)
>
> "…being able to take students to the planetarium or science museum…" Teacher 50, elementary-school)
>
> "…I cannot go on field trips so I would like groups to set up a traveling planetarium and exhibit program…" (Teacher 299, high-school)

> “…I wouldn't be opposed to having a small exhibit here at school...” (Teacher 10, elementary-school)
>
> …I would love to have access to museum programs or archived presentations from the experts. We are a very small district, too far away for easy field trips to museums and state parks where these topics could be presented. Our best resource would be on-line. Even the traveling museum presentations are more than we can afford… (Teacher 75, elementary-school)

In several instances, teachers recommended virtual trips or talks by experts whether in person or by teleconference or Skype:

> “…speakers would be great with their specialty in the field…not sure they would be willing to come to our small town, school…” (Teacher 271, high-school)
>
> “…industry people who can visit the class and work with our kids and share the real-world usefulness of the information…” (Teacher 29, elementary-school)
>
> “…I would like a specialist list for all related occupations. This would be someone I could contact for possible on site visits or Skype or phone conferences...” (Teacher 201, high-school)
>
> “universities - students in higher level core content classes; it would be fantastic to have students interested in certain aspects of the science curriculum pair with a college student and "chat" about the curriculum…” (Teacher 164, middle-school)

Several teachers recommended that outside experts could be helpful working with them to help develop appropriate content for their curriculum or technical expertise in using digital resources or applications:

> "…I would love to be able to partner with people in each field of science in order to improve my projects in the future…" (Teacher 167, middle-school)
>
> "…I would love to have a science specialist to come and help me plan educational activities that will help my students learn..." (Teacher 31, elementary-school)
>
> "...someone that is truly knowledgeable in current technology programs so that we get to know what is out there and how to incorporate the software into our lessons..." (Teacher 33, elementary-school)

Not only were travel distance and expense cited as obstacles, but the paperwork and bureaucracy required for visitors to gain physical access to the classroom was also identified as a challenge:

> "…I would like to bring in guest speakers, but the district policy is a huge pain to get through. Maybe if there was a trusted organization to streamline the paperwork? ..." (Teacher 200, high-school)

Several teachers said they were uncertain whom, how or what might be available to assist them; they were open to assistance and would gladly accept any assistance that might be offered but they were not sure what might be available:

> "…I'm not aware of individuals that would help but would like to have this information if I could..." (Teacher 24, elementary-school)

"…I am sure there are other things [I need], I am just not aware of who or what they are…" (Teacher 225, high-school)

"…only because I am not sure of where to look…this is my first year teaching earth science and space…my background is in Chemistry…" (Teacher 240, high-school)

"…I would take whatever I could get!…" (Teachers 114, middle-school; 218, high-school)

Conclusions

Quantitative results reflecting the perceptions and responses of 303 teachers in this study provided insight into the content, methods, support systems, and challenges under which space science was taught at the elementary, middle and high school grade levels in Texas. The survey instrument developed for the research program provided statistically significant psychometric and demographic factors. Correlations between factors served to show whether specific factors may affect the teacher's perception of technical and instructional abilities. In the analytical process, valuable information and insights were gained into the population of space science teachers, their experience, education, resources, and support systems. The qualitative results expanded upon the statistical data, providing greater depth and permitting a deeper understanding of the methods and challenges of space science teachers at the different grade levels. Obtaining and analyzing the data on the population of space science teachers enabled answering the three research questions. The next chapter will provides further interpretation and recommendations for future research and for program and product changes.

Chapter V

Discussion and Conclusion

To analyze the challenges in teaching space science subjects, a mixed method study design was developed to collect both quantitative and qualitative data. Having both types of data resulted in a more comprehensive and in-depth understanding of these challenges. Neither alone was sufficient for understanding the situation. The mixed method design included quantitative data from a survey using questions and responses that had been pilot tested in a prior study (Kitmacher, 2010b) and qualitative data from both the survey and from interviews. More than twelve hundred invitations to participate were sent to all Texas public school districts; 303 teachers from all regions of the state responded. A survey developed specifically for this study was used to gather much of the data. Interviews and classroom visitations augmented and enhanced the collection of teacher perspectives, resulting in a more considered and thoughtful understanding of the issues associated with teaching space science subjects.

In this chapter, the researcher provides a summary of the study, significance of the research, assumptions, limitations and delimitations, the findings and their significance, implications, and recommendations for further study.

Summary of the Study

This summary contains an overview of the problem, the significance of the research, and the study design. Also reviewed are sample and data collection, data analysis, assumptions, limitations, delimitations, organization of the study, and the purpose of the study.

Overview of the Problem

The purpose of this study was to characterize the population of teachers teaching space science-related subjects in Texas schools. This included examination of the teachers' backgrounds, the resources and support infrastructure they depend upon, and the challenges and difficulties that they faced in teaching these courses. Many teachers, through their responses, recommended potential improvements for the teaching and learning of space science.

Elements of space science are taught at many grade levels in Texas. New courses in Earth and space science (ESS) and astronomy were introduced at the high school senior level in 2010-2011. The new courses came about because of government and industry interest in providing new courses that motivated students to study STEM subjects (Texas Education Agency, 2010). Teachers throughout the elementary and middle-school grades taught elements of space science as part of composite science courses. The U.S. National Research Council (2012) proposed the introduction of space science on a national basis, to all grade levels. Government, industry and the educational community appear to support the widespread teaching of the space science subject content in the hope of piquing student's interests in STEM. However, a shared understanding of space science education, and what it includes, is neither well defined nor universally accepted. Past studies have shown that teachers of this subject faced challenges (Kitmacher 2010b). This study sought to initiate concerted research aimed at identifying and examining the issue with the goal of taking a step towards resolving the difficulties that teachers face.

Significance of the Research

The significance of this study is manifest. “There is an urgent need to understand K-12 teachers’ education, experience, and resources and their perception of the definition of the curriculum. There is, as well, a need to understand how these factors contribute to their ability to teach space science. The information gained from identifying strengths, weaknesses, and correlations can guide future decisions on how to better serve teachers’ and students' needs and, at the same time, meet some of the challenges that have surrounded this subject area of STEM education.

Study Design

The research design of this study was non-experimental. Six constructs were identified: experience, education, community support, resources, curriculum establishment, and ability. Each of the constructs was composed of principal factors. The factors were variables that supported or contributed to each construct. A survey was developed in which teachers could identify their perceptions, attitudes, and opinions for each factor. These factors, individually as a definition of the population characteristics, and in correlations to help identify relationships between variables through a series of regression analyses, were used to answer the research questions. All teachers were asked to provide additional details relative to these constructs in the form of narrative comments. In twelve cases, classes were visited, teachers interviewed, and additional information sought. These inputs provided the basis for qualitative analyses.

Sample and Data Collection

The sample for this study was one of convenience. It consisted of elementary, middle, and high school public school science teachers in Texas who were willing to complete the survey. The researcher contacted the Science Teachers Association of Texas (STAT) and the Texas Education Agency (TEA) and used their services to invite teachers from public schools across the state to participate. The survey was developed using a Google Forms service. In addition to the survey, in twelve instances the researcher contacted teachers, visited their classes, and gained clarifying information about the resources, content, and processes that the teachers used. In one instance, a high-school ESS and astronomy teacher permitted the researcher to review student notebooks from two years of classes to gain insight into the scope, sequence, and content of ESS and astronomy classes.

Data Analysis

Survey results were analyzed using Statistical Package for the Social Sciences (SPSS) 20. The researcher utilized descriptive statistics and inferential statistics to analyze quantitative data from the completed surveys. Participant characteristics were analyzed using descriptive statistics in the form of percentages, mode, means, and standard deviations. A series of regression analyses and analysis of variance (ANOVA) tests were used to identify relationships between the independent variables of the experience, education, community support, resources, and curriculum establishment constructs, with the dependent variable, ability. The qualitative analyses of the open-ended responses were analyzed in part through data reduction techniques recommended by Creswell (2007).

Assumptions

Assumptions that were made in this study:

1. All participants completed the surveys openly and honestly.
2. All participants were Texas teachers teaching space science related subjects.
3. The researcher successfully and without error coded and transferred information for use in the SPSS program.
4. The researcher selected and incorporated in an accurate and meaningful manner the narrative responses of survey respondents and interview participants.

Limitations

The study was limited because the survey used forced choices that may have led some participants to answer in a pattern. The survey collected data during a relatively brief time period and participants may have responded differently at another point in time. Terminology was used in the survey and study identifying four space science subject areas: Earth science, Earth and space science (ESS), space science, and astronomy. The terminology is commonly understood but not explicitly defined; in most Texas public schools, only two, ESS and Astronomy, are actual named courses. These terms were used in order to capture information about the range of related subject areas; all four include some aspects of space science. Another limitation in this study was the use of internet-based survey methods. The internet-based survey may also have influenced the participants' abilities or interests in completing all answers or filling out open-ended narratives as thoroughly as they otherwise might have. A final possible limitation was the initial focus of the researcher on the characteristics of high-school teachers and the subsequent expansion of the study to include elementary and middle-school teachers after they showed significant interest. However, the expansion was deemed appropriate in order to capture a broad understanding of space science teaching in Texas's public schools

Delimitations

The sample population purposely chosen and invited to participate were public school teachers who teach or have taught grades K-12 space science related subjects within the boundaries of the state of Texas. Although a number of teachers provided survey responses in which they identified that they were from other states and several identified themselves as higher education or private school instructors, these responses were not included in the data set. Results may not be generalizable to other regions, different schools, or different grade levels.

Organization of the Study

The researcher divided the dissertation into five major chapters. Chapter I described the need for research in this subject area, the background, the problem statement, the purpose, and the significance of the study. Chapter II was a review of the relevant literature as based on prior studies and expectations of findings of the current research. The literature review was intended to provide appropriate context to the research, a description of factors that influence teachers' abilities in this subject area, an overview of the resources used, the manner of teaching related subjects, and background information on space science. Chapter III presented the methodology used by the researcher to collect and analyze data for the study. Chapter IV detailed the data analyzed in the study. Data were collected for six individual constructs, each with respect to space science associated subjects and each construct analyzed for the total population and for individual subpopulations by grade level.

Purpose of the Study

The purpose of this study was to characterize the population of teachers teaching Earth and space science subjects in Texas schools. Additionally, a goal was to identify the challenges and difficulties that these teachers faced. The teachers' recommendations for improving their teaching and students' learning of space science were also sought.

Discussion of the Findings

The findings are discussed relative to the constructs that guided this study.

Characteristics of the Teachers

The surveys submitted for this study identified that space science topics are taught in Texas at the elementary, middle and high-school levels. The 303 respondents providing data used in the study were evenly represented between elementary, middle, and high-school teachers. A detailed listing of space science topics by grade or by course as represented in the TEKS was provided in Appendix A. The results suggest that one advantage in Texas is that space science content is offered to a majority of Texas' student students at the elementary and middle-school grade levels. In fact, space science content reaches essentially all students recurrently in most elementary and middle school grades. This happens because space science is considered an element of an integrated science curriculum, sometimes called composite science, in most of the elementary and middle-school grades. At the high-school level, two courses, Earth and Space Science (ESS), and Astronomy each offered as full school year courses, are dedicated to space science topics. These courses are typically offered to high school students in their senior year.

At the high-school level, 72% of teachers reported teaching one or two subjects. The remaining 28% identified that they were teaching three or more subjects. Physical science, which included physics or chemistry, was taught by 59% of respondents, ESS was taught by 50%, astronomy was taught by 24%, and most of the remainder was split between life science and Earth science. Many teachers taught a combination of ESS in conjunction with Astronomy or other subjects. Only a few high-school teachers reported teaching technology or engineering courses. Appendix H illustrates the number of respondents teaching each subject. Data were provided for all respondents and by grade level.

A number of respondents at all grade levels reported that there were frequently only one or two teachers at their schools who taught space science subjects. Others indicated that their districts employed no more than one or two space science teachers for the entire district. Many teachers reported feelings of self-reliance associated with the limited number of space science teachers. Others said they felt isolated because there were no other teachers with related expertise or responsibilities with whom to communicate.

Teacher Experience Construct

Two constructs, experience and education, were demographic in nature and established statistical information that characterized the background of the respondents. The experience construct and the factors through which the construct was measured were:

1. grade-level now teaching;
2. total years of teaching experience;
3. years of experience teaching individual subjects.

Looking at the population of all respondents, one-third of all respondents had 17 or more years teaching experience and those with fewer years of experience were approximately evenly divided between 0-4 years, 5-8 years, 9-12 years and 13-16 years. A majority of teachers, 63%, had nine years or more of total teaching experience with the mean in the 9-12 year range and a strong mode of 17 or more years of experience in the middle and high-school grades. Despite the long tenure of most teachers, looking only at the experience in teaching space science associated content, the means were shifted to the lower number of years of experience and the modes were all very strong at the minimum number of years, 0-4. Therefore, while many teachers had considerable experience in teaching other subjects, they had far less experience with space science associated subjects. The distribution of total experience for elementary teachers was a more even spread than at the other grade levels, though years of experience in teaching space science subjects was still considerably lower. Respondent teaching experience, expressed in terms of total teaching years and space science subject years, is shown graphically in Appendix I.

Teacher Education Construct

Education was a second demographic that served to establish characteristics of the respondents. The education construct and the factors through which the construct was measured were:

1. highest degree attained;
2. college major;
3. most recent training in space science.

Science degrees predominated over arts degrees. The data indicated that a significantly greater number of all respondents reported that they had a Bachelor of Science degree than had other bachelor’s degrees. In middle and in high-school, more teachers had a Master of Science degree than had other master’s degrees. While bachelor’s degrees predominated at the elementary and middle school grade levels, there were more teachers with advanced degrees than with only undergraduate degrees amongst the high-school respondents. Appendix J illustrated the number of bachelor’s, master’s and doctoral degrees identified by the total respondent population as well as by each individual grade level.

The importance of content knowledge in teaching science was cited by many reseachers as a critical factor in succesful teaching. Content knowledge was important in establishing the curricular content as well as in conveying concepts (Ball & McDiarmid, 1990; Carlsen, 1991; Fennema & Franke, 1992; Shulman, 1986). In general, science teachers were frequently teaching outside of their certification field (Wenglinsky & Silverstein, 2007). This study confirmed this tendency. Non-science or life science degrees predominated amongst the vast majority of respondents. This was particularly true at the elementary level where very few teachers had any kind of a science degree. There were more science degrees at the middle and high-school levels, though principally in life sciences rather than in majors more closely related to space science.

Overall, fewer than 10% of respondents had degrees in majors even peripherally associated with space, such as Earth or natural sciences. Few respondents reported having taken college-level space science courses; moreover, a significant number of the teachers reported they had never had any kind of training in areas associated with space science. Many teachers commented that their knowledge of the space science subject matter, instructional methodology, and potential sources of support and resources were limited. Some said they did not have the educational background they needed to explain the difficult concepts. Many teachers said they needed a better understanding of what they were teaching. The teachers said, as well, that they would welcome any professional development that was offerred in space science content or methodology.

A related college degree may be indicative of interest, knowledge, ability, or education. However, as the span of time between college graduation and professional experience grows, more recent training may become more significant. Two survey questions asked respondents about the nature and recency of their education, workshops, professional development or other not-for-college-credit training as well as college for-credit training in Earth or space science associated subjects. Respondents were queried, as well, for dates associated with both college credit and other training.

The responses to the question about the most recent training in space science were ordered and coded as: (1) never have completed training or coursework in space science areas, (2) not-for-credit (e.g., workshops or professional development) training within the last five years, (3) for-credit (i.e., college) course work 7 or more years ago, (4) for-credit course work 4-6 years ago, and (5) for-credit course work 0-3 years ago.

The results of this question were bi-modal in the elementary and middle-school grades with strong modes indicating either never having completed any training in the subjects or college training in the period from four to six years ago. Those with no training were the most predominant individual groups in the elementary and middle school grades. For the high-school level the most predominant group had received for-credit (college) training in the period from four to six years ago. However, a significant number reported never having had any prior training. The percentage of responses for each category of degree and most recent training is illustrated in Appendix J. Many teachers commented on the rapidly changing information content because of recent explorations, developments and discoveries. Teachers also questioned how best to stay current in the field of space science.

Several teachers suggested that in addition to content knowledge, they required training in methodologies; some suggested workshops or field work that they could bring back to the classroom to enhance their lessons. Some said they needed guidance into how to plan and conduct lab exercises in these areas and that they needed a better understanding of ways integrate technology to engage students.

Teaching Resources Construct

The survey asked the teachers to identify the resources they relied upon or required. In an earlier pilot study (Kitmacher, 2010b), many teachers brought up issues with finding appropriate resources for the recently initiated Earth and space science (ESS) and astronomy high-school courses. While writing the 2010 ESS TEKS, the TEKS authors had spoken about the lack of resources available for the new course and the issues they expected teachers would face as a result (Odell, 2011).

Teachers responding in the current study identified that they needed a variety of resources. Some of the resources were available on the internet, the primary source for most of the respondents. Many teachers said they primarily conducted internet searches only while in school and not during off-hours. Many teachers had no more than an hour of free-time during the school day to spend searching electronically for resources. Teachers said, as well, that searching for topical resources required a great deal of time. It was difficult, they said, to find what they needed in a timely fashion. The teachers were typically not looking for a single item; many said they were looking for a set of usable materials for any particular topic. Teachers were looking for readings, worksheets, ideas for discussion questions, interactive engagement activities and assignments, hands-on manipulable activities that would get the topic off of a computer screen and into the hands of their students. They were looking, as well, for assessment materials. They needed materials that would encourage their students to explore, make discoveries for themselves, develop a deeper understanding of the processes of scientific research. These materials, it was hoped, would prompt students to engage in a dialog about their findings. They needed materials that would promote critical thinking and deep learning. Frequently, resources were not available in a form where they were directly usable for their classes. Many said that material was ofte n not written for the appropriate grade level and was either too hard or too easy for the students. Several said they not only needed additional resources but they needed guidance in what to use and how to use it. Some said that they wished they had access to science specialists to come and help plan educational activities that would help their students. Appendix K illustrates the responses to questions about teaching resources.

Textbooks

Textbooks can play an important part in the instruction process. They serve as the basis of a traditional approach to learning. Teacher lecture, student note-taking, readings and questions from the end of each chapter established a standard educational process (Hocutt, 2003). Textbooks can be especially important at the beginning of a teacher's career if they provide many of the resources the students need and allow the teacher to focus on how they teach rather than on what to teach. More than simply a resource for teachers and students to refer to, the text was often relied upon as the basis for the curriculum and a printed tour guide to the subject, establishing the foundation of scientific principles; describing scientific practice or research; or describing a natural process from precursor events through its proceedings. Many textbooks were accompanied by a teacher's guide that spelled out in detail every step to be taken in teaching a lesson or chapter.

This study sought to identify the current situation with regard to textbooks, ancillary written materials, and technology. In this study, slightly fewer than half of the elementary teachers identified that they used textbooks for the Earth and space subjects. In middle school somewhat more, 57% used texts for Earth science though still fewer than 50% used texts for space subjects. In high-school, more classes, (two-thirds) used textbooks for astronomy and more than half used texts for Earth and space sciences. Of the total respondents in all three grade levels, about half were using textbooks and at the high-school level somewhat more had textbooks available. Appendix K-1A illustrates overall textbook availability and Appendix K-1B illustrates textbook availability for high-school astronomy.

However, although about half of the teachers teaching space science had textbooks, the quality and applicability of the textbooks was cause for concern according to many survey responses. Some of the textbooks used for senior high-school astronomy were borrowed from middle-schools where they had been in use more than a decade earlier. In the ESS course, there was frequently a text available for the Earth science portion of the class but not for space science. Many teachers at all grade levels reported their textbooks were long out of date. This comment was supported by the ESS TEKS authors who said that there was no textbook available for the subject (Odell, 2011).

However, a traditional textbook may not be the answer for space science. Most space science teachers are teaching the subject as a part of the composite science taught in elementary and middle-schools. For these grades, the subject often lasts no more than several weeks, as composite science is made up of a series of units covering a variety of science subjects. Many teachers indicated that current topics and the latest discoveries should be reflected in the space science textbooks as these were important for holding and maintaining students' interest. Several teachers suggested that an on-line text, which would be linked to complementary ancillary resources, would be desirable because it could be maintained and because their school districts would not be inclined to spend significant resources for textbooks for space science.

Written and Printed Materials

The survey addressed the use of ancillary materials in the form of readings and worksheets; the majority of teachers at every grade level indicated that these were commonly in use. Appendices K-2A and K-2B illustrate the percentages of teachers using written materials and worksheets, respectively.

Many textbooks are part of a teaching system in which the publisher may provide lesson plans, ancillary materials and ideas for additional activities. Often a text is accompanied by audio or video materials that help students develop related knowledge. The system can facilitate language development and knowledge acquisition. Often the system is written and developed by a panel of experts with careful review to ensure that each lesson guides the teacher's approach.

Bruner (1960, 1977) wrote that the integration of knowledge rather than simply the mastery of facts was at the center of learning. Interaction would increase achievement because of the cognition that took place during information assimilation (Inhelder & Piaget, 1958). Teachers wrote of a desire to provide integrated science lessons to their students. These would include lectures, readings, interactive dialog, laboratories, activities, worksheets and assessments. Many of the teachers at all grade levels wrote about the challenges of finding and integrating the required materials and the difficulties of providing an intensive, rigorous series of activities that promote thinking and learning. With the lack of a consensus on curriculum, the development of a series of brief modular units, each covering a particular space science topic, might be more useful than a monolithic space science text.

Computers

Across the US, in 2009, 97 % of teachers had a computer located in their classroom and most of those were connected to the internet. Computers were often in use in the classroom, about 40% of the time. Digital projectors were connected to the computers between 36 and 48 % of the time; of those with projectors, the projectors were used for instruction 72 % of the time. The ratio of students to computers in the classroom on a daily basis was 5.3 to 1. Nationally these data show that electronic technology is becoming more common in the classroom. It is, however, in use only a fraction of the time. Moreover, students do not usually have access to computers in the classroom (Gray, Thomas & Lewis, 2010).

It is clear, however, that use of computers for instruction is growing. Fewer than 15% of teachers were using computers for instruction in 1995. Thirty percent of teachers were using the computers available to them in 1999. By year 2000, 35% of teachers said they felt adequately prepared to use computers or the internet for instruction (U.S. Department of Education, 2007).

In the current study, middle-school respondents identified that they were most reliant on computers in their classrooms with 94% of teachers using them. Elementary teachers were a bit further behind with about 85% using computers in their classrooms. High-school teachers used computers in the classroom the least at a rate of about 75%. Considerably fewer teachers, only an average of 40%, used computers outside of the classroom to support their teaching of space science. In school, an average of 55% of classes relied on some student computer use. Computer use by students outside of class is noticeably less prevalent; an average of about 36% of classes relied on the use of computers by students outside of the classroom. Appendix K-3A-D provides an average of computer use for all respondents. Appendix K-3E and F provide percentages of computer use for high-school teachers and students, respectively.

During the pilot study (Kitmacher 2010b), the schools visited and teachers interviewed identified that computer use by the teachers using a projected image was common. Computer use by students in the classroom was not usually possible because there were too few computers, and many of those were old, not in good repair and could not be relied upon. In addition, students were not given computer-based assignments for homework by any of the visited teachers for fear of creating a disadvantage for any students for whom computer access were restricted outside of the school. At the same time, smartphones were becoming more common and some teachers were occasionally using them as a resource for assignments. These observations served as the basis for the questions asked in the current study.

Technology can be used to create an environment for interactive, engaging, and active learning. Thus, technology might be a solution to the problem of student engagement. However, the results of the current study show that technology is not yet ubiquitous or pervasive in Texas space science education. An important message about computer use from these data is that on average, only about half of all students are using computers in school and fewer than half of either teachers or students are using computers for coursework when not in the classroom.

In one interview, a space science teacher said that more students had access to cellular smart phones and that he had successfully given students assignments using them. Perhaps these are proliferating because of functionality in the students' personal lives, portability and affordability. Nevertheless, results of the question asking about use of alternative means of digital technology, which specified cellphones or smartphones, showed that fewer teachers were using these alternatives than were using computers. Perhaps schools are in a transition phase as new technologies are beginning to have an influence on space science education. Appendix K-4 illustrates digital media use for all respondents.

More prevalent than either computers or other forms of digital technology in all classes and all grade levels was the use of pre-recorded videos. The two most cited on-line information sources, NASA and Discovery Education, were both identified as being principal sources of pre-recorded video programs. NASA produces educational videos for virtually all of its programs and projects in more than a dozen locations in the US and world-wide. They have invested considerable resources to enable on-line wide-scale video sharing (Perry, 2004).

Video provides a multi-sensory learning environment and can present information in an attractive and consistent manner, repetitively, and can allow students to view actual objects and realistic scenes, to see sequences in motion, and to listen to narration. Especially for space and astronomy, where so much information is returned from space and communicated visually, video can be a rich and powerful medium. Real video imagery can be mixed with animations, sounds, audio, and text to convey content. However, several studies, including Dillon and Gabbard (1999) and Mbarika, Sankar, Raju, and Raymond, (2001), have shown that videos do not necessarily improve learning outcomes unless the videos are properly integrated into the lesson and used interactively.

A major problem with the use of video was identified as lack of interactivity (Nugent (1982). Some teachers noted on survey responses that most videos were longer than the class period; they frequently needed to jump directly to the segment of a video in which they were interested, though were oftentimes unable to do so due to either technology or user limitations. Browsing a video was often more difficult and time consuming and left the class viewing extraneous content. The key to value appeared to be immediate access to short pertinent sequences, enabling interactivity and using the video to reinforce other content. Another problem identified by respondents was the lack of an integrated set of materials that would include readings, worksheets, discussion questions, an assessment and manipulable interactive resources that could be integrated with a video.

Community Support Construct

Respondents were asked to identify organizations, institutions, people or places they depend upon for their classes.

Internet

Analogous to the high percentage of use of computers by teachers in the classroom, the data from the study showed that the internet was the most depended upon community factor; teachers at all grade levels and for all subjects areas identified their reliance on the internet. Appendix L-1 illustrates the percentage of the reliance on the internet by all respondents. Computers and the internet have been available in schools since at least the mid-1990s, so they have now been available for nearly two decades. The explosive growth in use of the internet in the mid-1990s led many to expect immediate technological innovation in teaching. Nevertheless, the transition has been slow, and often not so much the result of difficulties in use of the technology as with difficulties and complexities of adopting and integrating the new capabilities.

Teachers noted that their primary use of the internet was in seeking new, up-to-date, current data on content that had been subject to recent changes. In many cases, they were using the internet to link to or download videos. Most commonly, teachers identified that they used the information and videos they found to show to their classes. There were several instances in which teachers identified they did not have adequate internet connectivity; this restricted their ability to use the internet routinely, repeatedly, frequently, or quickly enough. There were instances in which teachers said they had no connectivity or in which teachers identified that access to particular websites was restricted. Multiple teachers identified that services they had grown to depend upon were no longer available because of restrictive finances and loss of subscription services.

Administration and Teachers

Most teachers identified that they depended upon other community support factors much less than on the internet. Appendix L-2, L-3, and L-4 illustrate the amount of reliance on administration, local teachers and teachers outside of the district, respectively. While several teachers identified that their school or district administrations defined either the curriculum or the scope and sequence of topics to cover in their classes, more said they were provided with no definition of what to cover in their courses and that the definition they were provided was inadequate and not supported by the resources they were provided. At the lower grade levels, teachers usually worked in groups and often took a team approach in teaching science. Dependence on the teaching team was reflected in several teachers' survey submissions. At the high-school level, the two courses, Earth and space science (ESS), and astronomy are offered for the duration of the school year. In all of the cases of high-school teachers interviewed and classes visited there were never more than one or two teachers in a high-school teaching the space science subjects; some reported no more than one or two teachers teaching the subject in a school district. Some teachers revealed that isolation led to self-reliance and the comment that there was no one else to rely upon was made by multiple teachers. An average of all respondents showed little reliance on teachers outside of the local school district. Such support was only identified when individuals discovered similar interests at activities such as the CAST conference or at professional development training sessions. High-school teachers showed somewhat more reliance on teachers beyond the local school district than teachers had identified at the lower grade levels.

Colleges, Museums and Subject Matter Experts

In general, data provided by the respondents indicated that there was little dependence upon colleges and museums. Many teachers suggested that more activity with museums, colleges, field trips, and lecturers would be beneficial but that it was difficult to arrange this because of cost, schedule, distance, travel restrictions, or bureaucratic interference. High-school teachers identified more reliance on a wide variety of colleges, universities, individual departments and professors than at other grade levels. Appendix L-5 illustrates reliance on colleges by all respondents and Appendix L-6 illustrates reliance on colleges by high-school teachers.

In addition, some professional development programs offered by the University of Texas, the UT MacDonald Observatory and a limited number of other organizations were identified by a small number of teachers. Many teachers said they would like to be able to take students to visit museums and planetaria but that fiscal constraints and proximity precluded these kinds of trips. Several teachers recommended virtual field trips in which students could visit a museum on the computer, gain information about exhibits and artifacts and speak with experts.

Many teachers identified that they were wide open to professional development programs that might be run or hosted by subject matter experts. However, there were significant constraints to these. Most teachers indicated that they would not be able to pay for such programs and that in many cases their schools and districts would not pay either. The time required was also a significant concern for many. There was a wide variety of positions as far as the best time to schedule these programs. Proximity was another issue identified by many of the teachers. Another concern reflected was that any professional development program should give teachers new content and resources for use in their classes. Finally, several teachers said that while they had participated in some programs, typically the same kinds of resources, the same ideas, and the same content was repeatedly provided.

Very few teachers reflected dependence on subject matter experts from the community. Many teachers said it would be beneficial to establish relationships with subject matter experts either who could assist them in establishing meaningful education projects or who could work with, assist or speak to students. However, several teachers said they had no knowledge of how to go about finding such experts or establishing such a communications infrastructure. Appendix L-7 illustrates reliance on museums by all respondents and Appendix L-8 illustrates reliance on subject matter experts in the community.

In several instances, including one interview, teachers indicated that grants for purchasing equipment and instructional materials were sometimes available from Texas-based oil and chemical industry firms. However, the very small number of teachers who identified any reliance on grants indicates that the availability of such funding is either very restricted or not widely known. Appendix L-9 illustrates reliance on grants by all respondents.

Teacher Perception of Curriculum Establishment Construct

A series of questions asked participants to rate the degree to which curriculum was established for the four subject areas of Earth science, Earth and space science (ESS), space science and astronomy. ESS and Astronomy were added as high-school courses in the TEKS beginning in 2010. Earth science was not commonly taught as an independent course in Texas public schools and there were data that indicated that space science was not taught as an independent course. The division of the subjects into these four associated areas of Earth science, ESS, space science and astronomy was consistently employed throughout the study.

It should be noted that the four subject area divisions are not universally accepted or recognized. There are significant overlaps and gaps in the Texas state standards (Appendix A), in the national standards, as well as in numerous textbooks (Arny, 2006; Bisque & Heller, 1967; Cassidy, D. C., Hermann & Thompson, 1996; Chaisson & McMillan, 2011; Holton, Mitchell & Roberson, 2002; Chisolm, G. J., & Rutherford, F. J. 2002; Damon, 2001; Egolf, 2005; Frameworks, 2012; Harra & Mason, 2004; Kortz & Smay, 2010; Lee, 2000; Moche, 2009; Morrison, Murck, Skinner & Mackenzie, 2010; Wolff & Fraknoi, 1995; National Aeronautics and Space Administration, 1969; Prather, Slater, Adams & Brissenden, 2008; Research and Education Association, 1998; Seeds, 2002; Sellers, J, 2007; Sills, 2008; Slater & Freedman, 2012; Texas Education Agency, 2010; Trefil, 2005).

Data was collected in the study by teachers responding to the Likert-style scales for curriculum establishment in the four individual subject areas; the differentiation between the subject areas showed that teachers attempted to distinguish between the areas. In all cases, the most established curriculum was perceived to be Earth science, followed by ESS, then space science; the least defined curriculum was for astronomy. There was one exception to this order; high-school astronomy curriculum was rated more established than high school space science curriculum. For all grade levels, astronomy curriculum was very positively skewed, indicating most teachers felt the curriculum was not well established. In the case of high-school teachers, the positive skew and poor curriculum establishment extended to ESS and space science as well. In no cases did curriculum establishment receive a predominant number of high ratings indicating thorough establishment. Appendix M illustrates degree of curriculum establishment for each subject area for all respondents and by each grade level.

The data showed that most teachers characterized themselves as teaching integrated or composite science that included space science content. Integrated or composite science was a subject category that included a wide range of life science, physical science, Earth science, and technology, as well as space science subjects. At the elementary grade level, 92% of teachers identified themselves as teachers of integrated or composite science and at the middle-school level, 94% characterized themselves in this manner.

Data showed that the high-school ESS course appeared to be taught by most respondents as Earth science during one-half of the school year and space science during the alternate half of the school year. Even the Earth science portion of high-school ESS course often included elements of space science as some teachers reported that the information they presented to characterize Earth was often compared with information for other planets and information which situated the earth in the solar system. Some of the Earth science content that teachers presented was based on observations made from space and so space technology and space science products were sometimes used during the portion of the course focused on Earth.

Some teachers noted that the order in which the Earth science and space science portions of the high school ESS course was presented was important; one teacher said the first year she had taught space science in the fall in order to give the big picture, and that she taught Earth science in the spring. However, she said she found that space science content really captured the students' interest while the Earth science content was more mundane. It was hard to hold the students' attention in the spring because their minds were on graduation and not on their classes. After her first year teaching the subject she changed the order and taught Earth science in the fall and space science in the spring in order to try to better hold their attention.

In most high-schools, students are allowed to select from a variety of alternate electives. When given a choice, only a fraction of the student population selected the ESS or astronomy elective courses. In some schools only one of the two courses, ESS or astronomy, was offered because of perceived overlap in the content of the courses or because of an inadequate number of teachers or lack of interested students. In addition to the high-school ESS and astronomy courses, some other subjects such as physical science or engineering were taught that included some space science content.

At the high-school level, both ESS and astronomy often covered a wide variety of aspects of cosmology, the sun and solar system, the space program and space exploration, Earth observations, and the practical uses of spaceflight. Space science content at the elementary and middle school levels appeared to focus on basic observational astronomy such as patterns of the stars in the sky, motions of the sun, moon, stars and planets, or phases of the moon in the early grades and then expanded into characteristics of the sun, moon and planets in the later grades. In some grades, space technology and space missions were sometimes introduced.

It was notable that a representative of the Texas Education Agency said that one reason for introducing the ESS and Astronomy courses in Texas high-schools was the interest shown by NASA representatives (Pickhardt, 2011). Texas hosts the NASA space center responsible for human space flight and astronaut training. NASA was the one information resource cited by the greatest number of survey respondents. But only in a single case did a respondent identify a human space flight program as a significant area of focus for their courses. While every NASA program produces a variety of content for the internet including extensive video resources (Perry, 2004), several teachers reported the lack of apparent availability or perhaps the difficulty of finding an integrated set of resources including readings, videos, discussion points, simulations, and activities did not support comprehensive instructional content.

Multiple comments from many teachers at all grade levels indicated the need for more definition of the curriculum content to teach in these courses. Several comments received from elementary and middle school teachers recommended there should be more continuity in the content covered from one grade to the next.

Motivational Value of Space Science in School

Survey data suggested that space science could be a trigger for generating interest, and for motivating, inspiring, and capturing students' curiosity and imagination. The value of space science in the curriculum and the particular aspects of the subject that capture their students' interest were addressed by a number of teachers.

Several teachers noted that incorporation of the real world was important in space science. They referred to the availability of the daytime and nighttime sky for field experiences outside of school. Some said they would host evening viewing sessions and "star parties" that were often attended by their students, the students' families, and the community. Some teachers said that there was no better way to learn than to take the students outside to see nature. Taking them to see with their own eyes, they gained first-hand experience, it stuck with them and they paid more attention on their own and came back to the classroom excited to learn more. It increased excitement for science.

The wide variety of resources available on-line, including multi-media video and graphics that are visually captivating were identified as important for capturing students' attention and curiosity. Teachers said that particularly if the videos reflect the latest discoveries and if these are current, or have recently been in the news, they gain the students' interest.

Many teachers recommended that in order to enhance what they do they needed to open their classes to more accessibility, dialog, and communications outside of the classroom. They indicated that they needed to find “someone truly knowledgeable in current technology programs” so that they could get to know what was out there. They cited the potential of using Skype to establish web chats with university professors, university students, graduate students, NASA experts, or others. They suggested that only with such external expertise could they get to know more about “abstract ideas” or to gain a greater depth of knowledge, “more than just general knowledge.”

One teacher said that while Earth science would need to be a huge focus of any professional development training because of his lack of knowledge of the subject, space would be more important because “space science would get the students hooked”. At the high-school level some teachers said that the order of the two semesters, alternatively teaching Earth science and then space science, was important because space science topics helped to maintain the students’ interest during the spring semester when the their interests were otherwise not on school-work.

Scientific Literacy

Data collected showed that relevance is important in the teacher’s selection of curriculum content. To make space science relevant to the students, several teachers recommended providing examples of the applicability of research and discoveries to everyday life. This included looking at the Earth from space and looking back into space to compare with or find other places in space similar to Earth. Some said that if they wanted students to take ownership then they needed to show students career opportunities and advise them on how to pursue careers in those fields. However, several teachers said they felt they knew very little about how to do this.

Teachers said that in addition to the technical content they teach, it is important for the students to gain knowledge of the history of the science as well as to communicate recent changes and new research and data to show how the understanding of space is changing. Teachers said that communicating how scientific thinking led to changes in understanding was important. They also said that it was important to relate how science is utilized and how engineering, technology, science, and society are interconnected. Some teachers said that students needed to grasp the evidence behind scientific understanding as well as the practical value of science's application. Several teachers said that they needed stories and examples to communicate why science is relevant.

Some teachers identified a number of specific topics, particularly for the upper elementary and middle-school grades, that captured the students' interest and helped them to understand the nature of science. These included developing an understanding of the wonder and scale of the universe; the potential for life beyond Earth; and the way in which life on Earth is dependent on astronomical objects; new findings about the solar system; and "*incredibly brain-bending topics* [emphasis added] that students have trouble thinking abstractly about" such as faster than light travel, solar sails, multiple universes/alternate universes, star creation and destruction, and modern cosmology. "Spaceflight and space exploration missions, or any type of space travel," were important because "the students asked about it all the time". These are "the stuff that students LOVE, that changes rapidly so I'm not always up to date."

Teacher Ability Construct

As in the first research question and all of the other constructs, item-level analysis was useful in helping to understand the larger patterns. In addition to item analysis, the treatment of the ability construct also included both bivariate and multiple regression analyses using the factors for each of the other five constructs:

1. experience,
2. education,
3. resources,
4. community support,
5. curriculum establishment;

as predictors of the four ability construct factors:

1. content knowledge,
2. knowledge currency,
3. knowledge of instructional methodology,
4. teaching preparedness.

In addition, an average of the four ability construct factors was computed and then this ability average was regressed against each of the independent variable factors.

The data collected in the study were perhaps most notable for the four ability factors, whether considered individually for each grade or together for all respondents, because of the consistency in responses. The self-appraisal of each individual ability factor for all respondents and for each grade level is provided in Appendix N-1 through

N-4. The ability average is illustrated in appendix N-5. The shape of the histograms, the shape of the normal curves, the means and the standard deviations are all consistent. The high strength of the reliability coefficient, Cronbach's α, averaging .910 for all respondents, suggests that the four ability factors measure a single underlying latent construct.

The message communicated by the data from the survey responses is that most teachers feel they were able to do a more than moderately adequate job. This applies to all of the ability factors of content knowledge, content currency, instructional methodology, and overall teaching preparedness. These strong self-appraisals were submitted despite the relatively low level of education and training in space science and the need for additional resources and better curriculum definitions that many of the teachers identified.

Multiple regressions looked at the 62 factors of the five independent variable constructs regressed against 20 dependent variables of the ability factors. Across all of the populations: all respondents, elementary, middle- and high-school teachers, 1240 potential predictors were possible.

Of these, 35 factors were identified as significant and 139 as highly significant. Of the 63 independent variables, more than half (34) were identified to be highly significant predictors of different ability factors for different grade levels. A listing of the significant and highly significant predictor variables for the ability average construct is provided in Appendix O. The more extensive identification of highly significant and significant predictors for all constructs and all grade levels is provided in Table 4.8. A complete set of statistical regression analyses identifying non-significant, significant and highly significant predictor variables for ability average and each ability factor is provided in the model summary, ANOVA and coefficient tables of Appendices P, Q, R and S. The appendices divide the analyses by the total population of all respondents, and the individual sub-populations of elementary, middle, and high-school teachers.

Many of the identified predictors were interpreted to be consistent with the statements of teachers on the surveys and in interviews as well as the descriptions the teachers established through the quantitative data. College major, for example, was an important indication of whether an individual had an interest in a subject. College major was significant or highly significant as a predictor for content knowledge at the middle and high-school levels, respectively.

Percentage-wise, the experience construct contained the highest percentage of potential predictive factors. Because so few teachers had degrees or recent training in space sciences, the old adage, learning by teaching, may have been be the only option for many of the teachers. Perhaps prior experience guided the performance of space science teachers in lieu of more closely related experience or education. Prior science teaching experience in general was a significant predictor for space science teaching ability. In particular, prior space science teaching experience was highly significant for content knowledge at all grade levels. Many of the teachers said they needed professional development in order to further enhance or develop their content knowledge, in order to maintain the currency of their knowledge, in order to provide guidance about the resources that were available and about how best to integrate and communicate space science. Therefore it was not surprising for the quantitative data to indicate that most recent training and not-for-credit, professional development; training was significant or highly significant for content knowledge at all grade levels. The analysis identified it as particularly important for the elementary level where it was a highly significant predictor for all aspects of ability. The data showed that elementary teachers otherwise have little education in the space science subject areas specifically or in science generally.

In their responses, teachers said that the ‘big’ questions about the universe, its scale, humanity’s place in the universe, whether focused on the Milky Way galaxy, the solar system, or the Earth; observations made in space, of space and from space; and space technology and exploration, are all subjects that hold the interest of their students. They have said that these subjects need to be taught. They said that although the answers might not yet be known, students should understand the big questions adequately enough to be able to discuss them. Teachers also said that a curriculum that takes students through twelve grades of learning these subjects in a coherent manner has not been established. Some said that an integrated curriculum model that goes from grade-to-grade is not being followed. The regression analysis showed that establishment of the space science curriculum is a highly significant predictor for multiple ability factors at all grade levels.

Only about half of all teachers for the space science subject areas said that textbooks were available for their use; even those teachers who had textbooks often did not use them because they found the texts to be dated or inappropriate for the students’ age and grade level. Some teachers said that it was unlikely their administrators would find the funds to purchase or maintain new books and several teachers said that textbooks might not be necessary if there were alternatives. Some said they were using on-line textbooks or other resources in place of a hard-copy textbook. For high-school space science content knowledge, textbooks were identified as a significant predictor of ability.

Prior research identified the inability of teachers to deal with too large a quantity of potential computer-based curriculum resources and materials (O'Connor, Goldberg, Russell, Bebell, & O'Dwyer, 2004). The data from the current study identified that there was no shortage of space science content on-line but that it was so voluminous and so poorly organized that the teachers spent considerable time searching for what they needed and often they could not assemble a complementary suite of resources to provide an integrated set of teaching tools. Teachers said an integrated set of resources would include reading materials, vocabulary, video segments, and simulations that could be used for analyses, laboratory exercises, discussion questions, activities and assessments. They required a suite of resources that would create opportunities for interactivity and allow students to move away from the computer screen towards hands-on manipulables. Videos needed to be brief enough for teachers to have students focus on and incorporate into lessons, highlighting specific topics to establish basic principles and enable discussion and review.

Teachers said they needed activities that would develop critical thinking skills. Many teachers said they did not have either the time or the background knowledge to develop either activities or full integrated suites of teaching materials that promoted critical thinking. Science teachers often focus on teaching factual knowledge. By definition, an expert has lots of factual knowledge. However, what makes an expert an effective teacher is an organizational structure that facilitates the absorption, retrieval and application of knowledge by the student. This requires transcending from a focus on facts to a focus on structure (Wieman & Perkins, 2005). The constructivist philosophy says that people learn by creating their own understanding. Learning requires psychological engagement, cognitive processing, and an interest in the outcome. A key to effective learning is to get cognitive activity into the classroom. Most of the space science teachers who responded in this study said they could not do this without assistance. Effective teaching in science courses requires developing pedagogically effective materials, supporting technologies, and providing for faculty development. These all require resources.

In the research data, the teachers said that while they needed an organized archive of space science resources, they also said they would need routine and periodic updates to provide current news about ongoing discoveries and explorations. They would need access to real and original data that would allow their students to participate in the process of scientific discovery and exploration. Teachers said that while they needed more resources for use in class, they also needed resources that would enable students to work independently or collaboratively outside of the classroom. Regression analyses showed that several of the space science resources were highly significant predictors for all of the ability factors and this is consistent with the qualitative data.

A common recommendation by many teachers at all grade levels was to establish a network of mutual support with other teachers and a network for support by subject matter experts from college, industry or government. Support networks might enhance the ability of teachers to find and share resources. Support by colleges and teachers outside of the district were found to be highly significant predictors for content knowledge at the high-school level.

Summary of the Discussion

This study identified many commonalities and some differences between the perspectives, resources and dependencies of space science teachers at the different grade levels and in a wide variety of school and district types across Texas. The collection and interpretation of quantitative data led to important revelations about the knowledge, skills, resources, and practices of Texas public school space science teachers. The collection and analysis of qualitative data told much the same story and allowed for greater depth and understanding.

Many participants in this study felt they were moderately knowledgeable and could provide adequate teaching in the space sciences fields, but that their instruction could be enhanced through access to more and better subject content information, technology, resources, and training. There were several key findings. Teachers did not perceive the curricula to be uniformly defined. While space science content was taught in most K-8 grades, there was little continuity from one grade to the next. Moreover, while an abundance of technical content was available on the internet, the lack of organization for ease of use and the apparent difficulty in finding suitable classroom activities that promoted critical thinking skills required attention.

Perhaps the only real surprise was that some of the individual factors that seemed like they should be predictive of teacher ability were found to be non-predictive. The perception of curriculum definition was predictive for all ability factors and for all grade levels. Education was predictive of ability content knowledge for middle-school and high-school teachers and for all ability factors for elementary-teachers. However, education was not predictive of several ability factors for middle-school or high-school teachers. Community support was predictive of all ability factors for elementary-teachers. However, community support was not predictive of any ability factors for middle-school teachers. Resources were predictive of all ability factors for elementary and high-school teachers. However, resources were not predictive of most ability factors for middle-school teachers. So, while not all of the independent variables were always predictive, taken as whole constructs, individually all five constructs were predictive of space science teaching ability for the different grade levels in varying degrees. Further research is necessary to better understand the utility of any of the factors or their influence on establishing a supportive teaching environment.

Practical Significance

Based on the data that has been develop in this study, a number of specific changes are required in order to support the teaching of space science in Texas:

- A *model curriculum* needs to be developed. Because of the political controversy in roles and responsibilities for the definition of curriculum, the curriculum may not be a single set of content to be adopted universally, but rather a series of optional *lesson units*.

- The model curriculum needs to be integrated across grade levels in a coherent manner and optimized for specific grade and age levels.
- For each of the topics identified in the model curriculum, integrated sets of interactive *lesson units* need to be developed. Each unit should be short enough to complete in a proper timeframe, usually no more than a few days to a couple of weeks per topic; there needs to be to-the-point, focused sets of materials for each topic. They need to include lectures, readings, worksheets, ideas for discussion questions, interactive engagement activities and assignments, hands-on manipulables, laboratories, and assessments; they need to include videos or simulations that provide immediate access to short pertinent sequences, enabling interactivity and using the video to reinforce other content. Each unit needs to provide the ability for the teacher to create an environment for interactive, engaging, and active learning.

  An optimal way to develop these lesson units in an efficient manner at an expense level that can be supported, may be to develop professional development programs in which teachers work with subject matter experts to develop the content.
- Professional development programs optimized for the space science subjects and grade levels should be developed and conducted. Most should be made available using distance learning in order to reach as wide a population of teachers as possible. The professional development needs to cover the range of lessons

covered in the model curriculum and be used to further enhance or develop or maintain the teachers' content knowledge, the currency of their knowledge, methodological guidance of how to integrate and communicate the space science topics and provide guidance about the resources that are available.

- Use of the internet to support space science teaching should be broadened; currently it could be used to support professional development, talks by subject matter experts, virtual tours of space facilities or museums, and communications and sharing of lesson content and ideas by teachers and for teachers. As the lesson units described above are developed, these would be made available. A central organizing effort is required. As computers continue to proliferate into the hands of the students, more extensive use could be made for communication and sharing directly with students.

This study sought to contribute to the relatively small body of knowledge regarding how space science is taught in Texas as a step towards the establishment of more supportive teacher training and resources. While the information the study provided has the potential to be an asset in the future, enhancing the future of space science instruction will necessitate change.

Future Research

This study examined the perspectives, and relied upon the resources and dependencies of space science teachers in Texas public schools. The survey instrument used for the current study was developed over several years and in multiple trials and turned out to provide powerful and useful information that has the potential to be used or adapted for future studies. Such studies may indeed be useful for looking at teachers in other locations who may be more or less successful than teachers in Texas, or at future times as the availability and use of a wider variety of technologies pervades more classrooms.

Other aspects that could be investigated further are the relationship of the responses provided to this study's survey to the need for specific types of professional development and the relationships of the use of specific resources and curricula to student performance. In addition, responses to the survey could be analyzed with respect to school and school district size, location or performance levels.

One of the key findings in the study was that curricula for space science and related subject areas is a highly significant predictor of teacher ability; in fact it is the only highly significant predictor common across all of the grade levels. The level of curriculum definition varies considerably. This study found that some districts defined essentially no substantive curriculum; in some cases, we saw that teachers preferred this and in other cases, teachers identified the need for more curriculum definition together with the resources with which to teach it.

One controversy that took place while this study was being conducted was the implementation of curriculum in Texas schools. The Texas CSCOPE system, which was cited in the study by many teachers with a wide variety of perspectives, is under review and may be eliminated in favor of curricula to be drawn up by individual school districts (Klein, 2013; Texas Education Agency, 2013). CSCOPE had been enacted to varying degrees for space science, often appreciated by teachers for offering lesson plans and definition where there had been no other definition provided, yet at the same time often cited by teachers as inadequate as a total package of guidance or resources for the subject.

CSCOPE had been developed at the state and regional levels. Many in state education feel curriculum definition is a state prerogative. Some feel that curriculum should be defined at the federal level. Although not yet released at the time of completion of the study, the revised national science *Frameworks* (National Research Council, 2012) may provide a level of curriculum definition commensurate with the Texas TEKS. Curriculum definition and adoption is therefore fraught with some controversy and risk.

Because space science curriculum definition appears to be significant for all factors and all grade levels, beginning a process to establish a model curriculum so that teachers do not have to proceed in a vacuum would appear to be critical. Even as contenders might debate the bureaucratic level or means through which a curriculum might be enforced, it would be worthwhile to define a model for the space science curriculum and then to begin to fill in the resources and support structure required to implement. This could serve as a framework for organization of the space science framework on the internet or for educational product development by contributing organizations such as NASA or Discovery Video. A model would identify specific topics for incorporation in the space science curriculum. It could also help to identify the resources needed for teaching the subject. Organization of the resources could help to identify how an index for the resources could be best structured for accessibility. To not develop a space science curriculum framework leaves thousands of teachers on their own to try and determine what they need in order to instruct effectively.

Who would define a space science curriculum? Subject matter experts from Earth and space science and astronomy should be brought together with expertise from education. These experts should be called on to identify the subjects they feel are important to be included in the space science curriculum in the face of recommendations to reduce and focus curriculum content and emphasize critical thinking skills and greater scientific literacy and relevancy to society. Kantz (2004, p. 142) suggested that "an in-depth analysis devoted just to curriculum should be conducted as part of the development of any new program."

A Delphi structured communication evaluation could be used to attempt to achieve consensus among a group of experts in defining a space science curriculum. A structured questionnaire might be prepared and submitted to the panel who would then be asked to comment on the curriculum content and their responses would be compared and analyzed. Through multiple rounds, the researcher would attempt to establish consensus on curriculum content.

A Delphi process would be used because Delphi aims to provide expert group interaction in order to share a broader knowledge base, gain a wider perspective, and come to an understanding of opinions about a particular problem. Frequently a consensus can be reached by conducting a series of information exchanges and seeking controlled feedback from panel members (Clayton, 1997; Gordon, 2003; Toohey, 1999). The Delphi technique structures and facilitates group communication that focuses upon a complex problem so that, over a series of iterations, a group consensus can be achieved about a complex problem and planning some future direction (Linstone & Turoff, 1975; Loo, 2002). The Delphi method is particularly useful in new or emerging areas if it can capture areas of collective knowledge that are held but not often verbalized within or across professions.

There are many space science educators and practitioners and they come at the subject from a variety of areas of expertise including scientific research, educational research, teaching, teacher education, communicating to the public in less formal environments whether through verbal presentations or in writing, and from strengths in science, technology, history, or education and pedagogy. Senior experienced experts could be assembled virtually through the instantaneous communications of the internet. Without convening a conference on the subject, the Delphi method could permit an attempt to bring a group of space science experts to consensus on a model curriculum.

After establishing a model curriculum, a next step would be to convene space science educators. They could fill in the blanks for the resources required to support the curriculum. At a series of workshops, teachers could develop the integrated sets of resources of readings, videos, principles, discussion points, simulations, laboratory exercises and activities. These would enable interactivity and the development of critical thinking skills. This could be maintained through a series of on-line discussion and information sharing forums.

Conclusion

Research on implementation of innovative new subject areas has typically lacked an organizing framework and has seldom included multivariate analysis (Gillman, 1988). This study attempted to develop a generalizable framework for investigation. The result was a greater appreciation for the complexity of the situation. It appears that many of the Texas teachers share the Texas Education Agency's, TEKS authors', industry's, and government's interests in successfully teaching space science. The subject is more widely taught throughout Texas than anticipated at the study's outset, but it seems clear that content and methods differ with a wide variety of supporting systems of infrastructure, technologies, and resources.

It is hoped that the empirically-derived constructs and indices of teacher space science teaching abilities and measures of contextual construct factors could be refined as a tool for further assessing teacher ability and learning outcomes. In addition, it is hoped that the study can serve as a step towards development of a comprehensive space science curriculum framework.

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APPENDICES

APPENDIX A

EXCERPTS FROM THE

TEXAS TEKS

RELATED TO

EARTH, SPACE AND ASTRONOMY

ASSOCIATED REQUIREMENTS

FROM

CHAPTER 112. TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

FOR SCIENCE

http://ritter.tea.state.tx.us/rules/tac/chapter112/

Chapter 112. Texas Essential Knowledge and Skills for Science
Subchapter A. Elementary

(1) Science… "use of evidence to construct testable explanations and predictions
(2) Recurring themes are pervasive in sciences… technology. These ideas transcend disciplinary boundaries (3) implementing classroom and outdoor investigations students observe and describe the natural world using their five senses.
Districts are encouraged to facilitate classroom and outdoor investigations for at least 80% of instructional time.
Students do science as inquiry
develop and enrich their abilities to understand scientific concepts
develop vocabulary through their experiences…
active engagement in asking questions, communicating ideas, and exploring with scientific tools. …asking questions about the natural world
…seeking answers to those questions through simple observations and descriptive investigations.

§112.11. Science, Kindergarten, Beginning with School Year 2010-2011.

A. A central theme…**Earth and space**…
B. Weather is recorded and discussed on a daily basis
…patterns are observed in the appearance of objects in the sky.

(7) **Earth and space**. The student knows that the natural world includes earth materials. The student is expected to:
(A) observe, describe, compare, and sort rocks by size, shape, color, and texture;
(B) observe and describe physical properties of natural sources of water, including color and clarity; and
(C) give examples of ways rocks, soil, and water are useful.
(8) **Earth and space**. The student knows that there are recognizable patterns in the natural world and among objects in the sky. The student is expected to:
(A) observe and describe **weather** changes from day to day and over seasons;
(B) identify events that have repeating patterns, including **seasons** of the year and **day and night**; and
(C) observe, describe, and illustrate **objects in the sky** such as the **clouds, Moon**, and **stars**, including the **Sun**.

§112.12. Science, Grade 1, Beginning with School Year 2010-2011.

A. A central theme…**Earth and space**…
B. **Weather** is recorded and discussed on a daily basis
…patterns are observed in the **appearance of objects in the sky**.

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 1.

(7) **Earth and space**. The student knows that the natural world includes rocks, soil, and water that can be observed in cycles, patterns, and systems. The student is expected to:
(A) observe, compare, describe, and sort components of soil by size, texture, and color;
(B) identify and describe a variety of natural sources of water, including streams, lakes, and oceans; and
(C) gather evidence of how rocks, soil, and water help to make useful products.

(8) **Earth and space**. The student knows that the natural world includes the air around us and **objects in the sky**. The student is expected to:
(A) **record weather information**, including relative temperature, such as hot or cold, clear or cloudy, calm or windy, and rainy or icy;
(B) **observe and record changes in the appearance of objects in the sky** such **as clouds, the Moon, and** including the **Sun**;
(C) identify characteristics of **the seasons of the year** and **day and night**; and
(D) demonstrate that **air is all around us** and observe that **wind is moving air**.

§112.13. Science, Grade 2, Beginning with School Year 2010-2011.
(B) Within the natural environment, students will observe the properties of earth materials as well as predictable patterns that occur on Earth and in the sky.
(C) Students examine how living organisms depend on each other and on their environment.

(7) **Earth and space**. The student knows that the natural world includes earth materials. The student is expected to:
(A) observe and describe rocks by size, texture, and color;
(B) identify and compare the properties of natural sources of freshwater and saltwater;
(C) distinguish between natural and manmade resources.
(8) **Earth and space**. The student knows that there are **recognizable patterns** in the natural world and **among objects in the sky**. The student is expected to:
(A**) measure, record, and graph weather information**, including temperature, wind conditions, precipitation, and cloud coverage, in order to identify patterns in the data;
(B) identify the importance of weather and seasonal information to make choices in clothing, activities, and transportation;
(C) explore the processes in the water cycle, including evaporation, condensation, and precipitation, as connected to weather conditions; and
(D) **observe, describe, and record patterns of objects in the sky**, including the appearance of **the Moon**.

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 2.

§112.14. Science, Grade 3, Beginning with School Year 2010-2011.
classroom and outdoor investigations addressing the content and vocabulary in…earth…sciences
Districts are encouraged to facilitate investigations for at least 60% of instructional time.
(A) Students recognize that patterns, relationships, and cycles exist in matter.
(B) Students investigate how the surface of Earth changes and provides resources that humans use. As students **explore objects in the sky**, they describe how **relationships** affect patterns and **cycles on Earth**. Students will construct **models to demonstrate Sun, Earth, and Moon** system relationships and will describe the **Sun's role in the water cycle**.
(6) Force, motion, and energy…
(C) observe forces such as…gravity acting on objects.
(7) **Earth and space.** Earth…surface is constantly changing. The student is expected to:
(A) … weathering of rock …
(B) …rapid changes in Earth's surface … volcanic eruptions, earthquakes, and landslides;
(C) … landforms…mountains, hills, valleys, and plains; and
(D) … natural resources …

(8) **Earth and space.** The student knows there are **recognizable patterns** in the natural world and **among objects in the sky**.
(A) observe, measure, record, and compare day-to-day **weather changes** in different locations at the same time that include air temperature, wind direction, and precipitation;
(B) describe and illustrate the **Sun as a star** composed of gases that provides light and heat energy for the **water cycle**;
(C) construct models that demonstrate the relationship of the Sun, Earth, and Moon, including orbits and positions; and
(D) identify the planets in Earth's solar system and their position in relation to the Sun.

§112.15. Science, Grade 4, Beginning with School Year 2010-2011.
(4) In Grade 4, investigations are used to learn about the natural world. Districts are encouraged to facilitate classroom and outdoor investigations for at least 50% of instructional time.
(A) …explore **Sun, Earth, and Moon relationships**. The students will recognize that our major **source of energy is the Sun**.
(6) Force, motion, and energy…
(D) design an experiment to test the effect of force on an object such as …gravity

App A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements Page 3.

(7) **Earth and space**. The students know that **Earth** consists of useful **resources** and its **surface is constantly changing**. The student is expected to:

(B) observe and identify **slow changes to Earth's surface** caused by **weathering, erosion, and deposition** from water, wind, and ice; and

(C) identify and classify Earth's renewable resources, including air, plants, water, and animals; and nonrenewable resources, including coal, oil, and natural gas; and the importance of conservation.

(8) **Earth and space**. The student knows that there are **recognizable patterns** in the natural world and among the **Sun, Earth, and Moon** system. The student is expected to:

(A) measure and record **changes in weather** and make predictions using weather maps, weather symbols, and a map key;

(B) describe and illustrate the continuous **movement of water** above and on the surface of Earth through the water cycle and explain the role of the **Sun as a major source of energy** in this process; and

(C) collect and analyze data to identify **sequences and predict patterns** of change in **shadows, tides, seasons, and the observable appearance of the Moon** over time.

§112.16. Science, Grade 5, Beginning with School Year 2010-2011.

Districts are encouraged to facilitate classroom and outdoor investigations for at least 50% of instructional time.

(4) Models of objects and events are tools for understanding the natural world and can show how systems work.

(A) explore **Sun, Earth, and Moon relationships**. The students will recognize that our major source of energy is the Sun.

(3) Scientific investigation and reasoning…

(C) represent the natural world using models such as rivers, stream tables

(D) connect grade-level appropriate…history of science, science careers, and contributions of scientists.

(6) Force, motion, and energy.

(C) demonstrate that light travels in a straight line

(D) design an experiment that tests the effect of force on an object.

(7) **Earth and space**…Earth's surface... useful **resources**.

(A) explore the processes that led to the formation of sedimentary rocks and fossil fuels;

(B) recognize **landforms** such as deltas, canyons, and sand dunes are the result of changes by wind, water, ice;

(C) identify **alternative energy resources** such as wind, solar, hydroelectric, geothermal, and biofuels; and

(D) identify fossils…nature of the environments using models.

(8) **Earth and space.** .. recognizable patterns…**Sun, Earth, and Moon** system. The student is expected to:

(A) differentiate between weather and climate;

(B) explain how the **Sun and the ocean interact** in the water cycle;

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 4.

(C) demonstrate that **Earth rotates on its axis** once approximately every 24 hours causing the **day/night cycle** and the apparent **movement of the Sun across the sky**; and

(D) identify and compare the **physical characteristics of the Sun, Earth, and Moon**.

§112.17. Implementation of Texas Essential Knowledge and Skills for Science, Middle School, Beginning with School Year 2010-2011.

(1) Science…is the "use of evidence to construct testable explanations and predictions

(2) Scientific hypotheses are tentative and testable…capable of being supported or not supported

(3) science is interdisciplinary in nature…content focus is on physical science

National standards in science are organized as multi-grade blocks such as Grades 5-8 Recurring themes are pervasive…transcend disciplinary boundaries and include change and constancy, patterns, cycles, systems, models, and scale

§112.18. Science, Grade 6, Beginning with School Year 2010-2011.

strands for Grade 6

different modes of scientific inquiry

learn about the natural world

(C) **Earth and space**…Earth's processes…**Earth** as part of our **solar system** …organization of our solar system, the role of gravity, and **space exploration**.

(3.B) use **models** to represent aspects of the natural world such as a model of **Earth's layers**;

(10) **Earth and space**. The student understands the structure of Earth, the rock cycle, and plate tectonics. (A) **build a model** to illustrate the structural layers of Earth

(11) **Earth and space**. The student understands the organization of our **solar system**:

(A) physical properties, locations, and movements of the **Sun, planets, Galilean moons, meteors, asteroids, and comets**;

(B) understand **gravity** the force that governs the motion of our **solar system**

(C) describe the history and future of **space exploration**, including equipment, transportation for **space travel**.

§112.19. Science, Grade 7, Beginning with School Year 2010-2011.

The strands for Grade 7 include:

different modes of scientific inquiry

learn about the natural world

for at least 40% of the instructional time, conducts laboratory and field investigations

(C)Earth and space. phenomena observed in a variety of settings.

natural events and human activities can impact **Earth systems**

characteristics of Earth and relationships to objects in our solar system that allow life to exist.

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 5.

(8) **Earth and space**...**natural events and human activity** can impact Earth systems.

(A) types of **catastrophic events** impact ecosystems such as floods, hurricanes, or tornadoes;

(B) **effects of weathering**, erosion, and deposition on the environment in ecoregions of Texas

(C) model the effects of human activity on groundwater and surface water

(9) **Earth and space.** The student knows components of our **solar system**.

(A) analyze the **characteristics of objects in our solar system** that allow **life** to exist such as the proximity of the **Sun**, presence of **water**, and composition of the **atmosphere**; and

(B) identify the accommodations that enabled **manned space exploration**.

§112.20. Science, Grade 8, Beginning with School Year 2010-2011.

(C) Earth and space…natural events altering Earth systems…Cycles within Sun, Earth, and Moon systems…seasons, tides, and lunar phases… stars and galaxies are part of the universe...distances in space are measured…theories of the origin of the universe…how Earth features change over time by plate tectonics…land and erosional features on topographic maps…interactions in solar, weather, and ocean systems...changes in weather patterns and climate.

(6) Force, motion, and energy… speed, velocity, and acceleration…Newton's law… vehicle restraints, Earth's tectonic activities, and rocket launches

(7) **Earth and space**. effects from cyclical **movements** of the **Sun, Earth, and Moon**.

(A) **Earth rotates** on its axis, causing **day and night**, and **revolves** around the Sun causing **seasons**;

(B) predict the sequence of the lunar cycle; and

(C) relate the positions of the Moon and Sun to their effect on ocean tides.

(8) Earth and space. The student knows characteristics of the universe. The student is expected to:

(A) components of the **universe**, including **stars, nebulae, and galaxies**, and use models such as the **Herztsprung-Russell diagram** for classification;

(B) recognize that the **Sun** is a **medium-sized star** near the edge of a **disc-shaped galaxy** of stars and that the **Sun** is many thousands of times closer to Earth than any other star;

(C) explore how different **wavelengths of the electromagnetic spectrum** such as light and radio waves are used to gain information about **distances and properties of components in the universe**;

(D) model and describe how **light years** are **used to measure distances** and sizes in the universe; and

(E) research how scientific data are used as evidence to develop scientific theories to describe the **origin of the univers**e.

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 6.

(9) **Earth and space**. natural events can impact Earth systems.
(A) describe the historical development of evidence that supports **plate tectonic** theory;
(B) relate plate tectonics to the formation of crustal features; and
(C) interpret topographic **maps and satellite views** to identify land and erosional features and predict how these features may be reshaped by weathering.

(10) **Earth and space**. The student knows that **climatic interactions** exist among Earth, ocean, and weather systems
(A) recognize that the **Sun provides the energy** that drives convection within the atmosphere and oceans, producing winds and ocean currents;
(B) identify how **global patterns of atmospheric movement** influence local weather using weather maps that show high and low pressures and fronts; and
(C) identify the **role of the oceans** in the formation of weather systems such as hurricanes.

Chapter 112. Texas Essential Knowledge and Skills for Science Subchapter C. High School

§112.31. Implementation of Texas Essential Knowledge and Skills for Science, High School, Beginning with School Year 2010-2011.
§112.33. Astronomy, Beginning with School Year 2010-2011 (One Credit).
Suggested prerequisite: one unit of high school science.
This course is recommended for students in Grade 11 or 12.
informed decisions using critical thinking and scientific problem solving
conduct observations of the sky
Topics:
astronomy in civilization
patterns and objects in the sky
our place in space
the moon
reasons for the seasons
planets
sun
stars
galaxies
cosmology
space exploration

(2) Nature of science.
(3) Scientific inquiry-planned and deliberate investigation of the natural world

(4) Science and social ethics-distinguish between scientific decision-making and ethical and social decisions (5) Scientific systems-cycles, structures, and processes that interact
(c) Knowledge and skills.
(1) Scientific processes- 40% of instructional time conducting laboratory and field investigations
(2) use scientific methods during laboratory and field investigations
(I) use **astronomical technology** such as telescopes, binoculars, sextants, computers, and software
(B) communicate and apply scientific information from current events, news reports, published journal articles,
and marketing materials;
(D) impact of research on scientific thought, society, and the environment; and
(E) connection between **astronomy** and future **careers**.

(4)   the importance of **astronomy in civilization**
(A) **astronomy in ancient civilizations** such as the Egyptians, Mayans, Aztecs, Europeans, native Americans;
(B) contributions of **scientists** Ptolemy, Copernicus, Tycho Brahe, Kepler, Galileo, Newton, Einstein, Hubble,
women astronomers Maria Mitchell and Henrietta Swan Leavitt;
(C)   historical origins of **constellations** and the role of constellations in ancient and modern navigation
(D)   **modern astronomy** to today's **society**, asteroid/comet impact hazards and the Sun's effects on
communication, navigation, and high-tech devices.
(5)   familiarity with **the sky**
(A) observe and record the apparent **movement of the Sun and Moon** during the day;
(B) observe and record the **apparent movement of the Moon, planets, and stars** in the nighttime sky
(C) recognize and identify **constellations** such as Ursa Major, Ursa Minor, Orion, Cassiopeia, and zodiac
(6)   our place in space.
(A) compare and contrast the **scale, size, and distance of the Sun, Earth, and Moon**
(B) compare and contrast the **scale, size, and distance of objects in the solar system-** the Sun and planets
(C) **scale, size, and distance of the stars**, Milky Way, and other galaxies
(D) relate **apparent versus absolute magnitude** related to the distances of celestial objects
(E) units of **measurement** in astronomy
(7)   role of the **Moon in the Sun, Earth, and Moon** system
(A) **lunar phases**
(C) lunar and solar **eclipses**
(D) effects of the Moon on **tides.**

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 7.

(8) reasons for the **seasons**
(A) seasons caused by the tilt of Earth's axis
(B) latitudinal position affects the length of **day and night**
(C) angle of incidence of sunlight determines the concentration of solar energy received
(D) relationship of the seasons to **equinoxes, solstices, the tropics, and the equator**.
(9) **planets-sizes**, compositions, and surface features
(A) factors essential to life on Earth such as temperature, water, mass, and gases to conditions on other planets;
(B) **planets' orbits**, sizes, compositions, rotations, atmospheres, natural satellites, and geological activity
(C) Newton's law of universal **gravitation and the motions of the planets**, motion of satellites
(D) origins and significance of **asteroids, comets, and Kuiper belt objects**.
(10) the **Sun as the star** in our solar system
(A) mass, size, motion, temperature, structure, and **composition of the Sun**;
(B) nuclear **fusion** and nuclear **fission**
(C) eleven-year **solar cycle** and the significance of sunspots; and
(D) analyze **solar magnetic storm activity**, including coronal mass ejections, prominences, flares, and sunspots.
(11) Science concepts. The student knows the characteristics and **life cycle of stars**. The student is expected to:
(A) characteristics of **main sequence stars**, including surface temperature, age, relative size, and composition;
(B) characterize **star formation** in stellar nurseries
(C) relationship between mass and fusion on the **dying process** and properties of **stars**
(D) differentiate among the **end states of stars**, including white dwarfs, neutron stars, and black holes
(E) how the mass and gravity of a main sequence star will determine its end state as a white dwarf, neutron star, or black hole;
(F) relate the use of **spectroscopy** in obtaining physical data on celestial objects such as temperature, chemical composition, and relative motion; and
(G) use the **Hertzsprung-Russell diagram** to plot and examine the life cycle of stars from birth to death.
(12) variety and **properties of galaxies**
(A) characteristics of galaxies
(B) type, structure, and components of our **Milky Way galaxy** and location of our solar system
(C) different types of **galaxies**, including **spiral, elliptical, irregular, and dwarf.**
(13) Science concepts. The student knows the scientific **theories of cosmology**.
(A) the **Big Bang Theory**, including red shift, cosmic microwave background radiation, and other evidence
(B) theories of the **evolution of the universe**, including estimates for the age of the universe

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 8.

(C) the **fate of the universe**, open and closed universes and the role of dark matter and dark energy.

(14) benefits and challenges of **space exploration**

(A) contributions of **human space flight** and **future plans** and challenges;

(B) advancement of knowledge in astronomy through **robotic space flight**;

(C) importance of **ground-based technology** in astronomical studies;

(D) importance of **space telescopes**

(E) new developments and **discoveries in astronomy**.

§112.36. Earth and Space Science, Beginning with School Year 2010-2011 (One Credit).

Suggested prerequisite: one unit of high school science.

This course is recommended for students in Grade 11 or 12.

40% of instructional time laboratory and field investigations

(5) ESS themes.

(A) Earth in space and time-a chronological framework

origin, evolution, and properties of Earth

origin, evolution, and properties of **planetary systems**

origin and distribution of **resources that sustain life** on Earth

(B) Solid Earth-geosphere

(C) Fluid Earth-hydrosphere, cryosphere, and atmosphere

(6) Earth and space science strands.

(A) Systems

geosphere, hydrosphere, atmosphere, cryosphere, and biosphere

planetary and stellar system

(B) **Energy** internal and external thermal energy

(C) Relevance.

(2) Scientific processes.

(F) use a wide variety of additional course apparatuses, equipment, techniques, and procedures

satellite imagery

remote sensing data

Geographic Information Systems (GIS)

Global Positioning System (GPS)

scientific probes

microscopes

telescopes

modern video and image libraries

weather stations

planetary globes

scientific processes.

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 9.

(D) impact of **research on scientific thought, society**, and public policy;
(E) **careers and collaboration among scientists** in Earth and space sciences;
(F) **contributions of scientists** to the historical development of Earth and space sciences.

(4) Earth in space and time.
Earth-based and space-based astronomical observations
theories about the structure, scale, composition, origin, and history of the universe.

(A) the **Big Bang model**
red shift and cosmic microwave background radiation
current **theories of the evolution of the universe**,
estimates for the **age of the universe**;

(B) explain how **the Sun** and other stars transform matter into energy through nuclear **fusion**;
(C) process by which a **supernova** can lead to the formation of **successive generation stars and planets**

(5) Earth in space and time
solar nebular accretionary disk model
(A) gravitational condensation of solar nebula-accretion of **planetesimals** and **protoplanets**;
(B) thermal energy sources-kinetic heat of impact accretion, gravitational compression, and radioactive decay,
protoplanet differentiation into layers;
(C) characteristics of **comets, asteroids, and meteoroids** and their positions in the solar system
orbital regions of the terrestrial planets, the asteroid belt, gas giants, Kuiper Belt, and Oort Cloud
(D) hypotheses for the **origin of the Moon**
(E) **terrestrial planets** and **gas-giant planets** in the solar system
including structure, composition, size, density, orbit, surface features, tectonic activity, temperature, and
suitability for life;
(F) compare **extra-solar planets** with planets in our solar system and describe how such planets are detected.

(6) Earth in space and time.
Earth's atmospheres, hydrosphere, and geosphere formation and evolution through time.

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 10.

(A) changes of **Earth's atmosphere** that could have occurred **through time**
original hydrogen-helium atmosphere
carbon dioxide-water vapor-methane atmosphere
current nitrogen-oxygen atmosphere;
(B) role of volcanic outgassing and impact of water-bearing comets on Earth's atmosphere and
hydrosphere;
(6) Earth in space and time
Earth's history expressed in the geologic time scale.
(A) dating methods
(B) **ages of rocks from Earth, Moon and meteorites**
(C) Earth's approximate 4.6-billion-year history
(8) Earth in space and time. The student knows that fossils provide evidence for geological and biological evolution. Students are expected to:
(D) describe the **formation and structure of Earth's magnetic field**, including its interaction with **charged solar particles** to form the **Van Allen belts** and **auroras**.

Appendix A. Excerpts from the Texas TEKS Related to Earth, space and astronomy requirements. Page 11.

Appendix B

STEM EDUCATION ASSESSMENT REPORTS 1983-2012

The following reports provide a broad range of analysis on the problems and potential of STEM education.

2012. *STEM Education: Preparing for the Jobs of the Future*
U.S. Congress Joint Economic Committee
http://www.jec.senate.gov/public/index.cfm?a=Files.Serve&File_id=6aaa7e1f-9586-47be-82e7-326f47658320

2012. *Trends in International Mathematics and Science Study (TIMSS)*
http://timss.bc.edu/data-release-2011/pdf/TIMSS-NRC-List-Press-Release.pdf

2012. *U.S. Education Reform and National Security*
U.S. Council on Foreign Relations
http://www.cfr.org/united-states/us-education-reform-national-security/p27618

2012. *Science and Engineering Indicators*
National Science Board
http://www.nsf.gov/statistics/seind12/

2011. *Building a STEM Agenda*.
National Governors Association.
http://www.nga.org/cms/stem

2011. Center on Education and the Workforce: STEM Webinar
Georgetown University
http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/STEMWEBINAR.pdf

2011. *National Survey Findings on How to Inspire the Next Generation of Doctors, Scientists, Software Developers and Engineer*. Microsoft.
http://www.microsoft.com/en-us/news/press/2011/sep11/09-07MSSTEMSurveyPR.aspx

2011. *STEM: Good Jobs Now and for the Future*
U.S. Department of Commerce Economics and Statistics Administration
http://www.esa.doc.gov/sites/default/files/reports/documents/stemfinaljuly14.pdf

2010. *Preparing Teachers: Building Evidence for Sound Policy*.
National Research Council
http://www.nap.edu/catalog.php?record_id=12882

2010. *Transforming American Education: Learning Powered by Technology*. (The National Educational Technology Plan.)
Office of Educational Technology, U.S. Department of Education.
http://www2.ed.gov/about/offices/list/os/technology/netp.pdf

2010. *Engineering in K-12 Education*.
National Academy of Engineering.
http://www.nap.edu/catalog.php?record_id=12635

Appendix B. STEM Education Assessment Reports 1983-2012, page 1.

2009. *The Economic Impact of the Achievement Gap in America's Schools.*
McKinsey and Company.
http://www.sph.unc.edu/images/stories/units/minority_health/documents/achievement_gap_report.pdf

2009. *The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy.*
The Carnegie Corporation of New York and the Institute for Advanced Study.
http://carnegie.org/fileadmin/Media/Publications/PDF/OpportunityEquation.pdf

2009. *Learning Science in Informal Environments: People, Places and Pursuits.*
National Academy.
http://www.nap.edu/catalog.php?record_id=12190

2008. *Tapping America 's Potential: Gaining Momentum, Losing Ground*
http://www.tap2015.org/news/tap_2008_progress.pdf

2008. *High School Level STEM Initiatives in the States*
http://mb2.ecs.org/reports/Report.aspx?id=1409

2008. *Institute of Education Sciences, National Center for Education Statistics, Attrition of Public School Mathematics and Science Teachers Issue Brief*
http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2008077

2008. *Rowing Together Panel Briefing on Science Generation, A National Imperative, An American Museum of Natural History Summit*
http://www.amnh.org/science/specials/summit/

2008. *The National Mathematics Advisory Panel, Foundations for Success*
http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

2008. *Congressional Research Service Report for Congress, America COMPETES Act: Programs,Funding, and Selected Issues.*
http://assets.opencrs.com/rpts/RL34328_20080122.pdf

2008. *Fostering Learning in a Networked World.*
National Science Foundation Task Force on Cyberlearning.
http://www.nsf.gov/pubs/2008/nsf08204/nsf08204.pdf

2008. *Foundations for Success.* Final Report.
National Mathematics Advisory Panel.
http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

2008. *Out of Many, One*. *Toward Rigorous Common Core Standards From the Ground Up.*Achieve, Inc.
http://www.achieve.org/files/OutofManyOne.pdf

Appendix B. STEM Education Assessment Reports 1983-2012, page 2.

2007. *Business-Higher Education Forum, An American Imperative, Transforming the Recruitment, Retention, and Renewal of Our nation's Mathematics and Science Teaching Workforce*
http://www.bhef.com/solutions/anamericanimperative.asp

2007. *A Report from Public Agenda, Important, but Not for Me, Parents and Students in Kansas and Missouri Talk About Math, Science and Technology Education*
http://www.publicagenda.org/importantbutnotforme/pdfs/important_but_not_for_me.pdf

2007. *Is America Falling Off the Flat Earth*, Norman R. Augustine
National Research Council
http://www.nap.edu/catalog.php?record_id=12021

2007. *Science for a Better Life, United States of America, Bridging the Diversity Gap in Science and Engineering: Introducing STEM Industries to K-12 Best Practice programs Highlights Report*.Bayer.
http://www.bayerus.com/msms/HIGHLIGHTS.pdf

2007. *U.S. Population Data Sheet, A Profile of the Labor Force with a Focus on Scientists and Engineers*.Population Reference Bureau.
http://www.prb.org/Home.aspx

2007. *State Indicators of Science and Mathematics Education*
http://www.ccsso.org/projects/Science_and_Mathematics_Education_Indicators/

2007. *America's Perfect Storm Three Forces Changing Our Nation's Future*
Educational Testing Service, Policy Information Report
http://www.learndoearn.org/For-Educators/AmericasPerfectStorm.pdf

2007. *Assess Science and Engineering in America, Houston, Do We REALLY Have a Problem Here?* The Urban Institute.
http://www.urban.org/publications/901125.html

2007. *Commission on 21st Century Education in Science, Technology, Engineering, and Mathematics.* National Science Board.
http://www.nsf.gov/nsb/edu_com/

2007. *A National Action Plan For Addressing the Critical Needs of the U.S. Science, Technology, Engineering, and Mathematics Education System*.National Science Board.
http://www.nsf.gov/nsb/edu_com/

Appendix B. STEM Education Assessment Reports 1983-2012, page 3.

2007. *50-State Analysis of the Preparation of Teachers and the Conditions for Teaching, Results from the NCES Schools and Staffing Survey.* The Council of Chief State School Officers.
http://www.ccsso.org/content/pdfs/50StateAnalysisofthePreparationofTeachersrev101007.pdf

2007: *State Indicators of Science and Mathematics Education, 2007*. The Council of Chief State School Officers
http://www.ccsso.org/Resources/Publications/State_Indicators_of_Science_and_Mathematics_Education_2007.html

2007. *The National Math and Science Initiative, Bringing Government, Corporations, Foundations and Educators Together to Improve STEM Education*
http://www.nationalmathandscience.org/

2007. *Preparing STEM Teachers: The Key to Global Competitiveness.*
http://www.aacte.org/Governmental_Relations/AACTE_STEM_Directory2007.pdf

2007. *Academic Competitiveness Council.* U.S. Department of Education.
http://www.ed.gov/about/inits/ed/competitiveness/acc-mathscience/index.html

2007. *Report for Congress, Science, Engineering, and Mathematics Education: Status and Issues.* Congressional Research Service.
http://www.fas.org/sgp/crs/misc/98-871.pdf

2007. *Americans Support Bridging the Sciences.*
Research America.
http://www.researchamerica.org/uploads/btspollreport.pdf

2007. *Taking Science to School: Learning and Teaching Science in K-8*
National Research Council.
http://books.nap.edu/catalog.php?record_id=11625

2006-07. *Innovation America.* Governors Association.
http://www.nga.org/portal/site/nga/menuitem.751b186f65e10b568a278110501010a0/?vgnextoid=e34e2bad2b6dd010VgnVCM1000001a01010aRCRDandvgnextchannel=92ebc7df618a2010VgnVCM1000001a01010aRCRD

2007. *Rigor at Risk. Reaffirming Quality in the High School Core Curriculum.*ACT, Inc.
http://www.act.org/research/policymakers/pdf/rigor_report.pdf

2007. *Report of the Academic Competitiveness Council.* U.S. Department of Education.
http://science.nsta.org/nstaexpress/acc.pdf

2007. *Taking Science to School.*National Academy.
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Appendix B. STEM Education Assessment Reports 1983-2012, page 4.

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APPENDIX C

HUMAN SUBJECTS APPROVAL LETTER

UNIVERSITY of **HOUSTON**

DIVISION OF RESEARCH

November 26, 2012

Gary Kitmacher
c/o Dr. Bernard R. Robin
Curriculum and Instruction

Dear Gary Kitmacher,

Based upon your request for exempt status, an administrative review of your research proposal entitled "Development of a Curriculum for Space Science with a Basis in Pedagogical and Theoretical Frameworks for Learning" was conducted on October 11, 2012.

At that time, your request for exemption under **Category 1A** was approved pending modification of your proposed procedures/documents.

The changes you have made adequately respond to the identified contingencies. As long as you continue using procedures described in this project, you do not have to reapply for review. * Any modification of this approved protocol will require review and further approval. Please contact me to ascertain the appropriate mechanism.

If you have any questions, please contact Nettie Martinez at 713-743-9204.

Sincerely yours,

Kirstin Rochford, MPH, CIP, CPIA
Director, Research Compliance

*Approvals for exempt protocols will be valid for 5 years beyond the approval date. Approval for this project will expire **October 1, 2017**. If the project is completed prior to this date, a final report should be filed to close the protocol. If the project will continue after this date, you will need to reapply for approval if you wish to avoid an interruption of your data collection.

Protocol Number: 13068-EX

316 E. Cullen Building Houston, TX 77204-2015 (713) 743-9204 Fax: (713) 743-9577
COMMITTEES FOR THE PROTECTION OF HUMAN SUBJECTS

Appendix C. Approval letter from University of Houston Committee for Protection of Human Subjects.

APPENDIX D

INVITATION LETTER

(TEMPLATE)

Cover Letter

Dear _______________

I would like to invite you to participate in a research project: Development of a Curriculum for Space Sciences.

The initial survey for a project titled: Development of a Curriculum for Space Sciences is now being distributed. The goal is to use this survey to identify the experiences and requirements of Earth/Space Science and Astronomy teachers. I am looking for the widest possible dissemination of this announcement to teachers or administrators associated with these subjects in Texas.

If you are now or have in the past taught or served in a coordinating or administrative position for Earth and Space Science, Astronomy, Earth Science, Space Science, or related areas, then your input on this survey would be of great value assisting in understanding the status of the associated curriculum for the courses and the needs of teachers of these subjects.

This survey can be filled out on-line at: www.tinyurl.com/8wdj2gj

The purpose of the study is answering the following research questions:

1. What comprises a comprehensive curriculum for Space Sciences?

2. What professional development assistance do space sciences teachers feel would be beneficial?

The principal investigator in this study is Gary H. Kitmacher, from the College of Education at the University of Houston. This research is being conducted as one element of a doctoral dissertation under the supervision of Dr. Bernard Robin.

This project has been reviewed by the University of Houston Committee for the Protection of Human Subjects (713) 743-9204.

You may wish to remain anonymous for this survey. You need not provide identification information. Your participation is voluntary. You may choose not to participate and you may refuse to answer any question.

The results of this study may be published in professional and/or scientific journals. It may also be used for educational purposes or for professional presentations. However, no individual subject will be identified.

If you have any questions, you may contact Gary Kitmacher at 281-483-1059 or gkitmach@mail.uh.edu, or Dr. Bernard Robin, faculty sponsor, at 713-743-4952. Any questions regarding your rights as a research subject may be addressed to the University of Houston Committee for the Protection of Human Subjects (713-743-9204).

Gary H. Kitmacher

Appendix D. Cover letter/invitation sent to school district coordinators.

APPENDIX E

LETTER OF INFORMED CONSENT TO PARTICIPATE IN RESEARCH

UNIVERSITY OF HOUSTON
CONSENT TO PARTICIPATE IN RESEARCH

Project title: **Development of a Curriculum for Space Sciences**
You are being invited to participate in a research project conducted by Gary Kitmacher from the College of Education at the University of Houston. This research is being conducted as one element of a doctoral dissertation under the supervision of Dr. Bernard Robin.

Non-participation:
Your participation is voluntary and you may refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. You may also refuse to answer any question.

Purpose of the Study: Development of a Curriculum for Space Science
1. What comprises a comprehensive curriculum for Space Sciences?
2. What professional development assistance do Space Sciences teachers feel would be beneficial?
There is limited research on the composition of the space sciences curriculum. TEKS authors understood that the Space Science curriculum were not well established and that new texts and source materials would be required. The 2012 National Academies report Framework for K-12 Science Education identifies the adoption of Earth and Space Sciences nationally. There is a lack of research examining the space sciences elements. The proposed study will rely upon Texas teachers to provide insight and recommendations into a recommended curriculum for high school courses, as well as required prerequisite learning in earlier grades. This study is beginning in 2012 and is expected to conclude in the spring semester, 2013.

Procedures
You will be one of approximately 200 subjects from districts throughout Texas to be asked to participate in this project. Subjects will be sought from attendees at Texas science teacher conferences, through internet science teacher associations, through news-lists, and via email. Initial participation will be through a survey. Survey participants may remain anonymous if they wish. A subset group of participants may volunteer to be interviewed, class syllabus reviewed, or classes/class activities observed.

Subject participation in the survey should require no more than 15 minutes. Subject participation in interviews or class observations may take from one to several hours.

Confidentiality
Your participation in this project is anonymous if you so choose. Please do not write your name on any of the research materials to be returned to the principal investigator if you prefer to remain anonymous. Subject's actual names will not be used in portraying the results of this investigation. Identification of subjects will remain confidential.

Risks/Discomforts
No risks or discomforts are foreseen.

Benefits
Your participation may help to better understand space science instruction.

Alternatives
Participation in this project is voluntary. You may choose not to participate.

Publication Statement
The results of this study may be published in professional and/or scientific journals. It may also be used for educational purposes or for professional presentations. However, no individual subject will be identified.

If you have any questions, you may contact Gary Kitmacher at 281-483-1059 or gkitmach@mail.uh.edu, or Dr. Bernard Robin, faculty sponsor, at 713-743-4952. ANY QUESTIONS REGARDING YOUR RIGHTS AS A RESEARCH SUBJECT MAY BE ADDRESSED TO THE UNIVERSITY OF HOUSTON COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (713-743-9204).
Principal Investigator's Name: **Gary H. Kitmacher** Signature

Appendix E. Letter of informed consent to participate in research.

APPENDIX F

SCIENCE TEACHERS ASSOCIATION OF TEXAS

RESEARCH SUPPORT LETTER

STAT
Science Teachers Association of Texas

October 22, 2012

Dear Review Board,

The Science Teachers Association of Texas (STAT) has been provided with an overview and more detailed information pertaining to Mr. Kitmacher's dissertation research on the subject of Development of a Curriculum for Space Science. STAT is dedicated to the advancement of science teaching and learning in Texas and serves as a resource for science educators. Mr. Kitmacher's workshop was reviewed by the workshop committee and approved for the upcoming Conference for the Advancement of Science Teaching in Corpus Christi. The Executive Committee is aware of and supportive of the research he is conducting.

Sincerely,

Sharon Kamas
President, Science Teachers Association of Texas

Appendix F. STAT research support letter.

APPENDIX G:

SURVEY OF TEACHERS

OF EARTH SCIENCE , ESS, SPACE SCIENCE AND ASTRONOMY

Do you have 15 minutes to help? Are you now or have you recently taught or served in a coordinating or administrative position for Earth and space science, Earth science, space science, astronomy or related areas? Currently there is limited research on the composition of the space sciences curriculum. This research study is examining Texas teachers who have taught in these subject areas and who can assist us in understanding the status of the associated curriculum for the courses. It is your opportunity to provide insight and recommendations. You can help fill in the knowledge gap. The information will go back to state educational institutions and to NASA and may be used to enhance offerings for instructors in these areas. Sevral additional questions pertain to your background. You may wish to remain anonymous for this survey so do not have to provide identification information. This project has been reviewed by the University of Houston Committee for the Protection of Human Subjects (713) 743-9204.

Part A. Curriculum and resources for Earth/space science and astronomy.

1. How well established do you feel curriculum is defined for each subject?

Earth Science	1	2	3	4	5
Earth and Space Science	1	2	3	4	5
Space Science	1	2	3	4	5
Astronomy	1	2	3	4	5

2. Resources you regularly use for your classes. Check all that apply.

Earth Science
_____ Textbook
_____ Written content besides text such as magazines, books, copies
_____ Worksheets
_____ Computers in the classroom for teacher use
_____ Computers in the classroom for student use
_____ Computers outside of the classroom for teacher use
_____ Computers outside of the classroom for student use
_____ Digital media besides computers (e.g. cell phone, smart phone)
_____ Pre-recorded video or audio ‘program’, visualizations or simulations

Appendix G. Survey of teachers of Earth science, ESS, space science and astronomy, page 1.

Earth and Space Science
_____ Textbook
_____ Written content besides text such as magazines, books, copies
_____ Worksheets
_____ Computers in the classroom for teacher use
_____ Computers in the classroom for student use
_____ Computers outside of the classroom for teacher use
_____ Computers outside of the classroom for student use
_____ Digital media besides computers (e.g. cell phone, smart phone)
_____ Pre-recorded video or audio ‘program’, visualizations or simulations
Space Science
_____ Textbook
_____ Written content besides text such as magazines, books, copies
_____ Worksheets
_____ Computers in the classroom for teacher use
_____ Computers in the classroom for student use
_____ Computers outside of the classroom for teacher use
_____ Computers outside of the classroom for student use
_____ Digital media besides computers (e.g. cell phone, smart phone)
_____ Pre-recorded video or audio ‘program’, visualizations or simulations
Astronomy
_____ Textbook
_____ Written content besides text such as magazines, books, copies
_____ Worksheets
_____ Computers in the classroom for teacher use
_____ Computers in the classroom for student use
_____ Computers outside of the classroom for teacher use
_____ Computers outside of the classroom for student use
_____ Digital media besides computers (e.g. cell phone, smart phone)
_____ Pre-recorded video or audio ‘program’, visualizations or simulations

3. Can you provide additional information on resources, including books, AV or computer programs, that you depend upon in these classes?

4. Can you identify resources you need for these classes but do not have access to?

Appendix G. Survey of teachers of Earth science, ESS, space science and astronomy, page 2.

5. Who do you depend upon to assist you in providing class content and resources?

	0-do not depend upon			very dependent upon=3
District or school administration	0	1	2	3
Teachers within your district	0	1	2	3
Teachers outside of your district	0	1	2	3
Teachers outside of your district	0	1	2	3
Colleges or other educational institutions	0	1	2	3
Colleges or other educational institutions	0	1	2	3
Museums or professional organizations	0	1	2	3
Subject matter experts in the community	0	1	2	3
Subject matter experts found on the internet	0	1	2	3
Grants from governments or corporations	0	1	2	3

6. Can you identify organizations, institutions, people or places you depend upon for your classes?

7. Are there institutions, people or places you would like to have access to but don't, for your classes?

Part B. Your personal background

1. How many years have you taught?

	0-4	5-8	9-12	13-16	17 or more
Total number of years teaching	__	__	__	__	__
Earth science	__	__	__	__	__
Earth and space science	__	__	__	__	__
Space science	__	__	__	__	__
Astronomy	__	__	__	__	__
Physical science (physics, chemistry)	__	__	__	__	__
Life sciences	__	__	__	__	__
Technology or engineering	__	__	__	__	__
Mathematics	__	__	__	__	__

2. _____ Total number of years teaching

3. Other subjects you have taught: _______________

Appendix G. Survey of teachers of Earth science, ESS, space science and astronomy, page 3.

4. Number of subjects you currently teach	1	2	3	4	5
5. Number of individual preparations	1	2	3	4	5

6. Subjects you currently teach

_____ Earth science

_____ Earth and space science

_____ Space science

_____ Astronomy

_____ Physical science (physics, chemistry)

_____ Life sciences

_____ Technology or engineering

_____ Mathematics

_____ Other: ______________

7. Grades you currently teach

_____ K-5, elementary

_____ 6-8, Middle

_____ 9-10, freshman-sophomore

_____11-12, junior-senior

_____ College

_____ Other: ______________

Appendix G. Survey of teachers of Earth science, ESS, space science and astronomy, page 4.

8. Degrees you have completed

_____ BA

_____ BS

_____ MA

_____ MS

_____ PhD or Dr.

_____ Other: _______________

9. Your major fields of study: _______________

10. What was your most recent training in earth/space science or astronomy?

Check all that apply.

_____ for-credit coursework in the last 1-3 years

_____ for-credit coursework in the last 4-6 years

_____ for-credit coursework in the last 7 years or longer

_____ non-credit training including workshops or professional development within the last 5 years

_____ have never completed training or coursework in these subjects

_____ Other: _______________

Part C. Identify how you would characterize your abilities:

1. I feel my technical/scientific knowledge in the areas of Earth science, space science or astronomy is:

INADEQUATE 1 2 3 4 5 THOROUGH

Appendix G. Survey of teachers of Earth science, ESS, space science and astronomy, page 5.

2. I feel my technical/scientific knowledge in the areas of Earth science, space science or astronomy is:

OUT OF DATE	1	2	3	4	5	CURRENT

3. I feel my knowledge of instructional methods in Earth science, space science or astronomy is:

INADEQUATE	1	2	3	4	5	THOROUGH

4. As an instructor or coordinator in the areas of Earth science, space science or astronomy I feel I am:

INADEQUATE	1	2	3	4	5	PREPARED AND KNOWLEDGEABLE

Part D. Professional development:

1. If you had an opportunity to enhance your knowledge in Earth, space science, or astronomy, what would you focus on?
2. What level of interest do you have in professional development

	1=little interest	2=some interest	3=most interest
Face-to-face	1	2	3
Distance learning	1	2	3
1-2 hour program	1	2	3
½ day	1	2	3
1 day	1	2	3
2-3 days	1	2	3
Weekends	1	2	3
Week or longer	1	2	3
During summer or school breaks	1	2	3
College courses for college credit	1	2	3

Appendix G. Survey of teachers of Earth science, ESS, space science and astronomy, page 6.

3. Are there specific considerations for your participation in professional development? Examples:
   Cost-you will only take advantage of professional development that is free
   Location-you will only take professional development that is near-by, remote
   Time- you will only take professional development that is during school breaks or other
   Credit- you will only take professional development that provides academic credit, continuing credit

YES	NO	Would you be willing to be interviewed about the subject of this survey?
YES	NO	Are you interested in the results of this survey?
YES	NO	Would you be interested in joining an on-line community to discuss resources and experience pertaining to ESS or astronomy education?

M F Your gender?

Contact information – please provide the following information; if you wish to remain anonymous please do not include your name, email or phone.

Your name: ___________________________________

School: ___________________________________

District: ___________________________________

Email: ___________________________________

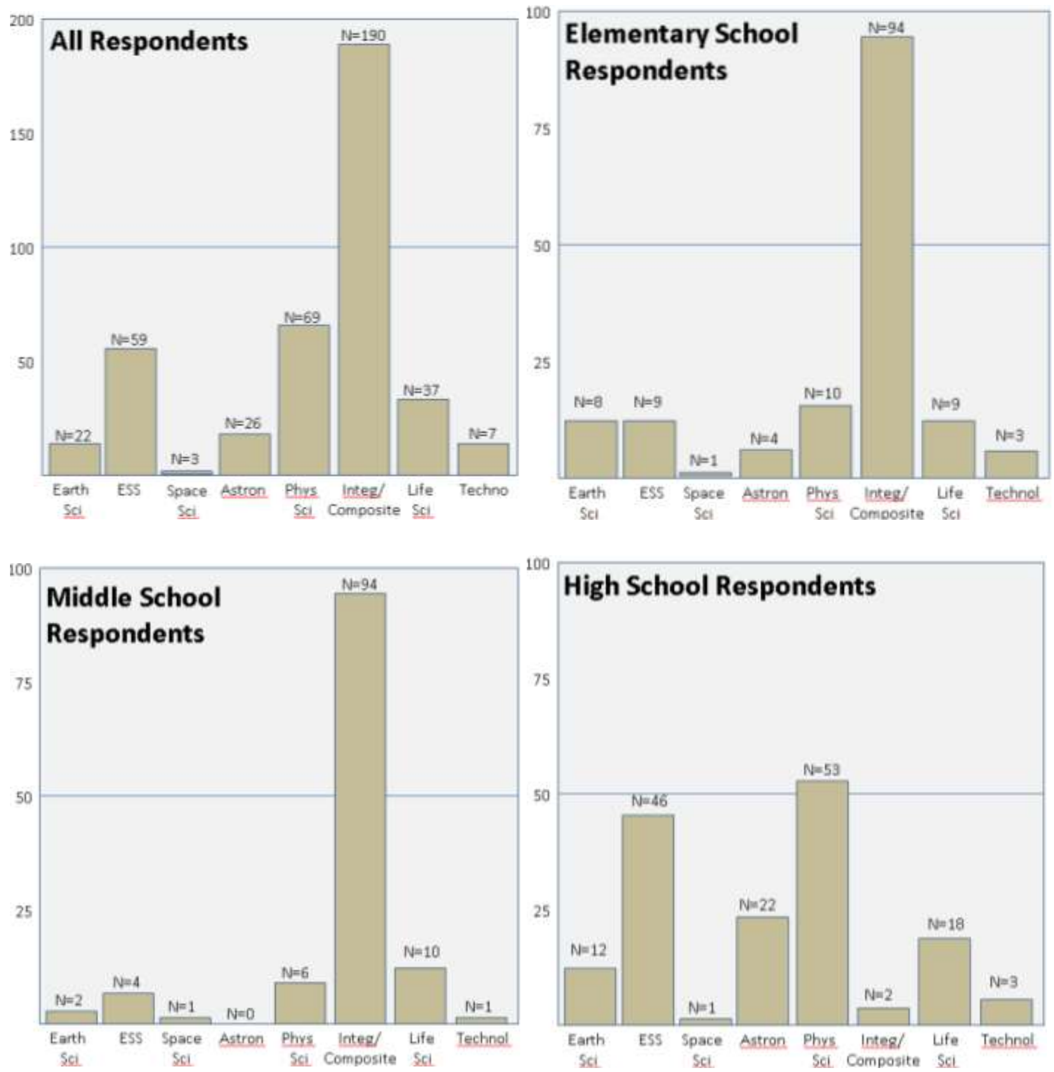
Phone: ___________________________________

Appendix G. Survey of teachers of Earth science, ESS, space science and astronomy, page 7.

APPENDIX H.

ILLUSTRATION OF THE NUMBER OF RESPONDENTS TEACHING EACH SUBJECT.

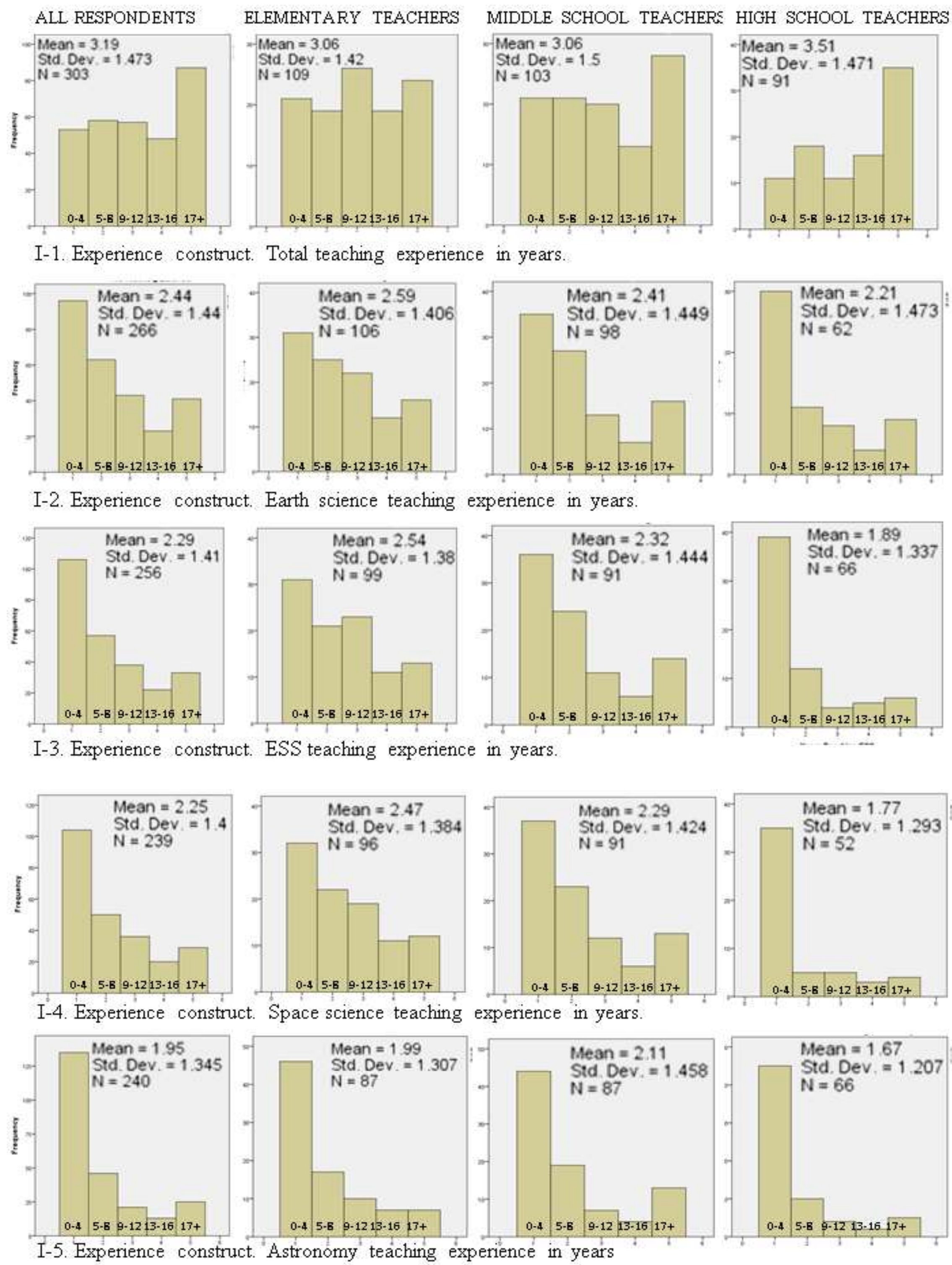
DATA IS PROVIDED FOR ALL RESPONDENTS AND BY GRADE LEVEL.



APPENDIX H. Illustration of the number of respondents teaching each subject. Data is provided for all respondents and by grade level.

APPENDIX I.

THE EXPERIENCE CONSTRUCT. DESCRIPTIVE STATISTICS FOR TEACHING EXPERIENCE TOTAL AND FOR INDIVIDUAL GRADE LEVELS



Appendix I. The Teacher Experience Construct. Descriptive Statistics. For teaching experience total, individual grade levels and individual subject areas.

APPENDIX J.

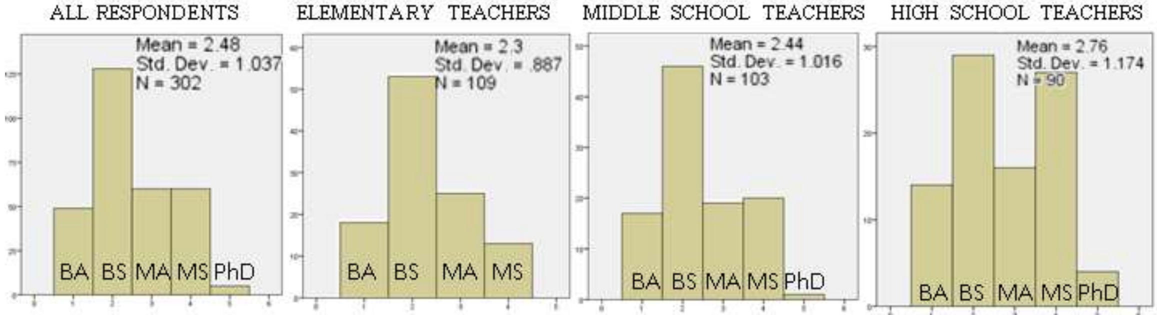
THE TEACHER EDUCATION CONSTRUCT.

DESCRIPTIVE STATISTICS FOR

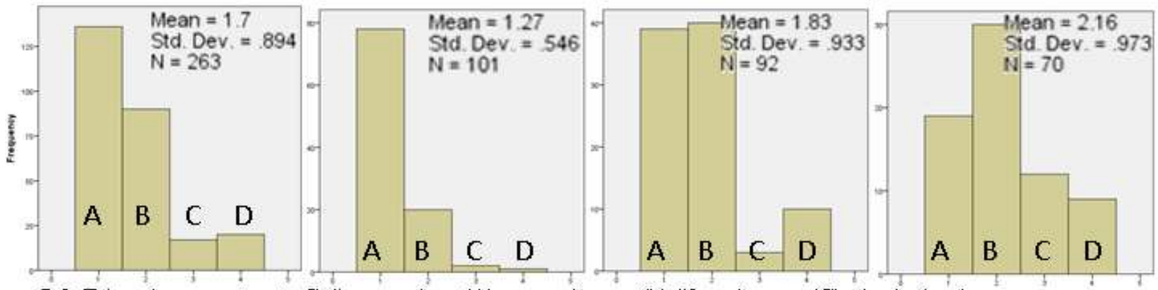
TEACHER EDUCATION

BY

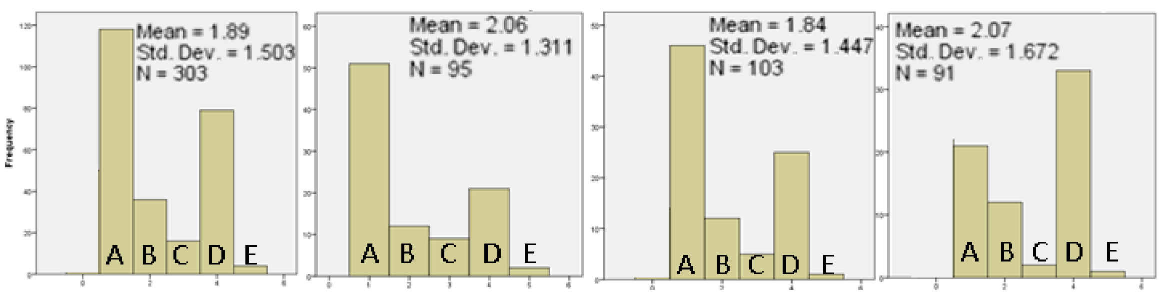
DEGREE, MAJOR AND MOST RECENT TRAINING



J-1. Education construct. Highest degree earned.



J-2. Education construct. College major: (A) non-science, (b) life-science, (C) physical-science, (D) ESS-associated sciences.

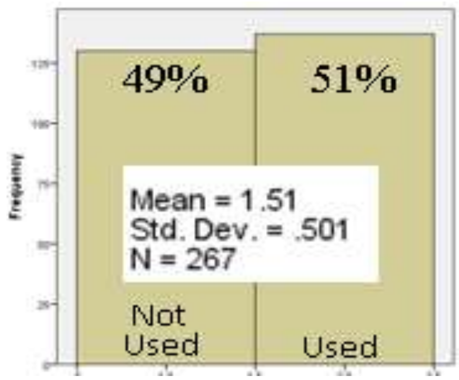


J-3. Education construct. Most Recent Training in ESS areas: (A) have never completed any training in ESS subjects; (B) not-for-credit training in last 5 years; (C) for-credit courses in last 7 years or longer; (D) for-credit courses in last 4-6 years; (E) for-credit courses in the last 3 years.

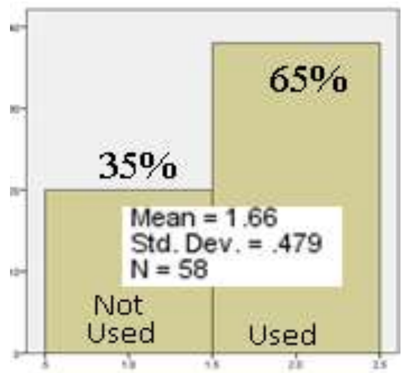
Appendix J. The Teacher Education Construct. Descriptive statistics for teaching education by degree, major and most recent training.

APPENDIX K.

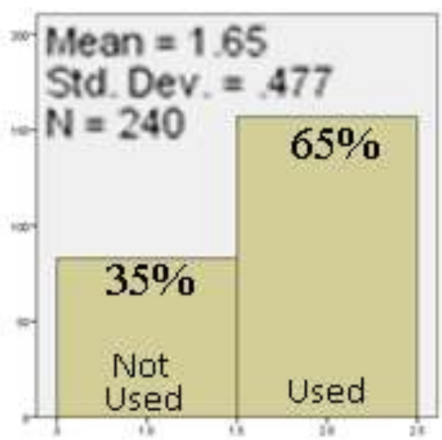
THE RESOURCES CONSTRUCT. DESCRIPTIVE STATISTICS FOR RESOURCES USE FOR ALL RESPONDENTS AND FOR INDIVIDUAL GRADES AND COURSES



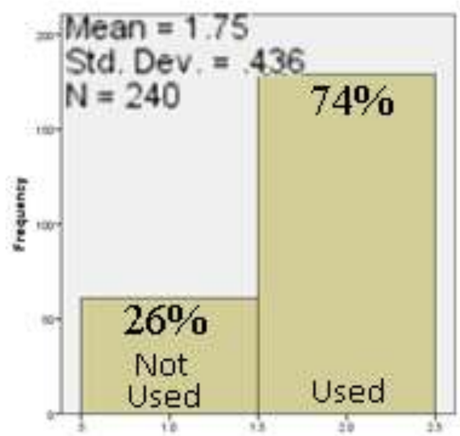
K-1A. Average textbook use for all space science subjects, all grade levels.



K-1B. High-school astronomy textbook use was somewhat higher

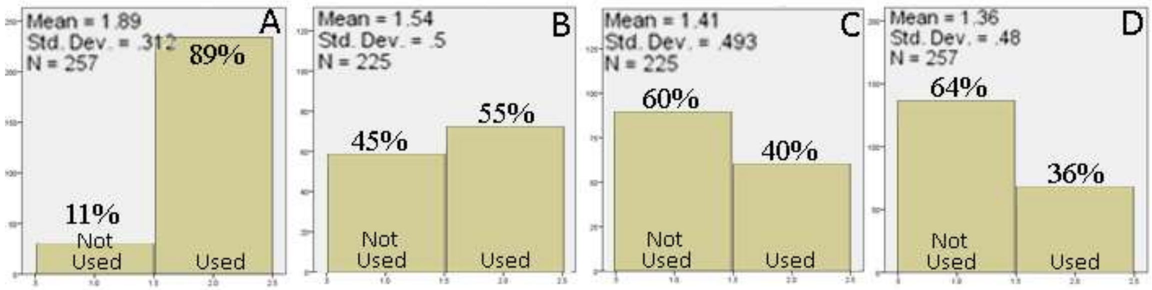


K-2A. Average use of written materials other than texts for all subjects, all grade levels.

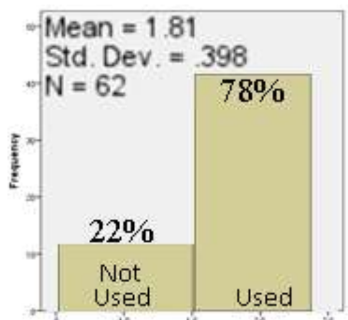


K-2B. Average use of worksheets for all subjects, all grade levels.

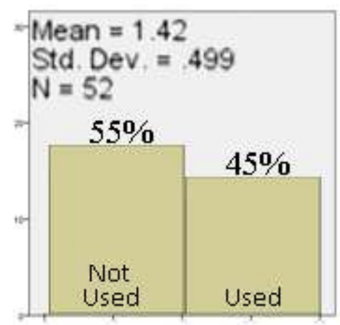
Appendix K. The Resources Construct. Descriptive statistics for resources use for all respondents and for individual grades and courses, page 1.



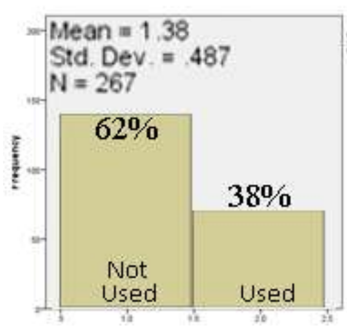
K-3. Average computer use for all subjects, all grade levels.
A. use in classroom by teachers; B. use in classroom by students;
C. use out of the classroom by teachers; D. use out of the classroom by students.



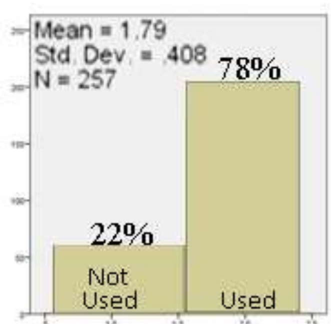
K-3E. Average high-school in classroom computer use by teachers.



K-3F. Average high-school in classroom computer use by students.



K-4A. Average digital media use for all subjects, all grade levels.



K-4B. Average pre-recorded media program use for all subjects, all grade levels.

Appendix K. The resources construct. Descriptive statistics for resources use for all respondents and for individual grades and courses, page 2.

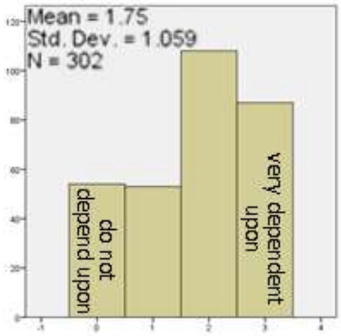
APPENDIX L.

THE COMMUNITY SUPPORT CONSTRUCT. DESCRIPTIVE STATISTICS

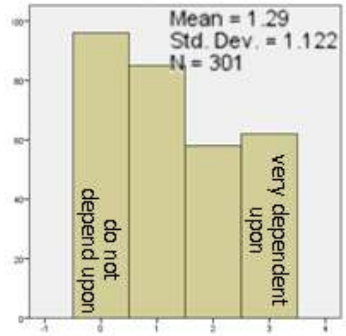
FOR

RESOURCES USE FOR ALL RESPONDENTS AND FOR INDIVIDUAL

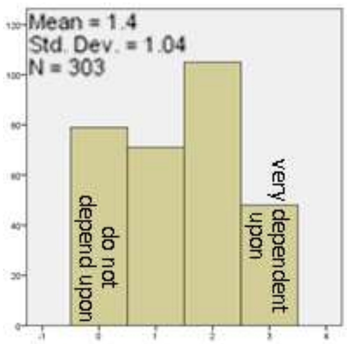
GRADES AND COURSES.



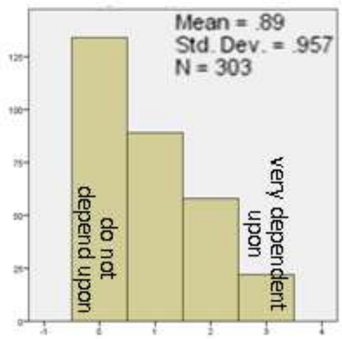
L-1. Reliance on the internet.
All respondents.



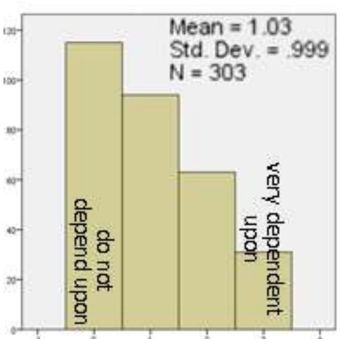
L-2. Reliance on administration.
All respondents.



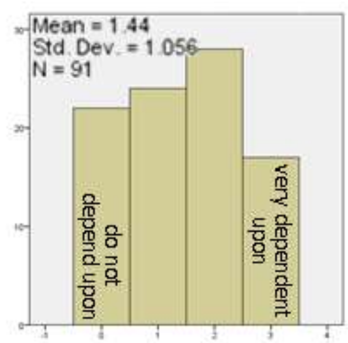
L-3. Reliance on teachers
within your district.
All respondents.



L-4. Reliance on teachers
outside of your district.
All respondents.

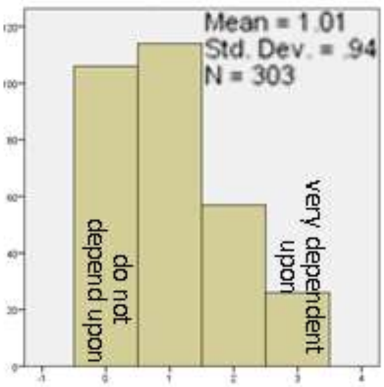


L-5. Community support construct.
Reliance on colleges and formal
educational institutions.
All respondents.

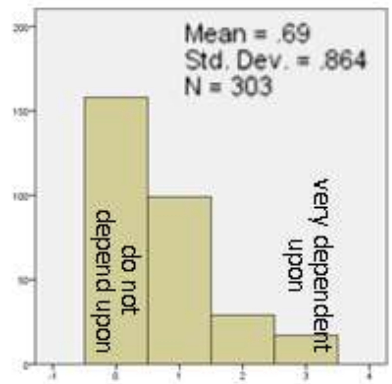


L-6. Community support construct.
Reliance on colleges and formal
educational institutions.
High-school teachers.

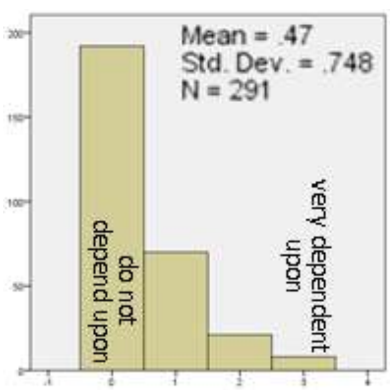
Appendix L. Community support construct descriptive statistics. Page 1.



L-7. Community support construct.
Reliance on museums and informal educational institutions.
All respondents.



L-8. Community support construct.
Reliance on subject matter experts in the community.
All respondents.



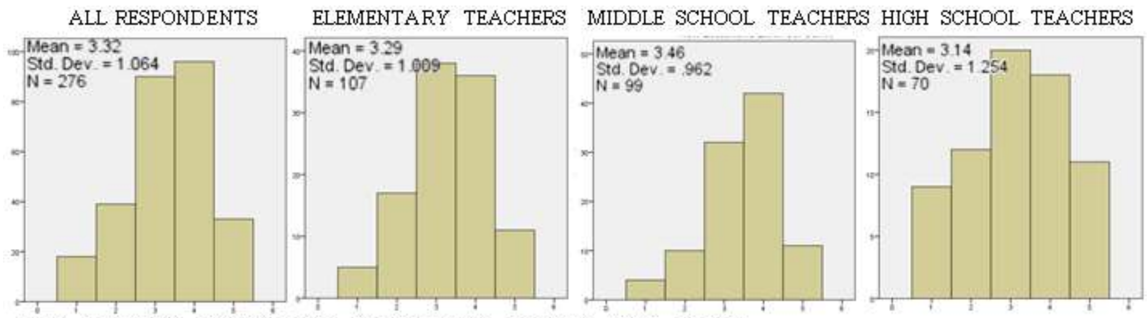
L-9. Community support construct.
Reliance on grants.
All respondents.

Appendix L. Community support construct descriptive statistics. Page 2.

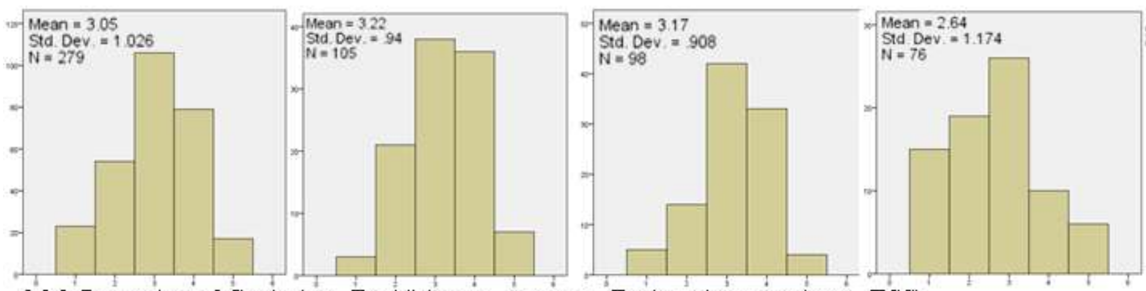
APPENDIX M.

THE CURRICULUM ESTABLISHMENT CONSTRUCT. DESCRIPTIVE STATISTICS FOR

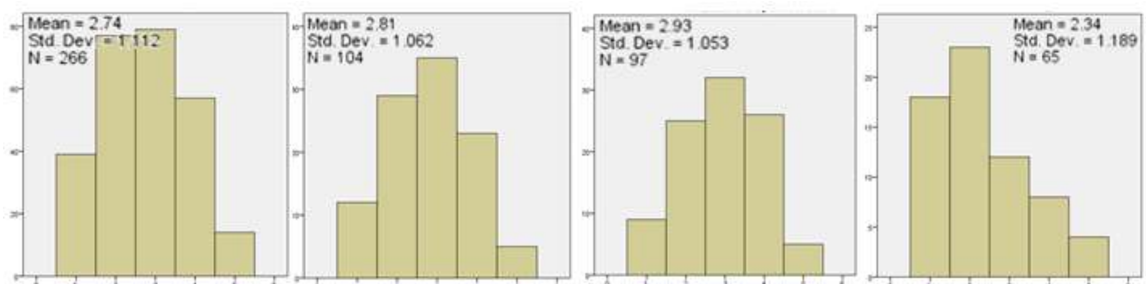
TEACHERS' PERCEPTION OF CURRICULUM ESTABLISHMENT FOR INDIVIDUAL SUBJECTS AREAS.



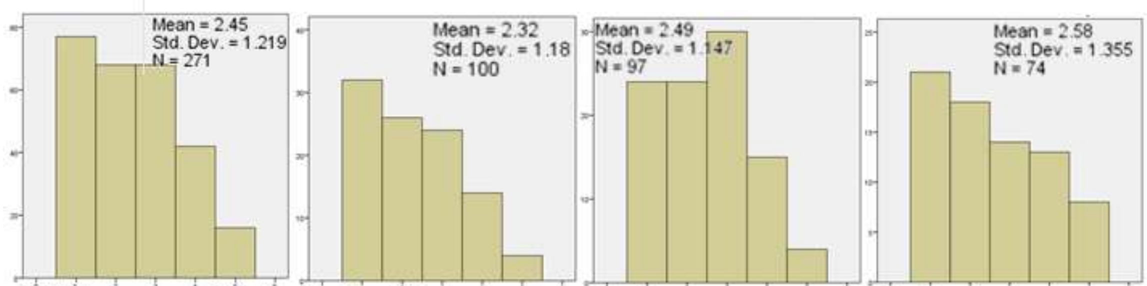
M-1. Perception of Curriculum Establishment construct. Earth science.



M-2. Perception of Curriculum Establishment construct. Earth and space science (ESS).



M-3. Perception of Curriculum Establishment construct. Space science.



M-4. Perception of Curriculum Establishment construct. Astronomy.

Perceived curriculum establishment for Earth science, ESS, space science and astronomy, Rated on a five point scale from (1) least established to (5) most established.

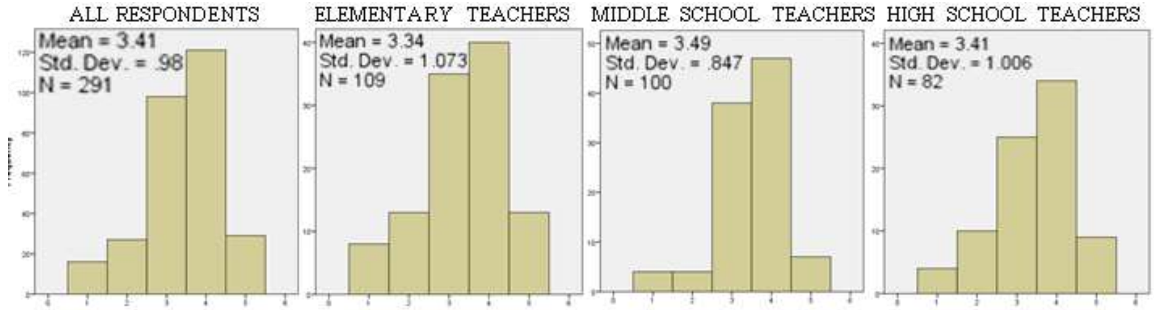
Appendix M. The Curriculum Establishment Construct. Descriptive statistics for teachers' perception of curriculum establishment for individual subjects areas.

APPENDIX N.

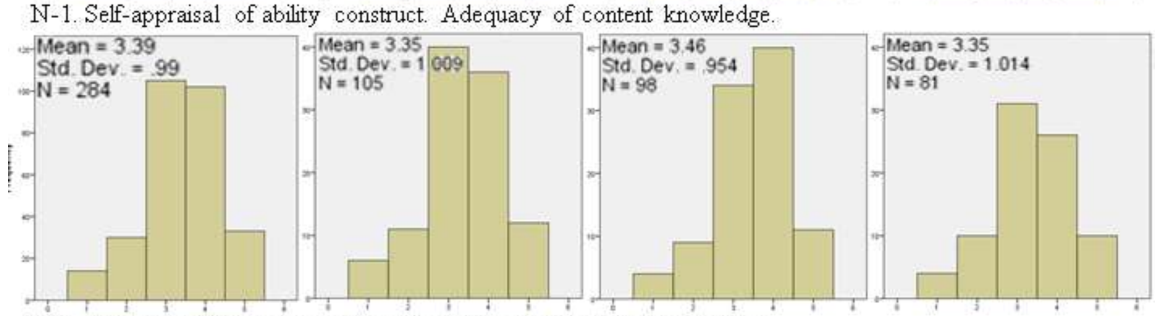
THE TEACHER ABILITY CONSTRUCT. DESCRIPTIVE STATISTICS FOR

TEACHER SELF-APPRAISAL OF ABILITY

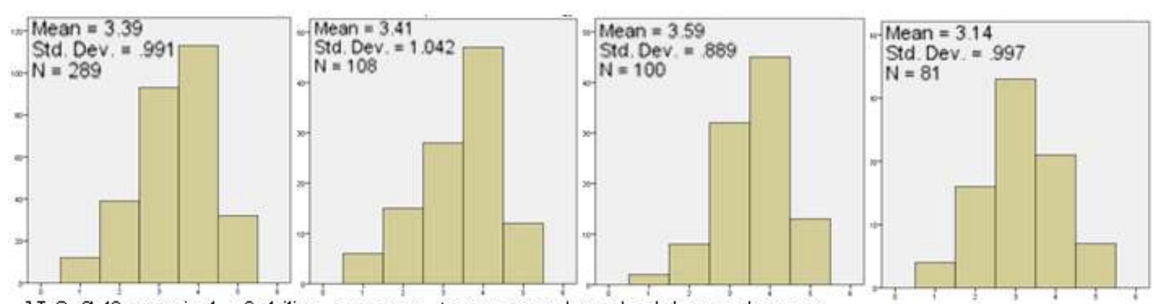
FOR ALL RESPONDENTS AND BY GRADE LEVEL.



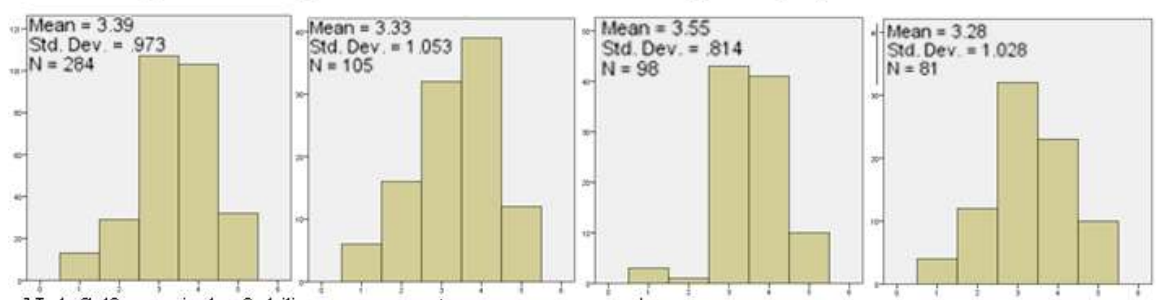
N-1. Self-appraisal of ability construct. Adequacy of content knowledge.



N-2. Self-appraisal of ability construct. Currency of subject knowledge.



N-3. Self-appraisal of ability construct. Instructional methodology adequacy.



N-4. Self-appraisal of ability construct. Instructor preparedness.

Appendix N. Teacher Ability Construct. Descriptive statistics for individual ability parameters.

Rated on a five point scale from (1) least able/inadequate to (5) most able/adequate. Page 1.

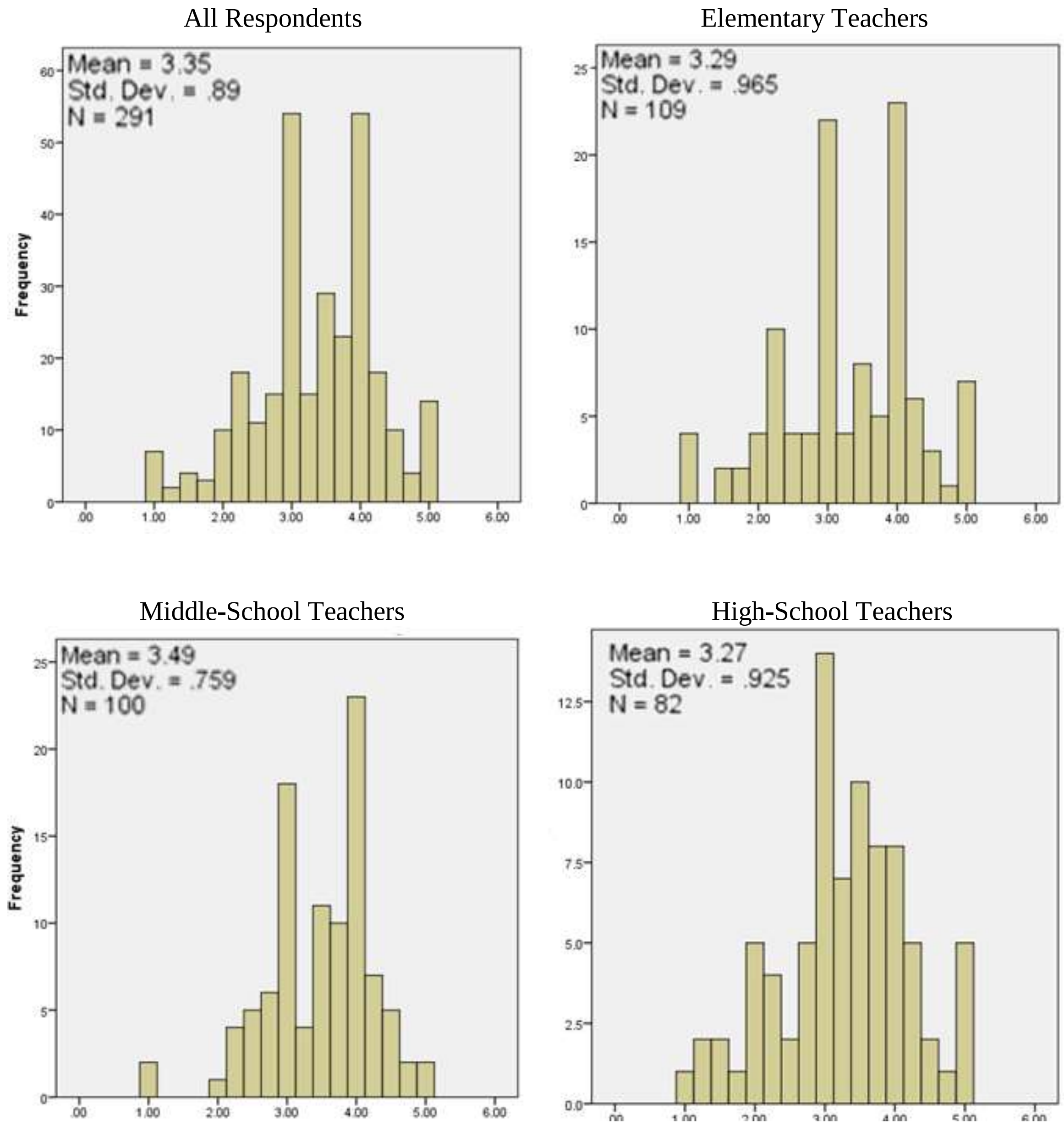


Figure N-5. Ability Average.

Histograms reflecting the averages of each self-appraised ability rating level
Values: **1**= inadequate**, 2=**minimally adequate, **3=**moderately adequate,
4= somewhat adequate **5**= thoroughly adequate

Appendix N. Ability construct for ability average. Rated on a five point scale. Page 2.

APPENDIX O.

PREDICTORS OF ABILITY AVERAGE BASED ON REGRESSIONS AGAINST FIVE CONSTRUCTS

Highly Significant Predictors (sig $\leq$ .01)

Elementary teachers	**Middle-school Teachers**	**High-school Teachers**
Experience		
		Teaching astronomy
Education		
Not-for-credit training		
Community		
District/administration support		Support of distant teachers
Internet accessibility		Support of colleges
Support from grants		Support from grants
Curriculum		
ESS curriculum	Space Science curriculum	ESS curriculum
Resources		
Space science worksheets		Astronomy digital media
Astronomy pre-record programs		ESS pre-recorded programs
Space science computers for teachers in & out classroom		

Significant Predictors (sig $\leq$ .05)

Elementary teachers	**Middle-school Teachers**	**High-school Teachers**
No significant predictors	Total years teaching experience	Teaching experience: life science
	Teaching experience, all subjects	Degree in education

Appendix O: Predictors of Ability Average, summary based on regressions against five constructs (Ability Average is an average of Ability Content, Currency, Methodology and Preparedness; it has been considered the dependent variable in the regression).

APPENDIX P

MULTIPLE REGRESSIONS

ALL RESPONDENTS

MULTIPLE REGRESSIONS
INDEPENDENT VARIABLES

A. EXPERIENCE
1. Total Years Teaching
2. Years Teaching Earth Science
3. Years Teaching ESS
4. Years Teaching Space Science
5. Years Teaching Astronomy
6. Years Teaching Physical Sci
7. Years Teaching Life Sci
8. Years Teaching Tech/Enginr
9. Years Teaching Math

B. EDUCATION
1. Highest Degree Earned
2. Major
3. Education Degree
4. Most Recent Training
5. Not for Credit Training

C. COMMUNITY SUPPORT
1. District/Administration
2. Local Teachers
3. Distant Teachers
4. Colleges and Educational Institutions (formal education)
5. Museums or Professional Organizations (informal education)
6. Community Subject Matter Experts
7. Internet
8. Grants (government or corporate)

D. CURRICULUM
1. Earth Science
2. ESS
3. Space Science
4. Astronomy

E. RESOURCES
1. Textbook
2. Written Content
3. Worksheets
4. Computers
5. Digital Media
6. Prerecorded programs

DEPENDENT VARIABLE
TEACHER ABILITY CONSTRUCT

1. Ability Average
2. Subject Knowledge
3. Knowledge Currency
4. Instructional Methodology Knowledge
5. Instructor Preparedness

APPENDIX P. All Respondents Multiple Regressions. Page 2

Independent Variable: A. **EXPERIENCE** **ALL RESPONDENTS**
Dependent Variable: 1. **ABILITY AVERAGE**
Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

Model:	Variables Entered
1.	Yrs Teaching Astronomy
2.	Yrs Teaching Life Sci
3.	Yrs Teaching ESS

All requested variables entered.

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.250[a]	.063	.059	.84613	.063	20.078	1	301	.000
2	.289[b]	.083	.077	.83811	.021	6.786	1	300	.010
3	.343[c]	.118	.109	.82369	.034	11.600	1	299	.001

a. Predictors: (Constant), Yrs Teaching Astronomy
b. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci
c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci, Years Teaching ESS
d. Dependent Variable: ABILITY AVG

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.375	1	14.375	20.078	.000[b]
	Residual	215.498	301	.716		
	Total	229.872	302			
2	Regression	19.142	2	9.571	13.625	.000[c]
	Residual	210.731	300	.702		
	Total	229.872	302			
3	Regression	27.012	3	9.004	13.271	.000[d]
	Residual	202.861	299	.678		
	Total	229.872	302			

a. Dependent Variable: ABILITY AVG
b. Predictors: (Constant), Yrs Teaching Astronomy
c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci
d. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci, Years Teaching ESS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.996	.093		32.241	.000		
	Yrs Teaching Astronomy	.182	.041	.250	4.481	.000	1.000	1.000
2	(Constant)	3.143	.108		29.105	.000		
	Yrs Teaching Astronomy	.238	.046	.326	5.217	.000	.783	1.278
	Yrs Teaching Life Sci	-.099	.038	-.163	-2.605	.010	.783	1.278
3	(Constant)	3.091	.107		28.829	.000		
	Yrs Teaching Astronomy	.133	.054	.182	2.448	.015	.532	1.880
	Yrs Teaching Life Sci	-.181	.044	-.296	-4.066	.000	.556	1.797
	Years Teaching ESS	.203	.059	.301	3.406	.001	.378	2.644

a. Dependent Variable: ABILITY AVG

There was a moderate positive correlation between
ABILITY AND EXPERIENCE
Model 1 (r=.250, N= 302) R^2 = .063, F (1, 301) =20.078, P=.000, <.01 (highly significant)
Model 2 (r=.289, N= 302) R^2 = .083, F (2, 300) =13.625, P=.000, <.01 (highly significant)
Model 3 (r=.343, N= 302) R^2 = .118, F (3, 299) =13.271, P=.000, <.01 (highly significant)
Models 1,2,3 are highly predictive

Appendix P. All Respondents Multiple Regressions, Page 3

Independent Variable: A. **EXPERIENCE** **ALL RESPONDENTS**
Dependent Variable: 2. **ABILITY SUBJECT CONTENT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered
1. Yrs Teaching ESS
2. Yrs Teaching Life Sci
All requested variables entered.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.229[a]	.052	.049	.936	.052	16.587	1	301	.000
2	.289[b]	.083	.077	.923	.031	10.158	1	300	.002

a. Predictors: (Constant), Years Teaching ESS
b. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci
c. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.546	1	14.546	16.587	.000[b]
	Residual	263.969	301	.877		
	Total	278.515	302			
2	Regression	23.191	2	11.596	13.625	.000[c]
	Residual	255.324	300	.851		
	Total	278.515	302			

a. Dependent Variable: Adequacy in Knowlege of Subject
b. Predictors: (Constant), Years Teaching ESS
c. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.024	.109		27.619	.000		
	Years Teaching ESS	.169	.042	.229	4.073	.000	1.000	1.000
2	(Constant)	3.164	.116		27.173	.000		
	Years Teaching ESS	.286	.055	.386	5.207	.000	.557	1.797
	Yrs Teaching Life Sci	-.159	.050	-.236	-3.187	.002	.557	1.797

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate positive correlation between
ABILITY AND EXPERIENCE

Model 1 (r=.229, N= 302) R^2 = .052, F (1, 301) =16.587, P=.000, <.01 (highly significant)
Model 2 (r=.289, N= 302) R^2 = .083, F (2, 300) =113.625, P=.000, <.01 (highly significant)

Models 1,2 are highly predictive

Appendix P. All Respondents Multiple Regressions, Page 4

Independent Variable: A. **EXPERIENCE** **ALL RESPONDENTS**
Dependent Variable: 3. **ABILITY SUBJECT KNOWLEDGE CURRENCY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.225[a]	.051	.048	.935	.051	16.119	1	301	.000
2	.283[b]	.080	.074	.922	.029	9.564	1	300	.002
3	.329[c]	.108	.099	.909	.028	9.482	1	299	.002

a. Predictors: (Constant), Yrs Teaching Astronomy
b. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci
c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci, Yrs Teaching Space Sci
d. Dependent Variable: How Current Knowledge of Subject

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.099	1	14.099	16.119	.000[b]
	Residual	263.295	301	.875		
	Total	277.394	302			
2	Regression	22.234	2	11.117	13.070	.000[c]
	Residual	255.161	300	.851		
	Total	277.394	302			
3	Regression	30.077	3	10.026	12.121	.000[d]
	Residual	247.318	299	.827		
	Total	277.394	302			

a. Dependent Variable: How Current Knowledge of Subject
b. Predictors: (Constant), Yrs Teaching Astronomy
c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci
d. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci, Yrs Teaching Space Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.036	.103		29.560	.000		
	Yrs Teaching Astronomy	.181	.045	.225	4.015	.000	1.000	1.000
2	(Constant)	3.228	.119		27.167	.000		
	Yrs Teaching Astronomy	.253	.050	.316	5.044	.000	.783	1.278
	Yrs Teaching Life Sci	-.130	.042	-.194	-3.093	.002	.783	1.278
3	(Constant)	3.164	.119		26.587	.000		
	Yrs Teaching Astronomy	.134	.063	.167	2.127	.034	.485	2.062
	Yrs Teaching Life Sci	-.201	.047	-.300	-4.243	.000	.595	1.682
	Yrs Teaching Space Sci	.214	.069	.277	3.079	.002	.369	2.713

a. Dependent Variable: How Current Knowledge of Subject

There was a moderate positive correlation between
ABILITY AND EXPERIENCE

Model 1 (r=.225, N= 302) R^2 = .051, F (1, 301) =16.119, P=.000, <.01 (highly significant)
Model 2 (r=.283, N= 302) R^2 = .080, F (2, 300) =13.070, P=.000, <.01 (highly significant)
Model 3 (r=.329, N= 302) R^2 = .108, F (2, 299) =12.121, P=.000, <.01 (highly significant)

Models 1,2,3 are highly predictive

Independent Variable: A. **EXPERIENCE** **ALL RESPONDENTS**

Dependent Variable: 4. **ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.248[a]	.062	.058	.939	.062	19.739	1	301	.000
2	.290[b]	.084	.078	.930	.022	7.313	1	300	.007

a. Predictors: (Constant), Yrs Teaching Space Sci

b. Predictors: (Constant), Yrs Teaching Space Sci, Yrs Teaching Life Sci

c. Dependent Variable: How Adequate Instructional Methodolgy

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.418	1	17.418	19.739	.000[b]
	Residual	265.613	301	.882		
	Total	283.031	302			
2	Regression	23.738	2	11.869	13.733	.000[c]
	Residual	259.293	300	.864		
	Total	283.031	302			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), Yrs Teaching Space Sci

c. Predictors: (Constant), Yrs Teaching Space Sci, Yrs Teaching Life Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.960	.112		26.517	.000		
	Yrs Teaching Space Sci	.193	.043	.248	4.443	.000	1.000	1.000
2	(Constant)	3.081	.119		25.856	.000		
	Yrs Teaching Space Sci	.289	.056	.371	5.184	.000	.595	1.681
	Yrs Teaching Life Sci	-.131	.048	-.194	-2.704	.007	.595	1.681

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak positive correlation between
ABILITY INSTRUCTIONAL METHODOLOGY and EXPERIENCE

Model 1 (r =.248, N= 302) R^2 = .062, F (1, 301) =19.739, P=.000, <.01 (highly significant)

Model 2 (r =.290, N= 302) R^2 = .084, F (2, 300) =13.733, P=.000, <.01 (highly significant)

Models 1 and 2 are highly predictive

Independent Variable: A. **EXPERIENCE** **ALL RESPONDENTS**
Dependent Variable: 5. **ABILITY INSTRUCTOR PREPAREDNESS**
Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.245[a]	.060	.057	.915	.060	19.147	1	301	.000
2	.282[b]	.079	.073	.907	.020	6.397	1	300	.012
3	.310[c]	.096	.087	.900	.017	5.488	1	299	.020

a. Predictors: (Constant), Yrs Teaching Astronomy
b. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci
c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci, Yrs Teaching Space Sci
d. Dependent Variable: Self Appraisal of Preparedness as Instructor

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.018	1	16.018	19.147	.000[b]
	Residual	251.813	301	.837		
	Total	267.831	302			
2	Regression	21.275	2	10.638	12.943	.000[c]
	Residual	246.556	300	.822		
	Total	267.831	302			
3	Regression	25.719	3	8.573	10.587	.000[d]
	Residual	242.112	299	.810		
	Total	267.831	302			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor
b. Predictors: (Constant), Yrs Teaching Astronomy
c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci
d. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci, Yrs Teaching Space Sci

Coefficients[a]

Model		Unstandardized Coefficients: B	Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	VIF
1	(Constant)	3.020	.100		30.066	.000		
	Yrs Teaching Astronomy	.192	.044	.245	4.376	.000	1.000	1.000
2	(Constant)	3.174	.117		27.177	.000		
	Yrs Teaching Astronomy	.251	.049	.318	5.085	.000	.783	1.278
	Yrs Teaching Life Sci	-.104	.041	-.158	-2.529	.012	.783	1.278
3	(Constant)	3.126	.118		26.549	.000		
	Yrs Teaching Astronomy	.161	.062	.204	2.588	.010	.485	2.062
	Yrs Teaching Life Sci	-.158	.047	-.240	-3.369	.001	.595	1.682
	Yrs Teaching Space Sci	.161	.069	.212	2.343	.020	.369	2.713

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak positive correlation between
ABILITY INSTRUCTOR PREPAREDNESS and EXPERIENCE
Model 1 (r =.245, N= 302) R^2 = .060, F (1, 301) =19.147, P=.000, <.01 (highly significant)
Model 2 (r =.282, N= 302) R^2 = .079, F (2, 300) =12.943, P=.000, <.01 (highly significant)
Model 3 (r =.310, N= 302) R^2 = .096, F (2, 299) =10.587, P=.000, <.01 (highly significant)
Models 1,2,3 are highly predictive

Independent Variable: B. **EDUCATION** **ALL RESPONDENTS**
Dependent Variable: 1. **ABILITY AVERAGE**
Method: Enter
Model: Variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.171[a]	.029	.013	.86675	.029	1.797	5	297	.113

a. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

b. Dependent Variable: ABILITY AVG

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.748	5	1.350	1.797	.113[b]
	Residual	223.124	297	.751		
	Total	229.872	302			

a. Dependent Variable: ABILITY AVG

b. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.882	.247		11.664	.000		
	Highest Degree Earned	-.025	.049	-.030	-.510	.610	.952	1.051
	Major	.086	.063	.082	1.352	.177	.893	1.120
	Education Training	.110	.115	.057	.957	.339	.906	1.104
	Most Recent Training	.073	.033	.125	2.169	.031	.985	1.015
	NonCredTraining in Last 5 years	.156	.103	.088	1.524	.129	.972	1.028

a. Dependent Variable: ABILITY AVG

There was a weak positive correlation between
ABILITY AVERAGE and EDUCATION
Model 1 (r=.171, N= 302) R^2 = .029, F (5, 297) =4.797, P=.113, >.05 (not significant)
The model not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix P. All Respondents Multiple Regressions, Page 8

Independent Variable: B. **Education** **ALL RESPONDENTS**
Dependent Variable: 2. **ABILITY SUBJECT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.191[a]	.036	.033	.944	.036	11.352	1	301	.001
2	.243[b]	.059	.053	.935	.023	7.241	1	300	.008
3	.269[c]	.072	.063	.930	.013	4.228	1	299	.041

a. Predictors: (Constant), Most Recent Training
b. Predictors: (Constant), Most Recent Training, Major
c. Predictors: (Constant), Most Recent Training, Major, NonCredTraining in Last 5 years
d. Dependent Variable: Adequacy in Knowlege of Subject

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.122	1	10.122	11.352	.001[b]
	Residual	268.393	301	.892		
	Total	278.515	302			
2	Regression	16.448	2	8.224	9.414	.000[c]
	Residual	262.068	300	.874		
	Total	278.515	302			
3	Regression	20.102	3	6.701	7.753	.000[d]
	Residual	258.414	299	.864		
	Total	278.515	302			

a. Dependent Variable: Adequacy in Knowlege of Subject
b. Predictors: (Constant), Most Recent Training
c. Predictors: (Constant), Most Recent Training, Major
d. Predictors: (Constant), Most Recent Training, Major, NonCredTraining in Last 5 years

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	(Constant)	3.182	.087		36.423	.000		
	Most Recent Training	.122	.036	.191	3.369	.001	1.000	1.000
2	(Constant)	2.881	.141		20.412	.000		
	Most Recent Training	.124	.036	.195	3.472	.001	.999	1.001
	Major	.174	.065	.151	2.691	.008	.999	1.001
3	(Constant)	2.760	.152		18.108	.000		
	Most Recent Training	.132	.036	.206	3.686	.000	.989	1.012
	Major	.160	.065	.138	2.470	.014	.988	1.012
	NonCredTraining in Last 5 years	.226	.110	.116	2.056	.041	.977	1.023

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a weak to moderate positive correlation between
ABILITY SUBJECT KNOWLEDGE and EDUCATION
Model 1 (r=.191, N= 302) R^2 = .036, F (1, 301) =11.352, P<.01, (highly significant)
Model 2 (r=.243, N= 302) R^2 = .059, F (2, 300) =9.414, P<.01, (highly significant)
Model 3 (r=.269, N= 302) R^2 = .072, F (3, 299) =7.753, P<.01, (highly significant)
Models 1,2,3 are highly predictive

Appendix P. All Respondents Multiple Regressions, Page 9

Independent Variable: B. **Education** **ALL RESPONDENTS**
Dependent Variable: 3. **ABILITY KNOWLEDGE CURRENCY**

Method: ENTER

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.100[a]	.010	-.007	.962	.010	.606	5	297	.696

a. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

b. Dependent Variable: How Current Knowledge of Subject

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.800	5	.560	.606	.696[b]
	Residual	274.594	297	.925		
	Total	277.394	302			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.159	.274		11.525	.000		
	Highest Degree Earned	-.006	.055	-.007	-.118	.906	.952	1.051
	Major	.024	.070	.021	.340	.734	.893	1.120
	Education Training	.040	.128	.019	.316	.752	.906	1.104
	Most Recent Training	.062	.037	.097	1.674	.095	.985	1.015
	NonCredTraining in Last 5 years	.049	.114	.025	.431	.667	.972	1.028

a. Dependent Variable: How Current Knowledge of Subject

There was a weak, not significant correlation between ABILITY KNOWLEDGE CURRENCY and EDUCATION

Model 1 (r=.100, N= 302) R^2 = .010, F (5, 297) =.606, P=.696, >.05 (not significant)

Model is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: B. **EDUCATION** **ALL RESPONDENTS**
Dependent Variable: 4. **ABILITY INSTRUCTIONAL METHODOLOGY**

Method: ENTER

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.109[a]	.012	-.005	.970	.012	.720	5	297	.609

a. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

b. Dependent Variable: How Adequate Instructional Methodolgy

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.388	5	.678	.720	.609[b]
	Residual	279.644	297	.942		
	Total	283.031	302			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.056	.277		11.048	.000		
	Highest Degree Earned	-.007	.055	-.008	-.130	.897	.952	1.051
	Major	.032	.071	.028	.457	.648	.893	1.120
	Education Training	.101	.129	.048	.786	.433	.906	1.104
	Most Recent Training	.029	.037	.045	.777	.438	.985	1.015
	NonCredTraining in Last 5 years	.174	.115	.089	1.518	.130	.972	1.028

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak, not significant correlation between
ABILITY INSTRUCTIONAL METHODOLOGY and EDUCATION

Model 1 (r =.109, N= 302) R^2 = .019, F (5, 297) =.720, P=.609, >.05 (not significant)

Model is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: B. **EDUCATION** **ALL RESPONDENTS**
Dependent Variable: 5. **ABILITY INSTRUCTOR PREPAREDNESS**

Method: ENTER

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.122[a]	.015	-.002	.943	.015	.900	5	297	.482

a. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.996	5	.799	.900	.482[b]
	Residual	263.835	297	.888		
	Total	267.831	302			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Most Recent Training, Highest Degree Earned, Major

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.146	.269		11.709	.000		
	Highest Degree Earned	-.031	.054	-.034	-.582	.561	.952	1.051
	Major	.060	.069	.053	.872	.384	.893	1.120
	Education Training	.031	.125	.015	.249	.803	.906	1.104
	Most Recent Training	.045	.036	.072	1.243	.215	.985	1.015
	NonCredTraining in Last 5 years	.161	.112	.084	1.439	.151	.972	1.028

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak, not significant correlation between ABILITY INSTRUCTOR PREPAREDNESS and EDUCATION

Model 1 (r =. 122, N= 302) R^2 = .015, F (5, 297) =.900, P=.482, >.05 (not significant)

Model is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: C. **COMMUNITY** **ALL RESPONDENTS**
Dependent Variable: 1. **ABILITY AVERAGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.129[a]	.017	.013	.86665	.017	5.058	1	301	.025

a. Predictors: (Constant), Degree of Support from Museums

b. Dependent Variable: ABILITY AVG

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.799	1	3.799	5.058	.025[b]
	Residual	226.074	301	.751		
	Total	229.872	302			

a. Dependent Variable: ABILITY AVG

b. Predictors: (Constant), Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.230	.073		44.168	.000		
	Degree of Support from Museums	.119	.053	.129	2.249	.025	1.000	1.000

a. Dependent Variable: ABILITY AVG

There was a weak positive correlation between ABILITY AVERAGE and COMMUNITY

Model 1 (r=.129, N= 302) R^2 = .017, F (1, 301) =5.058, P=.025, <.05 (significant)

Models is predictive

Independent Variable: C. **COMMUNITY** **ALL RESPONDENTS**
Dependent Variable: 2. **ABILITY SUBJECT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.154[a]	.024	.020	.950	.024	7.312	1	301	.007

a. Predictors: (Constant), Degree of Support from Coleges

b. Dependent Variable: Adequacy in Knowlege of Subject

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.605	1	6.605	7.312	.007[b]
	Residual	271.910	301	.903		
	Total	278.515	302			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Degree of Support from Coleges

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.260	.079		41.474	.000		
	Degree of Support from Coleges	.148	.055	.154	2.704	.007	1.000	1.000

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a weak positive correlation between
ABILITY SUBJECT KNOWLEDGE and COMMUNITY

Model 1 (r=.154, N= 302) Model 1: R^2 = .024, F (1, 301) =7.312, P=.007, <.01 (highly significant)

Models is predictive

Appendix P. All Respondents Multiple Regressions, Page 14

Independent Variable: C. **COMMUNITY** **ALL RESPONDENTS**
Dependent Variable: 3. **ABILITY KNOWLEDGE CURRENCY**

Method: ENTER

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.167[a]	.028	.001	.958	.028	1.052	8	294	.397

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Internet SME, Degree of Support from District, Degree of Support from Teachers Out of Dist, Degree of Support from Community SME, Degree of Support from Coleges, Degree of Support from Museums

b. Dependent Variable: How Current Knowledge of Subject

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.722	8	.965	1.052	.397[b]
	Residual	269.672	294	.917		
	Total	277.394	302			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Internet SME, Degree of Support from District, Degree of Support from Teachers Out of Dist, Degree of Support from Community SME, Degree of Support from Coleges, Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.385	.137		24.635	.000		
	Degree of Support from District	-.015	.053	-.018	-.285	.776	.879	1.138
	Degree of Support from Local Teachers	-.023	.056	-.025	-.411	.681	.879	1.137
	Degree of Support from Teachers Out of Dist	-.080	.066	-.080	-1.207	.229	.759	1.318
	Degree of Support from Coleges	.062	.067	.065	.923	.357	.673	1.485
	Degree of Support from Museums	.104	.075	.102	1.378	.169	.608	1.645
	Degree of Support from Community SME	.029	.077	.026	.373	.710	.681	1.468
	Degree of Support from Internet SME	-.057	.060	-.063	-.963	.336	.764	1.310
	Degree of Support from Grants	.081	.083	.062	.968	.334	.813	1.231

a. Dependent Variable: How Current Knowledge of Subject

There was a weak, not significant correlation between
ABILITY KNOWLEDGE CURRENCY AND COMMUNITY

Model 1 (r=.167, N= 302) R^2 = .028, F (8, 294) =1.052, P=.397, >.05 (not significant)

Model is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: C. **COMMUNITY** **ALL RESPONDENTS**
Dependent Variable: 4. **ABILITY INSTRUCTIONAL METHODOLOGY**

Method: ENTER

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.119[a]	.014	-.013	.974	.014	.532	8	294	.832

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Internet SME, Degree of Support from District, Degree of Support from Teachers Out of Dist, Degree of Support from Community SME, Degree of Support from Coleges, Degree of Support from Museums

b. Dependent Variable: How Adequate Instructional Methodolgy

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.039	8	.505	.532	.832[b]
	Residual	278.993	294	.949		
	Total	283.031	302			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Internet SME, Degree of Support from District, Degree of Support from Teachers Out of Dist, Degree of Support from Community SME, Degree of Support from Coleges, Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.324	.140		23.781	.000		
	Degree of Support from District	.009	.053	.011	.171	.864	.879	1.138
	Degree of Support from Local Teachers	-.017	.057	-.018	-.291	.771	.879	1.137
	Degree of Support from Teachers Out of Dist	.014	.067	.014	.209	.835	.759	1.318
	Degree of Support from Coleges	-.075	.068	-.077	-1.095	.275	.673	1.485
	Degree of Support from Museums	.120	.076	.116	1.563	.119	.608	1.645
	Degree of Support from Community SME	-.002	.079	-.002	-.022	.983	.681	1.468
	Degree of Support from Internet SME	.005	.061	.006	.090	.928	.764	1.310
	Degree of Support from Grants	.039	.085	.029	.455	.649	.813	1.231

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak, not significant correlation between
ABILITY INSTRUCTIONAL METHODOLOGY AND COMMUNITY

Model 1 (r=. 119, N= 302) R^2 = .014, F (8, 294) =..532, P=.832, >.05 (not significant)

Model is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix P. All Respondents Multiple Regressions, Page 16

Independent Variable: C. **COMMUNITY** **ALL RESPONDENTS**
Dependent Variable: 5. **ABILITY INSTRUCTOR PREPAREDNESS**

Method: ENTER

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.138[a]	.019	-.008	.945	.019	.712	8	294	.681

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Internet SME, Degree of Support from District, Degree of Support from Teachers Out of Dist, Degree of Support from Community SME, Degree of Support from Coleges, Degree of Support from Museums

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.087	8	.636	.712	.681[b]
	Residual	262.744	294	.894		
	Total	267.831	302			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Internet SME, Degree of Support from District, Degree of Support from Teachers Out of Dist, Degree of Support from Community SME, Degree of Support from Coleges, Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.374	.136		24.874	.000		
	Degree of Support from District	-.023	.052	-.027	-.435	.664	.879	1.138
	Degree of Support from Local Teachers	-.060	.056	-.066	-1.068	.286	.879	1.137
	Degree of Support from Teachers Out of Dist	-.013	.065	-.013	-.202	.840	.759	1.318
	Degree of Support from Coleges	-.037	.066	-.039	-.560	.576	.673	1.485
	Degree of Support from Museums	.079	.074	.079	1.060	.290	.608	1.645
	Degree of Support from Community SME	-.022	.076	-.020	-.292	.770	.681	1.468
	Degree of Support from Internet SME	.046	.059	.051	.777	.438	.764	1.310
	Degree of Support from Grants	.083	.082	.065	1.007	.315	.813	1.231

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a moderate but non-significant correlation between ABILITY INSTRUCTOR PREPAREDNESS and COMMUNITY Support

Model 1 (r=. 138, N= 302) R^2 = .019, F (8,294) =.712, P=.681, >.05 (not significant)

Model is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: **D. CURRICULUM** **ALL RESPONDENTS**
Dependent Variable: **1. ABILITY AVERAGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.286[a]	.082	.079	.84581	.082	26.322	1	295	.000

a. Predictors: (Constant), How Establishd ESS Curric

b. Dependent Variable: ABILITY AVG

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.831	1	18.831	26.322	.000[b]
	Residual	211.041	295	.715		
	Total	229.872	296			

a. Dependent Variable: ABILITY AVG

b. Predictors: (Constant), How Establishd ESS Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.577	.158		16.262	.000		
	How Establishd ESS Curric	.254	.049	.286	5.131	.000	1.000	1.000

a. Dependent Variable: ABILITY AVG

There was a moderate, significant correlation between ABILITY AVERAGE and CURRICULUM

Model 1 (r=. 286, N= 296) Model 1: R^2 = .082, F (1, 295) =26.322, P=.000, <.01 (highly significant)

Model is highly predictive

Appendix P. All Respondents Multiple Regressions, Page 18

Independent Variable: **D. CURRICULUM** **ALL RESPONDENTS**
Dependent Variable: **2. ABILITY SUBJECT CONTENT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Requested Variables Entered

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.226[a]	.051	.048	.947	.051	15.835	1	295	.000
2	.258[b]	.067	.060	.940	.016	4.940	1	294	.027

a. Predictors: (Constant), How Establishd Astronomy Curric

b. Predictors: (Constant), How Establishd Astronomy Curric, How Establishd Earth Sci Curric

c. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.189	1	14.189	15.835	.000[b]
	Residual	264.327	295	.896		
	Total	278.515	296			
2	Regression	18.556	2	9.278	10.493	.000[c]
	Residual	259.959	294	.884		
	Total	278.515	296			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), How Establishd Astronomy Curric

c. Predictors: (Constant), How Establishd Astronomy Curric, How Establishd Earth Sci Curric

Coefficients[a]

Model		Unstandardized Coefficients: B	Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	VIF
1	(Constant)	2.951	.128		22.996	.000		
	How Establishd Astronomy Curric	.188	.047	.226	3.979	.000	1.000	1.000
2	(Constant)	2.647	.187		14.156	.000		
	How Establishd Astronomy Curric	.125	.055	.150	2.285	.023	.734	1.362
	How Establishd Earth Sci Curric	.138	.062	.146	2.223	.027	.734	1.362

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a weak, not significant correlation between
ABILITY SUBJECT CONTENT KNOWLEDGE and CURRICULUM

Model 1 (r=.226, N= 296) Model 1: R^2 = .051, F (1, 295) =15.835, P=.000, <.01 (highly significant)
Model 2 (r=.258, N= 296) Model 1: R^2 = .067, F (2, 294) =10.493, P=.000, <.01 (highly significant)

Models 1,2 are predictive

Appendix P. All Respondents Multiple Regressions, Page 19

Independent Variable: **D. CURRICULUM** **ALL RESPONDENTS**
Dependent Variable: **3. ABILITY KNOWLEDGE CURRENCY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.272[a]	.074	.071	.933	.074	23.627	1	295	.000

a. Predictors: (Constant), How Establishd Space Sci Curric

b. Dependent Variable: How Current Knowledge of Subject

All requested variables entered.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.569	1	20.569	23.627	.000[b]
	Residual	256.825	295	.871		
	Total	277.394	296			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), How Establishd Space Sci Curric

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	2.702	.151		17.876	.000		
	How Establishd Space Sci Curric	.251	.052	.272	4.861	.000	1.000	1.000

a. Dependent Variable: How Current Knowledge of Subject

There was a weak, not significant correlation between
ABILITY KNOWLEDGE CURRENCY and CURRICULUM

Model 1 (r=. 272, N= 296) R^2 = .074, F (1, 295) =23.627, P=.000, (highly significant)

Models 1 is highly predictive

Appendix P. All Respondents Multiple Regressions, Page 20

Independent Variable: **D. CURRICULUM** **ALL RESPONDENTS**
Dependent Variable: **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables Variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.281[a]	.079	.076	.940	.079	25.293	1	295	.000

a. Predictors: (Constant), How Establishd ESS Curric

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.350	1	22.350	25.293	.000[b]
	Residual	260.681	295	.884		
	Total	283.031	296			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), How Establishd ESS Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.552	.176		14.489	.000		
	How Establishd ESS Curric	.276	.055	.281	5.029	.000	1.000	1.000

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak to moderate significant correlation between ABILITY INSTRUCTIONAL METHODOLOGY and CURRICULUM

Model 1 (r=. 281, N= 296) R^2 = .079, F (1, 296) =25.293, P=.000, <.01 (highly significant)

Models 1 is highly predictive

Appendix P. All Respondents Multiple Regressions, Page 21

Independent Variable: **D. CURRICULUM** **ALL RESPONDENTS**
Dependent Variable: **4. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested Variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.239[a]	.057	.054	.925	.057	17.902	1	295	.000

a. Predictors: (Constant), How Establishd Space Sci Curric

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.323	1	15.323	17.902	.000[b]
	Residual	252.507	295	.856		
	Total	267.831	296			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), How Establishd Space Sci Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.802	.150		18.702	.000		
	How Establishd Space Sci Curric	.216	.051	.239	4.231	.000	1.000	1.000

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak, not significant correlation between
ABILITY INSTRUCTOR PREPAREDNESS and CURRICULUM

Model 1 (r=.239, N=296) R^2 = .057, F (1, 295) =17.902, P=.000, <.01 (highly significant)

Models 1 is highly predictive

Independent Variable: **E. RESOURCES** **ALL RESPONDENTS**
Dependent Variable: **1. ABILITY AVERAGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested Variables Entered

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.228[a]	.052	.049	.85948	.052	16.182	1	295	.000
2	.302[b]	.091	.085	.84305	.039	12.608	1	294	.000
3	.327[c]	.107	.098	.83718	.016	5.139	1	293	.024
4	.346[d]	.120	.107	.83254	.013	4.275	1	292	.040

a. Predictors: (Constant), Astro Digital
b. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs
c. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, SS Recorded
d. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, SS Recorded, SpaceSci Inside Comp Students
e. Dependent Variable: ABILITY AVG

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.954	1	11.954	16.182	.000[b]
	Residual	217.918	295	.739		
	Total	229.872	296			
2	Regression	20.915	2	10.458	14.714	.000[c]
	Residual	208.957	294	.711		
	Total	229.872	296			
3	Regression	24.517	3	8.172	11.660	.000[d]
	Residual	205.356	293	.701		
	Total	229.872	296			
4	Regression	27.480	4	6.870	9.911	.000[e]
	Residual	202.393	292	.693		
	Total	229.872	296			

a. Dependent Variable: ABILITY AVG
b. Predictors: (Constant), Astro Digital
c. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs
d. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, SS Recorded
e. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, SS Recorded, SpaceSci Inside Comp Students

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.695	.170		15.811	.000		
	Astro Digital	.474	.118	.228	4.023	.000	1.000	1.000
2	(Constant)	2.219	.214		10.356	.000		
	Astro Digital	.417	.117	.200	3.567	.000	.981	1.020
	SpaceSci Outside Comp Tchrs	.401	.113	.199	3.551	.000	.981	1.020
3	(Constant)	1.786	.286		6.242	.000		
	Astro Digital	.380	.117	.183	3.243	.001	.962	1.040
	SpaceSci Outside Comp Tchrs	.367	.113	.183	3.248	.001	.964	1.038
	SS Recorded	.295	.130	.128	2.267	.024	.959	1.043
4	(Constant)	1.542	.308		5.007	.000		
	Astro Digital	.367	.117	.177	3.148	.002	.959	1.043
	SpaceSci Outside Comp Tchrs	.328	.114	.163	2.878	.004	.937	1.067
	SS Recorded	.277	.130	.120	2.135	.034	.954	1.048
	SpaceSci Inside Comp Students	.227	.110	.116	2.068	.040	.958	1.044

a. Dependent Variable: ABILITY AVG

There was a moderate, highly significant correlation between ABILITY AVERAGE and Resources

Model 1 (r=. 228, N= 296) R^2 = .052, F (1, 295) =16.182, P=.000, <.01 (highly significant)
Model 2 (r=. 302, N= 296) R^2 = .091, F (2, 294) =14.714, P=.000, <.01 (highly significant)
Model 3 (r=.327, N= 296) R^2 = .107, F (2, 293) =11.660, P=.000, <.01 (highly significant)
Model 4 (r=.346, N= 296) R^2 = .120, F (2, 292) =9.911, P=.000, <.01 (highly significant)

Models 1,2,3,4 are highly predictive

Independent Variable: **E. RESOURCES** **ALL RESPONDENTS**
Dependent Variable: **2. ABILITY CONTENT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested Variables Entered

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.188[a]	.035	.032	.954	.035	10.776	1	295	.001
2	.237[b]	.056	.050	.946	.021	6.496	1	294	.011
3	.264[c]	.070	.060	.940	.014	4.337	1	293	.038

a. Predictors: (Constant), Astro Digital

b. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs

c. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, SpaceSci Recorded

d. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.816	1	9.816	10.776	.001[b]
	Residual	268.700	295	.911		
	Total	278.515	296			
2	Regression	15.624	2	7.812	8.736	.000[c]
	Residual	262.892	294	.894		
	Total	278.515	296			
3	Regression	19.458	3	6.486	7.336	.000[d]
	Residual	259.057	293	.884		
	Total	278.515	296			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Astro Digital

c. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs

d. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, SpaceSci Recorded

Coefficients[a]

Model		Unstandardized Coefficients: B	Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	VIF
1	(Constant)	2.818	.189		14.891	.000		
	Astro Digital	.430	.131	.188	3.283	.001	1.000	1.000
2	(Constant)	2.435	.240		10.132	.000		
	Astro Digital	.383	.131	.167	2.926	.004	.981	1.020
	SpaceSci Outside Comp Tchrs	.322	.127	.146	2.549	.011	.981	1.020
3	(Constant)	2.008	.315		6.372	.000		
	Astro Digital	.355	.131	.155	2.711	.007	.970	1.031
	SpaceSci Outside Comp Tchrs	.280	.127	.126	2.193	.029	.955	1.047
	SpaceSci Recorded	.300	.144	.120	2.082	.038	.959	1.043

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate, significant correlation between
ABILITY CONTENT KNOWLEDGE & RESOURCES
Model 1 (r=.188, N= 296) R^2 = .035, F (1, 295) =10.776, P=.000, <.01 (highly significant)
Model 2 (r=.237, N= 296) R^2 = .056, F (2,294) =8.736, P=.806, <.01 (highly significant)
Model 3 (r=.264, N= 296) R^2 = .070, F (3, 293) =7.336, P=.806, , <.01 (highly significant)

Models 1,2,3 are highly predictive

Independent Variable: **E. RESOURCES** **ALL RESPONDENTS**
Dependent Variable: **3. ABILITY KNOWLEDGE CURRENCY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested Variables Entered

Model Summary[f]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.250[a]	.063	.059	.939	.063	19.701	1	295	.000
2	.305[b]	.093	.087	.925	.030	9.810	1	294	.002
3	.340[c]	.116	.107	.915	.023	7.540	1	293	.006
4	.360[d]	.130	.118	.909	.014	4.700	1	292	.031
5	.377[e]	.142	.127	.904	.013	4.244	1	291	.040

a. Predictors: (Constant), Astro Digital

b. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs

c. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, EarthSci Recorded

d. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, EarthSci Recorded, EarthSci Digital

e. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, EarthSci Recorded, EarthSci Digital, SS Inside Comp Teachers

f. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.366	1	17.366	19.701	.000[b]
	Residual	260.029	295	.881		
	Total	277.394	296			
2	Regression	25.762	2	12.881	15.050	.000[c]
	Residual	251.633	294	.856		
	Total	277.394	296			
3	Regression	32.074	3	10.691	12.769	.000[d]
	Residual	245.320	293	.837		
	Total	277.394	296			
4	Regression	35.960	4	8.990	10.873	.000[e]
	Residual	241.434	292	.827		
	Total	277.394	296			
5	Regression	39.430	5	7.886	9.644	.000[f]
	Residual	237.964	291	.818		
	Total	277.394	296			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), Astro Digital

c. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs

d. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, EarthSci Recorded

e. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, EarthSci Recorded, EarthSci Digital

f. Predictors: (Constant), Astro Digital, SpaceSci Outside Comp Tchrs, EarthSci Recorded, EarthSci Digital, SS Inside Comp Teachers

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.597	.186		13.949	.000		
	Astro Digital	.572	.129	.250	4.439	.000	1.000	1.000
2	(Constant)	2.136	.235		9.086	.000		
	Astro Digital	.516	.128	.226	4.024	.000	.981	1.020
	SpaceSci Outside Comp Tchrs	.388	.124	.176	3.132	.002	.981	1.020
3	(Constant)	1.544	.317		4.865	.000		
	Astro Digital	.471	.128	.206	3.684	.000	.965	1.037
	SpaceSci Outside Comp Tchrs	.356	.123	.161	2.895	.004	.972	1.029
	EarthSci Recorded	.390	.142	.153	2.746	.006	.971	1.029
4	(Constant)	1.653	.319		5.177	.000		
	Astro Digital	.702	.166	.307	4.234	.000	.567	1.764
	SpaceSci Outside Comp Tchrs	.375	.123	.170	3.063	.002	.967	1.034
	EarthSci Recorded	.394	.141	.154	2.788	.006	.971	1.030
	EarthSci Digital	-.340	.157	-.157	-2.168	.031	.570	1.754
5	(Constant)	1.070	.425		2.517	.012		
	Astro Digital	.714	.165	.312	4.330	.000	.566	1.767
	SpaceSci Outside Comp Tchrs	.331	.124	.150	2.676	.008	.938	1.066
	EarthSci Recorded	.352	.142	.138	2.479	.014	.951	1.051
	EarthSci Digital	-.388	.158	-.179	-2.464	.014	.557	1.794
	SS Inside Comp Teachers	.404	.196	.117	2.060	.040	.907	1.102

a. Dependent Variable: How Current Knowledge of Subject

There was a moderate, significant correlation between ABILITY CONTENT KNOWLEDGE & RESOURCES

Model 1 (r=.250, N= 296) R^2 = .063, F (1, 295) = 19.701, P=.000, <.01 (highly significant)
Model 2 (r=.305, N= 296) R^2 = .093, F (2, 294) = 15.050, P=.000, <.01 (highly significant)
Model 3 (r=.340, N= 296) R^2 = .116, F (3, 293) = 12.769, P=.000, <.01 (highly significant)
Model 4 (r=.360, N= 296) R^2 = .130, F (4, 292) = 10.873, P=.000, <.01 (highly significant)
Model 5 (r=.377, N= 296) R^2 = .142, F (5, 291) = 9.644, P=.000, <.01 (highly significant)

Models 1,2,3, 4, 5 are highly predictive

Independent Variable: **E. RESOURCES** **ALL RESPONDENTS**
Dependent Variable: **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested Variables Entered

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.213[a]	.046	.042	.957	.046	14.072	1	295	.000
2	.262[b]	.068	.062	.947	.023	7.231	1	294	.008
3	.290[c]	.084	.075	.941	.016	5.070	1	293	.025
4	.311[d]	.097	.085	.936	.013	4.114	1	292	.043

a. Predictors: (Constant), SpaceSci Outside Comp Tchrs
b. Predictors: (Constant), SpaceSci Outside Comp Tchrs, SpaceSci Inside Comp Students
c. Predictors: (Constant), SpaceSci Outside Comp Tchrs, SpaceSci Inside Comp Students, SS Outside Comp Teachers
d. Predictors: (Constant), SpaceSci Outside Comp Tchrs, SpaceSci Inside Comp Students, SS Outside Comp Teachers, Astro Digital
e. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.886	1	12.886	14.072	.000[b]
	Residual	270.145	295	.916		
	Total	283.031	296			
2	Regression	19.371	2	9.686	10.800	.000[c]
	Residual	263.660	294	.897		
	Total	283.031	296			
3	Regression	23.855	3	7.952	8.990	.000[d]
	Residual	259.176	293	.885		
	Total	283.031	296			
4	Regression	27.456	4	6.864	7.842	.000[e]
	Residual	255.575	292	.875		
	Total	283.031	296			

a. Dependent Variable: How Adequate Instructional Methodolgy
b. Predictors: (Constant), SpaceSci Outside Comp Tchrs
c. Predictors: (Constant), SpaceSci Outside Comp Tchrs, SpaceSci Inside Comp Students
d. Predictors: (Constant), SpaceSci Outside Comp Tchrs, SpaceSci Inside Comp Students, SS Outside Comp Teachers
e. Predictors: (Constant), SpaceSci Outside Comp Tchrs, SpaceSci Inside Comp Students, SS Outside Comp Teachers, Astro Digital

Appendix P. All Respondents Multiple Regressions, Page 28

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.735	.184		14.823	.000		
	SpaceSci Outside Comp Tchrs	.476	.127	.213	3.751	.000	1.000	1.000
2	(Constant)	2.310	.241		9.573	.000		
	SpaceSci Outside Comp Tchrs	.412	.128	.185	3.228	.001	.966	1.035
	SpaceSci Inside Comp Students	.335	.125	.154	2.689	.008	.966	1.035
3	(Constant)	2.358	.241		9.800	.000		
	SpaceSci Outside Comp Tchrs	.802	.215	.360	3.737	.000	.337	2.964
	SpaceSci Inside Comp Students	.374	.125	.172	2.994	.003	.947	1.056
	SS Outside Comp Teachers	-.457	.203	-.219	-2.252	.025	.331	3.022
4	(Constant)	2.063	.280		7.363	.000		
	SpaceSci Outside Comp Tchrs	.770	.214	.345	3.596	.000	.336	2.981
	SpaceSci Inside Comp Students	.359	.125	.165	2.880	.004	.944	1.060
	SS Outside Comp Teachers	-.457	.202	-.219	-2.265	.024	.331	3.022
	Astro Digital	.263	.130	.114	2.028	.043	.977	1.024

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak, not significant correlation between
ABILITY INSTRUCTIONAL METHODOLOGY and RESOURCES

Model 1 (r=.213, N= 296) R^2 = .046, F (1,295) =14.072, P=.000, <.01 (highly significant)
Model 2 (r=.262, N= 296) R^2 = .068, F (2,294) =10.880, P=.000, <.01 (highly significant)
Model 3 (r=.290, N= 296) R^2 = .084, F (3,293) =8.990, P=.000, <.01 (highly significant)
Model 4 (r=.311, N= 296) R^2 = .097, F (4,292) =7.842, P=.000, <.01 (highly significant)

Models 1, 2, 3, 4 are highly predictive

Appendix P. All Respondents Multiple Regressions, Page 29

Independent Variable: **E. RESOURCES** **ALL RESPONDENTS**
Dependent Variable: **5. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested Variables Entered

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.211[a]	.045	.041	.931	.045	13.810	1	295	.000
2	.273[b]	.075	.068	.918	.030	9.486	1	294	.002
3	.310[c]	.096	.087	.909	.022	7.022	1	293	.008

a. Predictors: (Constant), SpaceSci Outside Comp Tchrs

b. Predictors: (Constant), SpaceSci Outside Comp Tchrs, Astro Digital

c. Predictors: (Constant), SpaceSci Outside Comp Tchrs, Astro Digital, SpaceSci Inside Comp Tchrs

d. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.977	1	11.977	13.810	.000[b]
	Residual	255.854	295	.867		
	Total	267.831	296			
2	Regression	19.974	2	9.987	11.846	.000[c]
	Residual	247.857	294	.843		
	Total	267.831	296			
3	Regression	25.775	3	8.592	10.400	.000[d]
	Residual	242.056	293	.826		
	Total	267.831	296			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), SpaceSci Outside Comp Tchrs

c. Predictors: (Constant), SpaceSci Outside Comp Tchrs, Astro Digital

d. Predictors: (Constant), SpaceSci Outside Comp Tchrs, Astro Digital, SpaceSci Inside Comp Tchrs

Appendix P. All Respondents Multiple Regressions, Page 30

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.758	.180		15.363	.000		
	SpaceSci Outside Comp Tchrs	.459	.123	.211	3.716	.000	1.000	1.000
2	(Constant)	2.290	.233		9.811	.000		
	SpaceSci Outside Comp Tchrs	.406	.123	.187	3.304	.001	.981	1.020
	Astro Digital	.392	.127	.174	3.080	.002	.981	1.020
3	(Constant)	1.465	.388		3.780	.000		
	SpaceSci Outside Comp Tchrs	.349	.123	.161	2.826	.005	.951	1.052
	Astro Digital	.373	.126	.166	2.960	.003	.978	1.023
	SpaceSci Inside Comp Tchrs	.493	.186	.150	2.650	.008	.964	1.038

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a moderate, significant correlation between
ABILITY INSTRUCTOR PREPAREDNESS and RESOURCES

Model 1 (r=.211, N= 296) R^2 = .045, F (1, 295) =13.810, P=.000, <.01 (highly significant)
Model 2 (r=.273, N= 296) R^2 = .075, F (2, 294) =11.846, P=.000, <.01 (highly significant)
Model 3 (r=.310, N= 296) R^2 = .096, F (3, 293) =10.400, P=.000, <.01 (highly significant)

Models 1, 2, 3 are highly predictive

Appendix P. All Respondents Multiple Regressions, Page 31

APPENDIX Q.

MULTIPLE REGRESSIONS

ELEMENTARY-SCHOOL TEACHERS

Independent Variable: A. **EXPERIENCE** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 1. **ABILITY AVERAGE**

Method: ENTER: All variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.356[a]	.127	.048	.94213	.127	1.599	9	99	.126

a. Predictors: (Constant), Yrs Teaching Math, Yrs Teaching Technolgy, Yrs Teaching Astronomy, Yrs Teaching Phys Sci, Years Teaching ESS, Total Years Teaching, Yrs Teaching Space Sci, Yrs Teaching Earth Sci, Yrs Teaching Life Sci

b. Dependent Variable: ABILITY Average

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.773	9	1.419	1.599	.126[b]
	Residual	87.874	99	.888		
	Total	100.647	108			

a. Dependent Variable: ABILITY Average

b. Predictors: (Constant), Yrs Teaching Math, Yrs Teaching Technolgy, Yrs Teaching Astronomy, Yrs Teaching Phys Sci, Years Teaching ESS, Total Years Teaching, Yrs Teaching Space Sci, Yrs Teaching Earth Sci, Yrs Teaching Life Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.205	.247		12.969	.000		
	Total Years Teaching	-.217	.121	-.318	-1.792	.076	.279	3.580
	Yrs Teaching Earth Sci	.403	.213	.579	1.898	.061	.095	10.562
	Years Teaching ESS	-.097	.171	-.132	-.566	.573	.163	6.143
	Yrs Teaching Space Sci	.233	.160	.313	1.452	.150	.190	5.254
	Yrs Teaching Astronomy	.042	.123	.051	.341	.734	.399	2.503
	Yrs Teaching Phys Sci	.179	.122	.243	1.470	.145	.322	3.105
	Yrs Teaching Life Sci	-.395	.213	-.571	-1.857	.066	.093	10.718
	Yrs Teaching Technolgy	-.003	.118	-.003	-.027	.979	.649	1.541
	Yrs Teaching Math	-.036	.114	-.049	-.320	.750	.379	2.641

a. Dependent Variable: ABILITY Average

There non-significant correlation between ABILITY AVERAGE and EXPERIENCE

Model 1 (r=.356, N= 108) R^2 = .127, F (9, 99) = 1.599, p>.05 (not significant)

Model is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix Q. Elementary School Teachers Multiple Regressions, Page 2

Independent Variable: A. **EXPERIENCE** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 2. **ABILITY SUBJECT KNOWLEDGE**
Method: ENTER: All variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.895[a]	.802	.784	1.630	.802	44.931	9	100	.000

a. Predictors: Yrs Teaching Math, Yrs Teaching Technolgy, Yrs Teaching Astronomy, Yrs Teaching Phys Sci, Years Teaching ESS, Total Years Teaching, Yrs Teaching Space Sci, Yrs Teaching Earth Sci, Yrs Teaching Life Sci

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: Adequacy in Knowlege of Subject

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1074.327	9	119.370	44.931	.000[c]
	Residual	265.673	100	2.657		
	Total	1340.000[d]	109			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

c. Predictors: Yrs Teaching Math, Yrs Teaching Technolgy, Yrs Teaching Astronomy, Yrs Teaching Phys Sci, Years Teaching ESS, Total Years Teaching, Yrs Teaching Space Sci, Yrs Teaching Earth Sci, Yrs Teaching Life Sci

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients: B	Unstandardized Coefficients: Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	Collinearity Statistics: VIF
1	Total Years Teaching	.346	.196	.332	1.766	.080	.056	17.851
	Yrs Teaching Earth Sci	.292	.367	.245	.796	.428	.021	47.822
	Years Teaching ESS	.242	.294	.197	.821	.414	.035	28.954
	Yrs Teaching Space Sci	-.030	.276	-.023	-.107	.915	.041	24.333
	Yrs Teaching Astronomy	.277	.211	.182	1.309	.193	.103	9.721
	Yrs Teaching Phys Sci	.201	.210	.156	.958	.341	.075	13.338
	Yrs Teaching Life Sci	-.628	.367	-.535	-1.711	.090	.020	49.325
	Yrs Teaching Technolgy	.479	.194	.266	2.467	.015	.171	5.864
	Yrs Teaching Math	.151	.196	.119	.772	.442	.084	11.923

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

There is a correlation between ABILITY SUBJECT KNOWLEDGE and EXPERIENCE
Model 1 (r=.895, N= 109) R^2 = .802, F (9, 100) = 44.931, p<.01 (highly significant)
Model is predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix Q. Elementary School Teachers Multiple Regressions, Page 3

Independent Variable: A. **EXPERIENCE** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 3**. ABILITY KNOWLEDGE CURRENCY**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[g,h]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.867[a]	.752	.750	1.749	.752	327.197	1	108	.000
2	.885[c]	.783	.779	1.644	.031	15.237	1	107	.000
3	.894[d]	.799	.793	1.588	.016	8.631	1	106	.004
4	.892[e]	.796	.792	1.593	-.003	1.639	1	106	.203
5	.900[f]	.810	.805	1.543	.014	8.023	1	106	.006

a. Predictors: Yrs Teaching Space Sci

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy

d. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy, Total Years Teaching

e. Predictors: Yrs Teaching Technolgy, Total Years Teaching

f. Predictors: Yrs Teaching Technolgy, Total Years Teaching, Yrs Teaching Astronomy

g. Dependent Variable: How Current Knowledge of Subject

h. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1000.659	1	1000.659	327.197	.000[c]
	Residual	330.294	108	3.058		
	Total	1330.954[d]	109			
2	Regression	1041.831	2	520.916	192.783	.000[e]
	Residual	289.123	107	2.702		
	Total	1330.954[d]	109			
3	Regression	1063.600	3	354.533	140.565	.000[f]
	Residual	267.354	106	2.522		
	Total	1330.954[d]	109			
4	Regression	1059.465	2	529.732	208.779	.000[g]
	Residual	271.489	107	2.537		
	Total	1330.954[d]	109			
5	Regression	1078.567	3	359.522	150.996	.000[h]
	Residual	252.387	106	2.381		
	Total	1330.954[d]	109			

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

c. Predictors: Yrs Teaching Space Sci

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy

f. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy, Total Years Teaching

g. Predictors: Yrs Teaching Technolgy, Total Years Teaching

h. Predictors: Yrs Teaching Technolgy, Total Years Teaching, Yrs Teaching Astronomy

Appendix Q. Elementary School Teachers Multiple Regressions, Page 4

Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	Yrs Teaching Space Sci	1.087	.060	.867	18.089	.000	1.000	1.000
2	Yrs Teaching Space Sci	.660	.123	.526	5.357	.000	.210	4.754
	Yrs Teaching Technolgy	.688	.176	.384	3.903	.000	.210	4.754
3	Yrs Teaching Space Sci	.239	.186	.190	1.280	.203	.086	11.657
	Yrs Teaching Technolgy	.636	.171	.354	3.714	.000	.208	4.806
	Total Years Teaching	.399	.136	.384	2.938	.004	.111	9.015
4	Yrs Teaching Technolgy	.742	.150	.414	4.941	.000	.272	3.677
	Total Years Teaching	.532	.087	.513	6.124	.000	.272	3.677
5	Yrs Teaching Technolgy	.529	.164	.295	3.231	.002	.215	4.659
	Total Years Teaching	.381	.100	.367	3.828	.000	.194	5.149
	Yrs Teaching Astronomy	.427	.151	.281	2.832	.006	.182	5.504

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY KNOWLEDGE CURRENCY and EXPERIENCE

Model 1 (r=.867, N= 109) R^2 = .752, F (1, 108) = 327.197, P=.000 (highly significant)
Model 2 (r=.885, N= 109) R^2 = .783, F (2, 107) = 192.783, P=.000 (highly significant)
Model 3 (r=.894, N= 109) R^2 = .799, F (3, 106) = 140.565, P=.000 (highly significant)
Model 4 (r=.892, N= 109) R^2 = .796, F (2,107) = 208.779, P=.000 (highly significant)
Model 5 (r=.900, N= 109) R^2 = .810, F (3, 106) = 150.996, P=.000 (highly significant)

Models 1,2,3,4,5 are highly predictive

Independent Variable: A. **EXPERIENCE ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 4**. ABILITY INSTRUCTIONAL METHODOLOGY**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[g,h]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.873[a]	.763	.760	1.742	.763	347.037	1	108	.000
2	.888[c]	.789	.785	1.651	.026	13.371	1	107	.000
3	.897[d]	.804	.798	1.599	.015	8.069	1	106	.005
4	.894[e]	.799	.795	1.611	-.005	2.621	1	106	.108
5	.900[f]	.810	.805	1.573	.011	6.179	1	106	.014

a. Predictors: Yrs Teaching Space Sci

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy

d. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy, Total Years Teaching

e. Predictors: Yrs Teaching Technolgy, Total Years Teaching

f. Predictors: Yrs Teaching Technolgy, Total Years Teaching, Yrs Teaching Astronomy

g. Dependent Variable: How Adequate Instructional Methodolgy

h. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1053.694	1	1053.694	347.037	.000[c]
	Residual	327.916	108	3.036		
	Total	1381.610[d]	109			
2	Regression	1090.120	2	545.060	200.080	.000[e]
	Residual	291.490	107	2.724		
	Total	1381.610[d]	109			
3	Regression	1110.740	3	370.247	144.889	.000[f]
	Residual	270.871	106	2.555		
	Total	1381.610[d]	109			
4	Regression	1104.041	2	552.020	212.798	.000[g]
	Residual	277.570	107	2.594		
	Total	1381.610[d]	109			
5	Regression	1119.330	3	373.110	150.792	.000[h]
	Residual	262.280	106	2.474		
	Total	1381.610[d]	109			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

c. Predictors: Yrs Teaching Space Sci

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy

f. Predictors: Yrs Teaching Space Sci, Yrs Teaching Technolgy, Total Years Teaching

g. Predictors: Yrs Teaching Technolgy, Total Years Teaching

h. Predictors: Yrs Teaching Technolgy, Total Years Teaching, Yrs Teaching Astronomy

Appendix Q. Elementary School Teachers Multiple Regressions, Page 6

Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	Yrs Teaching Space Sci	1.116	.060	.873	18.629	.000	1.000	1.000
2	Yrs Teaching Space Sci	.714	.124	.559	5.770	.000	.210	4.754
	Yrs Teaching Technolgy	.647	.177	.354	3.657	.000	.210	4.754
3	Yrs Teaching Space Sci	.304	.188	.238	1.619	.108	.086	11.657
	Yrs Teaching Technolgy	.596	.172	.326	3.461	.001	.208	4.806
	Total Years Teaching	.388	.137	.367	2.841	.005	.111	9.015
4	Yrs Teaching Technolgy	.731	.152	.400	4.817	.000	.272	3.677
	Total Years Teaching	.558	.088	.528	6.351	.000	.272	3.677
5	Yrs Teaching Technolgy	.541	.167	.296	3.241	.002	.215	4.659
	Total Years Teaching	.423	.102	.400	4.166	.000	.194	5.149
	Yrs Teaching Astronomy	.382	.154	.247	2.486	.014	.182	5.504

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY INSTRUCTIONAL METHODOLOGY and EXPERIENCE

Model 1 (r=.873, N= 109) R^2 = .763, F (1, 108) = 347.037, P=.000 (highly significant)
Model 2 (r=.888, N= 109) R^2 = .789, F (2, 107) = 200.080, P=.000 (highly significant)
Model 3 (r=.897, N= 109) R^2 = .804, F (3, 106) = 144.889, P=.000 (highly significant)
Model 4 (r=.894, N= 109) R^2 = .799, F (2,107) = 212.798, P=.000 (highly significant)
Model 5 (r=.900, N= 109) R^2 = .810, F (3, 106) = 150.792, P=.000 (highly significant)

Models 1,2,3,4,5 are highly predictive

Independent Variable: A. **EXPERIENCE** **ELEMENTARY SCHOOL TEACHERS**

Dependent Variable: 5**. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise

(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

Model: All requested variables entered.

Model Summary[e,f]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.867[a]	.751	.749	1.748	.751	326.083	1	108	.000
2	.889[c]	.790	.786	1.614	.039	19.620	1	107	.000
3	.897[d]	.805	.800	1.561	.015	8.431	1	106	.004

a. Predictors: Yrs Teaching Phys Sci

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Yrs Teaching Phys Sci, Yrs Teaching Technolgy

d. Predictors: Yrs Teaching Phys Sci, Yrs Teaching Technolgy, Total Years Teaching

e. Dependent Variable: Self Appraisal of Preparedness as Instructor

f. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	996.424	1	996.424	326.083	.000[e]
	Residual	330.020	108	3.056		
	Total	1326.444[d]	109			
2	Regression	1047.562	2	523.781	200.961	.000[e]
	Residual	278.883	107	2.606		
	Total	1326.444[d]	109			
3	Regression	1068.108	3	356.036	146.088	.000[f]
	Residual	258.336	106	2.437		
	Total	1326.444[d]	109			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

c. Predictors: Yrs Teaching Phys Sci

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: Yrs Teaching Phys Sci, Yrs Teaching Technolgy

f. Predictors: Yrs Teaching Phys Sci, Yrs Teaching Technolgy, Total Years Teaching

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	Yrs Teaching Phys Sci	1.114	.062	.867	18.058	.000	1.000	1.000
2	Yrs Teaching Phys Sci	.662	.117	.515	5.660	.000	.237	4.211
	Yrs Teaching Technolgy	.722	.163	.403	4.429	.000	.237	4.211
3	Yrs Teaching Phys Sci	.370	.151	.288	2.450	.016	.133	7.529
	Yrs Teaching Technolgy	.588	.164	.329	3.587	.001	.219	4.568
	Total Years Teaching	.331	.114	.319	2.904	.004	.152	6.575

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

There was a strong positive correlation between ABILITY INSTRUCTOR PREPAREDNESS and EXPERIENCE

Model 1 (r=.867, N= 109) R^2 = .751, F (1, 108) = 326.083, P=.000 (highly significant)
Model 2 (r=.889, N= 109) R^2 = .790, F (2, 107) = 200.961, P=.000 (highly significant)
Model 3 (r=.897, N= 109) R^2 = .805, F (3, 106) = 146.088, P=.000 (highly significant)

Models 1,2,3 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 8

Independent Variable: B. **EDUCATION** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 1**. ABILITY AVERAGE**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.960[a]	.921	.921	.96536	.921	1265.248	1	108	.000

a. Predictors: NonCredTraining in Last 5 years

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: ABILITY Average

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1179.103	1	1179.103	1265.248	.000[c]
	Residual	100.647	108	.932		
	Total	1279.750[d]	109			

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

c. Predictors: NonCredTraining in Last 5 years

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	NonCredTraining in Last 5 years	3.289	.092	.960	35.570	.000	1.000	1.000

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

There was a strong positive correlation between ABILITY AVERAGE and EDUCATION

Model 1 (r=.960, N= 109) R^2 = .921, F (1, 108) = 1265.248, P=.000 (highly significant)

Models 1 is highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 9

Independent Variable: B. **EDUCATION** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 2**. ABILITY CONTENT KNOWLEDGE**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.952[a]	.907	.906	1.073	.907	1054.967	1	108	.000

a. Predictors: NonCredTraining in Last 5 years

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: Adequacy in Knowlege of Subject

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1215.560	1	1215.560	1054.967	.000[c]
	Residual	124.440	108	1.152		
	Total	1340.000[d]	109			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

c. Predictors: NonCredTraining in Last 5 years

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	NonCredTraining in Last 5 years	3.339	.103	.952	32.480	.000	1.000	1.000

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY CONTENT KNOWLEDGE and EDUCATION

Model 1 (r=.952, N= 109) R^2 = .907, F (1, 108) = 1054.967, P=.000 (highly significant)

Models 1 is highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 10

Independent Variable: B. **EDUCATION** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 3**. ABILITY KNOWLEDGE CURRENCY**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.959[a]	.920	.920	.991	.920	1248.554	1	108	.000

a. Predictors: NonCredTraining in Last 5 years

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: How Current Knowledge of Subject

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1224.992	1	1224.992	1248.554	.000[c]
	Residual	105.962	108	.981		
	Total	1330.954[d]	109			

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

c. Predictors: NonCredTraining in Last 5 years

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	NonCredTraining in Last 5 years	3.352	.095	.959	35.335	.000	1.000	1.000

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

There was a strong positive correlation between ABILITY KNOWLEDGE CURRENCY and EDUCATION

Model 1 (r=.959, N= 109) R^2 = .920, F (1, 108) = 1248.554, P=.000 (highly significant)

Models 1 is highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 11

Independent Variable: B. **EDUCATION** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 4**. ABILITY INSTRUCTIONAL METHODOLOGY**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.957[a]	.916	.915	1.037	.916	1177.506	1	108	.000

a. Predictors: NonCredTraining in Last 5 years

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: How Adequate Instructional Methodolgy

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1265.536	1	1265.536	1177.506	.000[c]
	Residual	116.074	108	1.075		
	Total	1381.610[d]	109			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

c. Predictors: NonCredTraining in Last 5 years

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	NonCredTraining in Last 5 years	3.407	.099	.957	34.315	.000	1.000	1.000

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY INSTRUCTIONAL METHODOLOGY and EDUCATION

Model 1 (r=.957, N= 109) R^2 = .916, F (1, 108) = 1177.506, P=.000 (highly significant)

Models 1 is highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 12

Independent Variable: B. **EDUCATION** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 5**. ABILITY INSTRUCTOR PREPAREDNESS**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

					Change Statistics				
Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.956[a]	.913	.912	1.033	.913	1134.104	1	108	.000

a. Predictors: NonCredTraining in Last 5 years

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: Self Appraisal of Preparedness as Instructor

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1211.111	1	1211.111	1134.104	.000[c]
	Residual	115.333	108	1.068		
	Total	1326.444[d]	109			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

c. Predictors: NonCredTraining in Last 5 years

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	NonCredTraining in Last 5 years	3.333	.099	.956	33.676	.000	1.000	1.000

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY INSTRUCTOR PREPAREDNESS and EDUCATION

Model 1 (r=.957, N= 109) R^2 = .913, F (1, 108) = 1134.104, P=.000 (highly significant)

Models 1 is highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 13

Independent Variable: C. **COMMUNITY SUPPORT** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 5**. ABILITY AVERAGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[e,f]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.936[a]	.876	.875	1.21045	.876	765.441	1	108	.000
2	.947[c]	.897	.895	1.11195	.020	20.981	1	107	.000
3	.954[d]	.910	.908	1.04102	.014	16.078	1	106	.000

a. Predictors: Degree of Support from Grants

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Degree of Support from Grants, Degree of Support from Internet SME

d. Predictors: Degree of Support from Grants, Degree of Support from Internet SME, Degree of Support from District

e. Dependent Variable: ABILITY Average

f. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1121.510	1	1121.510	765.441	.000[c]
	Residual	158.240	108	1.465		
	Total	1279.750[d]	109			
2	Regression	1147.452	2	573.726	464.018	.000[e]
	Residual	132.298	107	1.236		
	Total	1279.750[d]	109			
3	Regression	1164.876	3	388.292	358.297	.000[f]
	Residual	114.874	106	1.084		
	Total	1279.750[d]	109			

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

c. Predictors: Degree of Support from Grants

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: Degree of Support from Grants, Degree of Support from Internet SME

f. Predictors: Degree of Support from Grants, Degree of Support from Internet SME, Degree of Support from District

Coefficients[a,b]

Model		Unstandardized Coefficients: B	Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	VIF
1	Degree of Support from Grants	2.246	.081	.936	27.667	.000	1.000	1.000
2	Degree of Support from Grants	1.388	.202	.578	6.880	.000	.137	7.315
	Degree of Support from Internet SME	.622	.136	.385	4.581	.000	.137	7.315
3	Degree of Support from Grants	.889	.226	.370	3.931	.000	.095	10.489
	Degree of Support from Internet SME	.543	.129	.336	4.222	.000	.134	7.490
	Degree of Support from District	.470	.117	.279	4.010	.000	.174	5.735

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY AVERAGE and COMMUNITY SUPPORT

Model 1 (r=.936, N= 109) R^2 = .876, F (1, 108) = 765.441, P=.000 (highly significant)
Model 2 (r=.947, N= 109) R^2 = .897, F (2, 107) = 464.018, P=.000 (highly significant)
Model 3 (r=.954, N= 109) R^2 = .910, F (3, 106) = 358.297, P=.000 (highly significant)

Models 1,2,3 are highly predictive

Independent Variable: C.**COMMUNITY SUPPORT ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 2. **ABILITY CONTENT KNOWLEDGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[e,f]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.932[a]	.869	.868	1.275	.869	716.884	1	108	.000
2	.942[c]	.888	.886	1.185	.019	18.020	1	107	.000
3	.948[d]	.899	.896	1.129	.011	11.727	1	106	.001

a. Predictors: Degree of Support from Grants
b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.
c. Predictors: Degree of Support from Grants, Degree of Support from District
d. Predictors: Degree of Support from Grants, Degree of Support from District, Degree of Support from Internet SME
e. Dependent Variable: Adequacy in Knowlege of Subject
f. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1164.557	1	1164.557	716.884	.000[c]
	Residual	175.443	108	1.624		
	Total	1340.000[d]	109			
2	Regression	1189.845	2	594.923	423.941	.000[e]
	Residual	150.155	107	1.403		
	Total	1340.000[d]	109			
3	Regression	1204.802	3	401.601	314.870	.000[f]
	Residual	135.198	106	1.275		
	Total	1340.000[d]	109			

a. Dependent Variable: Adequacy in Knowlege of Subject
b. Linear Regression through the Origin
c. Predictors: Degree of Support from Grants
d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.
e. Predictors: Degree of Support from Grants, Degree of Support from District
f. Predictors: Degree of Support from Grants, Degree of Support from District, Degree of Support from Internet SME

Coefficients[a,b]

Model		Unstandardized Coefficients: B	Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	VIF
1	Degree of Support from Grants	2.289	.085	.932	26.775	.000	1.000	1.000
2	Degree of Support from Grants	1.565	.188	.638	8.325	.000	.179	5.601
	Degree of Support from District	.559	.132	.325	4.245	.000	.179	5.601
3	Degree of Support from Grants	.992	.245	.404	4.043	.000	.095	10.489
	Degree of Support from District	.493	.127	.286	3.877	.000	.174	5.735
	Degree of Support from Internet SME	.478	.140	.289	3.424	.001	.134	7.490

a. Dependent Variable: Adequacy in Knowlege of Subject
b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY CONTENT KNOWLEDGE and EDUCATION

Model 1 (r=.932, N= 109) R^2 = .869, F (1, 108) = 716.884, P=.000 (highly significant)
Model 2 (r=.942, N= 109) R^2 = .888, F (2, 107) = 423.941, P=.000 (highly significant)
Model 3 (r=.948, N= 109) R^2 = .899, F (3, 106) = 314.870, P=.000 (highly significant)

Models 1,2,3 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 14

Independent Variable: C.**COMMUNITY SUPPORT ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 3**. ABILITY KNOWLEDGE CURRENCY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[e,f]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.934[a]	.872	.871	1.255	.872	737.180	1	108	.000
2	.944[c]	.892	.890	1.159	.020	19.507	1	107	.000
3	.951[d]	.904	.901	1.100	.012	12.819	1	106	.001

a. Predictors: Degree of Support from Grants
b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.
c. Predictors: Degree of Support from Grants, Degree of Support from District
d. Predictors: Degree of Support from Grants, Degree of Support from District, Degree of Support from Internet SME
e. Dependent Variable: How Current Knowledge of Subject
f. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1160.880	1	1160.880	737.180	.000[c]
	Residual	170.074	108	1.575		
	Total	1330.954[d]	109			
2	Regression	1187.105	2	593.552	441.505	.000[e]
	Residual	143.849	107	1.344		
	Total	1330.954[d]	109			
3	Regression	1202.625	3	400.875	331.123	.000[f]
	Residual	128.329	106	1.211		
	Total	1330.954[d]	109			

a. Dependent Variable: How Current Knowledge of Subject
b. Linear Regression through the Origin
c. Predictors: Degree of Support from Grants
d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.
e. Predictors: Degree of Support from Grants, Degree of Support from District
f. Predictors: Degree of Support from Grants, Degree of Support from District, Degree of Support from Internet SME

Coefficients[a,b]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	Degree of Support from Grants	2.285	.084	.934	27.151	.000	1.000	1.000
2	Degree of Support from Grants	1.548	.184	.633	8.414	.000	.179	5.601
	Degree of Support from District	.569	.129	.332	4.417	.000	.179	5.601
3	Degree of Support from Grants	.964	.239	.394	4.035	.000	.095	10.489
	Degree of Support from District	.502	.124	.293	4.052	.000	.174	5.735
	Degree of Support from Internet SME	.487	.136	.296	3.580	.001	.134	7.490

a. Dependent Variable: How Current Knowledge of Subject
b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY KNOWLEDGE CURRENCY and COMMUNITY SUPPORT

Model 1 (r=.934, N= 109) R^2 = .872, F (1, 108) = 737.180, P=.000 (highly significant)
Model 2 (r=.944, N= 109) R^2 = .892, F (2, 107) = 441.505, P=.000 (highly significant)
Model 3 (r=.951, N= 109) R^2 = .904, F (3, 106) = 331.123, P=.000 (highly significant)

Models 1,2,3 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 15

Independent Variable: C. **COMMUNITY SUPPORT ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 4**. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[f,g]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.930[a]	.865	.864	1.314	.865	691.885	1	108	.000
2	.941[c]	.885	.883	1.218	.020	18.753	1	107	.000
3	.946[d]	.896	.893	1.165	.011	10.870	1	106	.001
4	.950[e]	.902	.899	1.134	.006	6.949	1	105	.010

a. Predictors: Degree of Support from Grants

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Degree of Support from Grants, Degree of Support from Community SME

d. Predictors: Degree of Support from Grants, Degree of Support from Community SME, Degree of Support from District

e. Predictors: Degree of Support from Grants, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Internet SME

f. Dependent Variable: How Adequate Instructional Methodolgy

g. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1195.066	1	1195.066	691.885	.000[c]
	Residual	186.544	108	1.727		
	Total	1381.610[d]	109			
2	Regression	1222.885	2	611.443	412.186	.000[e]
	Residual	158.725	107	1.483		
	Total	1381.610[d]	109			
3	Regression	1237.649	3	412.550	303.763	.000[f]
	Residual	143.962	106	1.358		
	Total	1381.610[d]	109			
4	Regression	1246.585	4	311.646	242.345	.000[g]
	Residual	135.026	105	1.286		
	Total	1381.610[d]	109			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

c. Predictors: Degree of Support from Grants

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: Degree of Support from Grants, Degree of Support from Community SME

f. Predictors: Degree of Support from Grants, Degree of Support from Community SME, Degree of Support from District

g. Predictors: Degree of Support from Grants, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Internet SME

Coefficients[a,b]

Model		Unstandardized Coefficients: B	Std. Error	Standardized Coefficients: Beta	t	Sig.	Collinearity Statistics: Tolerance	VIF
1	Degree of Support from Grants	2.319	.088	.930	26.304	.000	1.000	1.000
2	Degree of Support from Grants	1.215	.268	.487	4.539	.000	.093	10.734
	Degree of Support from Community SME	1.207	.279	.465	4.330	.000	.093	10.734
3	Degree of Support from Grants	.847	.279	.340	3.031	.003	.078	12.776
	Degree of Support from Community SME	.986	.275	.380	3.588	.001	.088	11.409
	Degree of Support from District	.440	.134	.252	3.297	.001	.168	5.953
4	Degree of Support from Grants	.618	.285	.248	2.167	.032	.071	14.073
	Degree of Support from Community SME	.636	.299	.245	2.131	.035	.070	14.219
	Degree of Support from District	.424	.130	.243	3.261	.001	.168	5.966
	Degree of Support from Internet SME	.413	.157	.246	2.636	.010	.107	9.335

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

Appendix Q. Elementary School Teachers Multiple Regressions, Page 16

There was a strong positive correlation between ABILITY INSTRUCTIONAL METHODOLOGY and COMMUNITY SUPPORT

Model 1 (r=.930, N= 109) R^2 = .865, F (1, 108) = 691.885, P=.000 (highly significant)
Model 2 (r=.941, N= 109) R^2 = .883, F (2, 107) = 412.186, P=.000 (highly significant)
Model 3 (r=.946, N= 109) R^2 = .896, F (3, 106) = 303.763, P=.000 (highly significant)
Model 4 (r=.950, N= 109) R^2 = .902, F (4, 106) = 242.345, P=.000 (highly significant)

Models 1, 2, 3, 4 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 17

Independent Variable: C. **COMMUNITY SUPPORT ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 5**. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[e,f]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.928[a]	.862	.861	1.302	.862	674.175	1	108	.000
2	.939[c]	.881	.879	1.215	.019	17.059	1	107	.000
3	.945[d]	.892	.889	1.161	.011	11.265	1	106	.001

a. Predictors: Degree of Support from Grants

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: Degree of Support from Grants, Degree of Support from Internet SME

d. Predictors: Degree of Support from Grants, Degree of Support from Internet SME, Degree of Support from District

e. Dependent Variable: Self Appraisal of Preparedness as Instructor

f. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1143.294	1	1143.294	674.175	.000[c]
	Residual	183.151	108	1.696		
	Total	1326.444[d]	109			
2	Regression	1168.478	2	584.239	395.739	.000[e]
	Residual	157.967	107	1.476		
	Total	1326.444[d]	109			
3	Regression	1183.653	3	394.551	292.892	.000[f]
	Residual	142.791	106	1.347		
	Total	1326.444[d]	109			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

c. Predictors: Degree of Support from Grants

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: Degree of Support from Grants, Degree of Support from Internet SME

f. Predictors: Degree of Support from Grants, Degree of Support from Internet SME, Degree of Support from District

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	Degree of Support from Grants	2.268	.087	.928	25.965	.000	1.000	1.000
2	Degree of Support from Grants	1.422	.220	.582	6.452	.000	.137	7.315
	Degree of Support from Internet SME	.613	.148	.373	4.130	.000	.137	7.315
3	Degree of Support from Grants	.956	.252	.392	3.794	.000	.095	10.489
	Degree of Support from Internet SME	.539	.143	.328	3.760	.000	.134	7.490
	Degree of Support from District	.438	.131	.256	3.356	.001	.174	5.735

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

There was a strong positive correlation between
ABILITY INSTRUCTOR PREPAREDNESS and COMMUNITY SUPPORT

Model 1 (r=.928, N= 109) R^2 = .862, F (1, 108) = 676.175, P=.000 (highly significant)
Model 2 (r=.939, N= 109) R^2 = .881, F (2, 107) = 395.739, P=.000 (highly significant)
Model 3 (r=.944, N= 109) R^2 = .892, F (3, 106) = 292.892, P=.000 (highly significant)

Models 1, 2, 3 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 18

Independent Variable: D. **CURRICULUM ESTABLISHMENT ELEMEN SCHOOL TEACHERS**
Dependent Variable: 1**. ABILITY AVERAGE**
Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.943[a]	.889	.888	1.14715	.889	864.484	1	108	.000

a. Predictors: How Establishd ESS Curric

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: ABILITY Average

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1137.626	1	1137.626	864.484	.000[c]
	Residual	142.124	108	1.316		
	Total	1279.750[d]	109			

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

c. Predictors: How Establishd ESS Curric

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	How Establishd ESS Curric	.965	.033	.943	29.402	.000	1.000	1.000

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

There was a strong positive correlation between CURRICULUM ESTABLISHMENT and ABILITY AVERAGE

Model 1 (r=.943, N= 109) R^2 = .889, F (1, 108) = 864.484, P=.000 (highly significant)

Models 1 is highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 19

Independent Variable: D.**CURRICULUM ESTABLISHMENT ELEMEN SCHOOL TEACHERS**
Dependent Variable: 1. **ABILITY SUBJECT KNOWLEDGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.932[a]	.869	.868	1.275	.869	716.559	1	108	.000

a. Predictors: How Establishd ESS Curric

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: Adequacy in Knowlege of Subject

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1164.488	1	1164.488	716.559	.000[c]
	Residual	175.512	108	1.625		
	Total	1340.000[d]	109			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

c. Predictors: How Establishd ESS Curric

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	How Establishd ESS Curric	.976	.036	.932	26.769	.000	1.000	1.000

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

There was a strong positive correlation between
CURRICULUM ESTABLISHMENT and ABILITY SUBJECT KNOWLEDGE

Model 1 (r=.932, N= 109) R^2 = .869, F (1, 108) = 716.559, P=.000 (highly significant)

Models 1 is highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 20

Independent Variable: D. **CURRICULUM ESTABLISHMENT ELEMEN SCHOOL TEACHERS**
Dependent Variable: 3**. ABILITY KNOWLEDGE CURRENCY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c,d]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.944[a]	.892	.891	1.155	.892	890.466	1	108	.000

a. Predictors: How Establishd ESS Curric

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Dependent Variable: How Current Knowledge of Subject

d. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1186.990	1	1186.990	890.466	.000[c]
	Residual	143.964	108	1.333		
	Total	1330.954[d]	109			

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

c. Predictors: How Establishd ESS Curric

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	How Establishd ESS Curric	.986	.033	.944	29.841	.000	1.000	1.000

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

There was a strong positive correlation between
CURRICULUM ESTABLISHMENT and ABILITY KNOWLEDGE CURRENCY

Model 1 (r=.944, N= 109)Model 1 : R^2 = .892, F (1, 108) =890.446, P=.000 (highly significant)

Models 1 is highly predictive

Independent Variable: D. **CURRICULUM ESTABLISHMENT ELEMEN SCHOOL TEACHERS**
Dependent Variable: 4**. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[d,e]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.938[a]	.880	.879	1.237	.880	795.103	1	108	.000
2	.941[c]	.885	.883	1.220	.004	3.952	1	107	.049

a. Predictors: How Establishd ESS Curric

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: How Establishd ESS Curric, How Establishd Space Sci Curric

d. Dependent Variable: How Adequate Instructional Methodolgy

e. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1216.387	1	1216.387	795.103	.000[c]
	Residual	165.224	108	1.530		
	Total	1381.610[d]	109			
2	Regression	1222.272	2	611.136	410.393	.000[e]
	Residual	159.339	107	1.489		
	Total	1381.610[d]	109			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

c. Predictors: How Establishd ESS Curric

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: How Establishd ESS Curric, How Establishd Space Sci Curric

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	How Establishd ESS Curric	.998	.035	.938	28.198	.000	1.000	1.000
2	How Establishd ESS Curric	.704	.152	.662	4.625	.000	.053	18.983
	How Establishd Space Sci Curric	.338	.170	.284	1.988	.049	.053	18.983

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

There was a strong positive correlation between
CURRICULUM ESTABLISHMENT & ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 (r=.938, N= 109) R^2 = .880, F (1, 108) =795.103, P=.000 (highly significant)

Model 2 (r=.941, N= 109) R^2 = .885, F (2, 107) =410.393, P=.000 (highly significant)

Models 1, 2 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 22

Independent Variable: D. **CURRICULUM ESTABLISHMENT ELEMEN SCHOOL TEACHERS**
Dependent Variable: 4**. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[d,e]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.935[a]	.875	.874	1.238	.875	756.788	1	108	.000
2	.938[c]	.880	.878	1.221	.005	4.171	1	107	.044

a. Predictors: How Establishd ESS Curric

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: How Establishd ESS Curric, How Establishd Space Sci Curric

d. Dependent Variable: Self Appraisal of Preparedness as Instructor

e. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1160.790	1	1160.790	756.788	.000[c]
	Residual	165.654	108	1.534		
	Total	1326.444[d]	109			
2	Regression	1167.005	2	583.503	391.591	.000[e]
	Residual	159.439	107	1.490		
	Total	1326.444[d]	109			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

c. Predictors: How Establishd ESS Curric

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: How Establishd ESS Curric, How Establishd Space Sci Curric

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	How Establishd ESS Curric	.975	.035	.935	27.510	.000	1.000	1.000
2	How Establishd ESS Curric	.672	.152	.645	4.418	.000	.053	18.983
	How Establishd Space Sci Curric	.348	.170	.298	2.042	.044	.053	18.983

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

There was a strong positive correlation between
CURRICULUM ESTABLISHMENT and ABILITY INSTRUCTOR PREPAREDNESS

Model 1 (r=.935, N= 109) R^2 = .875, F (1, 108) =756.788, P=.000 (highly significant)
Model 2 (r=.938, N= 109) R^2 = .880, F (2, 107) =391.591, P=.000 (highly significant)

Models 1, 2 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 23

Independent Variable: E. **RESOURCES** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 1**. ABILITY AVERAGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[f,g]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.953[a]	.908	.907	1.04227	.908	1070.045	1	108	.000
2	.960[c]	.922	.920	.96850	.013	18.079	1	107	.000
3	.964[d]	.930	.928	.91760	.009	13.202	1	106	.000
4	.966[e]	.933	.930	.90376	.003	4.272	1	105	.041

a. Predictors: SpaceSci Inside Comp Tchrs

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets

d. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs

e. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs, Astro Recorded

f. Dependent Variable: ABILITY Average

g. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1162.426	1	1162.426	1070.045	.000[c]
	Residual	117.324	108	1.086		
	Total	1279.750[d]	109			
2	Regression	1179.384	2	589.692	628.669	.000[e]
	Residual	100.366	107	.938		
	Total	1279.750[d]	109			
3	Regression	1190.499	3	396.833	471.306	.000[f]
	Residual	89.251	106	.842		
	Total	1279.750[d]	109			
4	Regression	1193.989	4	298.497	365.459	.000[g]
	Residual	85.761	105	.817		
	Total	1279.750[d]	109			

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

c. Predictors: SpaceSci Inside Comp Tchrs

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets

f. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs

g. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs, Astro Recorded

Appendix Q. Elementary School Teachers Multiple Regressions, Page 24

Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	SpaceSci Inside Comp Tchrs	1.704	.052	.953	32.712	.000	1.000	1.000
2	SpaceSci Inside Comp Tchrs	1.066	.158	.596	6.758	.000	.094	10.616
	SpaceSci Worksheets	.732	.172	.375	4.252	.000	.094	10.616
3	SpaceSci Inside Comp Tchrs	.682	.183	.382	3.731	.000	.063	15.907
	SpaceSci Worksheets	.632	.165	.324	3.820	.000	.092	10.919
	SpaceSci Outside Comp Tchrs	.662	.182	.280	3.633	.000	.111	9.002
4	SpaceSci Inside Comp Tchrs	.451	.212	.252	2.129	.036	.045	22.036
	SpaceSci Worksheets	.568	.166	.291	3.427	.001	.088	11.310
	SpaceSci Outside Comp Tchrs	.595	.182	.251	3.265	.001	.108	9.293
	Astro Recorded	.391	.189	.195	2.067	.041	.072	13.886

a. Dependent Variable: ABILITY Average

b. Linear Regression through the Origin

There was a strong positive correlation between RESOURCES and ABILITY AVERAGE

Model 1 (r=.953, N= 109) R^2 = .908, F (1, 108) =1070.045, P=.000 (highly significant)
Model 2 (r=.960, N= 109) R^2 = .922, F (2, 107) =628.669, P=.000 (highly significant)
Model 3 (r=.964, N= 109) R^2 = .930, F (3, 106) =471.306, P=.000 (highly significant)
Model 4 (r=.966, N= 109) R^2 = .933, F (4, 105) =365.459, P=.000 (highly significant)

Models 1, 2,3,4 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 25

Independent Variable: E. **RESOURCES** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 2**. ABILITY SUBJECT KNOWLEDGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[e,f]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.944[a]	.890	.889	1.166	.890	877.842	1	108	.000
2	.952[c]	.905	.904	1.088	.015	17.041	1	107	.000
3	.955[d]	.911	.909	1.059	.006	6.826	1	106	.010

a. Predictors: SpaceSci Inside Comp Tchrs

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets

d. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs

e. Dependent Variable: Adequacy in Knowlege of Subject

f. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1193.202	1	1193.202	877.842	.000[c]
	Residual	146.798	108	1.359		
	Total	1340.000[d]	109			
2	Regression	1213.370	2	606.685	512.636	.000[e]
	Residual	126.630	107	1.183		
	Total	1340.000[d]	109			
3	Regression	1221.031	3	407.010	362.642	.000[f]
	Residual	118.969	106	1.122		
	Total	1340.000[d]	109			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

c. Predictors: SpaceSci Inside Comp Tchrs

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets

f. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs

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Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	SpaceSci Inside Comp Tchrs	1.726	.058	.944	29.628	.000	1.000	1.000
2	SpaceSci Inside Comp Tchrs	1.030	.177	.563	5.816	.000	.094	10.616
	SpaceSci Worksheets	.798	.193	.400	4.128	.000	.094	10.616
3	SpaceSci Inside Comp Tchrs	.712	.211	.389	3.372	.001	.063	15.907
	SpaceSci Worksheets	.715	.191	.358	3.745	.000	.092	10.919
	SpaceSci Outside Comp Tchrs	.550	.210	.227	2.613	.010	.111	9.002

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Linear Regression through the Origin

There was a strong positive correlation between RESOURCES and ABILITY SUBJECT KNOWLEDGE

Model 1 (r=.944, N= 109) R^2 = .890, F (1, 108) =1193.202, P=.000 (highly significant)
Model 2 (r=.952, N= 109) R^2 = .905, F (2, 107) =512.636, P=.000 (highly significant)
Model 3 (r=.955, N= 109) R^2 = .911, F (3, 106) =362.642, P=.000 (highly significant)

Models 1, 2,3 are highly predictive

Independent Variable: E. **RESOURCES** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 3**. ABILITY KNOWLEDGE CURRENCY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[f,g]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.950[a]	.903	.902	1.091	.903	1009.875	1	108	.000
2	.957[c]	.916	.915	1.021	.013	16.408	1	107	.000
3	.960[d]	.922	.920	.988	.006	8.269	1	106	.005
4	.963[e]	.927	.924	.961	.005	6.999	1	105	.009

a. Predictors: SS Inside Comp Teachers

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: SS Inside Comp Teachers, EarthSci Recorded

d. Predictors: SS Inside Comp Teachers, EarthSci Recorded, SpaceSci Worksheets

e. Predictors: SS Inside Comp Teachers, EarthSci Recorded, SpaceSci Worksheets, SS Outside Comp Teachers

f. Dependent Variable: How Current Knowledge of Subject

g. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1202.368	1	1202.368	1009.875	.000[c]
	Residual	128.586	108	1.191		
	Total	1330.954[d]	109			
2	Regression	1219.464	2	609.732	585.179	.000[e]
	Residual	111.489	107	1.042		
	Total	1330.954[d]	109			
3	Regression	1227.532	3	409.177	419.377	.000[f]
	Residual	103.422	106	.976		
	Total	1330.954[d]	109			
4	Regression	1233.995	4	308.499	334.082	.000[g]
	Residual	96.959	105	.923		
	Total	1330.954[d]	109			

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

c. Predictors: SS Inside Comp Teachers

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: SS Inside Comp Teachers, EarthSci Recorded

f. Predictors: SS Inside Comp Teachers, EarthSci Recorded, SpaceSci Worksheets

g. Predictors: SS Inside Comp Teachers, EarthSci Recorded, SpaceSci Worksheets, SS Outside Comp Teachers

Appendix Q. Elementary School Teachers Multiple Regressions, Page 28

Coefficients[a,b]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	SS Inside Comp Teachers	1.722	.054	.950	31.779	.000	1.000	1.000
2	SS Inside Comp Teachers	1.019	.181	.563	5.645	.000	.079	12.698
	EarthSci Recorded	.772	.191	.404	4.051	.000	.079	12.698
3	SS Inside Comp Teachers	.633	.220	.350	2.873	.005	.050	20.199
	EarthSci Recorded	.653	.189	.341	3.453	.001	.075	13.340
	SpaceSci Worksheets	.566	.197	.285	2.876	.005	.075	13.355
4	SS Inside Comp Teachers	.391	.233	.216	1.676	.097	.042	23.888
	EarthSci Recorded	.527	.190	.276	2.776	.007	.070	14.229
	SpaceSci Worksheets	.568	.191	.285	2.965	.004	.075	13.355
	SS Outside Comp Teachers	.503	.190	.209	2.646	.009	.111	8.986

a. Dependent Variable: How Current Knowledge of Subject

b. Linear Regression through the Origin

There was a strong positive correlation between
RESOURCES and ABILITY KNOWLEDGE CURRENCY

Model 1 (r=.950, N= 109) R^2 = .903, F (1, 108) =1202.368, P=.000 (highly significant)
Model 2 (r=.957, N= 109) R^2 = .916, F (2, 107) =609.732, P=.000 (highly significant)
Model 3 (r=.960, N= 109) R^2 = .922, F (3, 106) =409.177, P=.000 (highly significant)
Model 4 (r=.963, N= 109) R^2 = .927, F (4, 105) =308.499, P=.000 (highly significant)

Models 1, 2,3, 4 are highly predictive

Independent Variable: E. **RESOURCES** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 4**. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[g,h]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.949[a]	.901	.900	1.125	.901	983.394	1	108	.000
2	.957[c]	.916	.915	1.040	.015	19.365	1	107	.000
3	.963[d]	.927	.925	.978	.010	15.141	1	106	.000
4	.964[e]	.930	.927	.962	.003	4.520	1	105	.036
5	.963[f]	.928	.926	.969	-.002	2.599	1	105	.110

a. Predictors: SpaceSci Inside Comp Tchrs

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets

d. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs

e. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs, Astro Recorded

f. Predictors: SpaceSci Worksheets, SpaceSci Outside Comp Tchrs, Astro Recorded

g. Dependent Variable: How Adequate Instructional Methodolgy

h. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1244.892	1	1244.892	983.394	.000[c]
	Residual	136.719	108	1.266		
	Total	1381.610[d]	109			
2	Regression	1265.844	2	632.922	584.993	.000[e]
	Residual	115.767	107	1.082		
	Total	1381.610[d]	109			
3	Regression	1280.313	3	426.771	446.582	.000[f]
	Residual	101.298	106	.956		
	Total	1381.610[d]	109			
4	Regression	1284.493	4	321.123	347.189	.000[g]
	Residual	97.117	105	.925		
	Total	1381.610[d]	109			
5	Regression	1282.090	3	427.363	455.187	.000[h]
	Residual	99.521	106	.939		
	Total	1381.610[d]	109			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

c. Predictors: SpaceSci Inside Comp Tchrs

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets

f. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs

g. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Worksheets, SpaceSci Outside Comp Tchrs, Astro Recorded

h. Predictors: SpaceSci Worksheets, SpaceSci Outside Comp Tchrs, Astro Recorded

Appendix Q. Elementary School Teachers Multiple Regressions, Page 30

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	SpaceSci Inside Comp Tchrs	1.763	.056	.949	31.359	.000	1.000	1.000
2	SpaceSci Inside Comp Tchrs	1.054	.169	.567	6.222	.000	.094	10.616
	SpaceSci Worksheets	.813	.185	.401	4.401	.000	.094	10.616
3	SpaceSci Inside Comp Tchrs	.617	.195	.332	3.165	.002	.063	15.907
	SpaceSci Worksheets	.699	.176	.345	3.969	.000	.092	10.919
	SpaceSci Outside Comp Tchrs	.755	.194	.307	3.891	.000	.111	9.002
4	SpaceSci Inside Comp Tchrs	.364	.226	.196	1.612	.110	.045	22.036
	SpaceSci Worksheets	.629	.176	.311	3.569	.001	.088	11.310
	SpaceSci Outside Comp Tchrs	.682	.194	.277	3.516	.001	.108	9.293
	Astro Recorded	.428	.201	.205	2.126	.036	.072	13.886
5	SpaceSci Worksheets	.761	.158	.375	4.827	.000	.112	8.898
	SpaceSci Outside Comp Tchrs	.804	.180	.327	4.464	.000	.127	7.888
	Astro Recorded	.599	.172	.287	3.477	.001	.100	10.024

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Linear Regression through the Origin

There was a strong positive correlation between
RESOURCES and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 (r=.949, N= 109) R^2 = .901, F (1, 108) =983.394, P=.000 (highly significant)
Model 2 (r=.957, N= 109) R^2 = .916, F (2, 107) =584.993, P=.000 (highly significant)
Model 3 (r=.963, N= 109) R^2 = .927, F (3, 106) =446.582, P=.000 (highly significant)
Model 4 (r=.964, N= 109) R^2 = .930, F (4, 105) =347.189, P=.000 (highly significant)
Model 5 (r=.963, N= 109) R^2 = .928, F (3, 106) =455.187, P=.000 (highly significant)

Models 1, 2,3,4,5 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 31

Independent Variable: E. **RESOURCES** **ELEMENTARY SCHOOL TEACHERS**
Dependent Variable: 5**. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[f,g]

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.953[a]	.909	.908	1.057	.909	1080.338	1	108	.000
2	.959[c]	.920	.919	.993	.011	15.276	1	107	.000
3	.962[d]	.926	.923	.965	.005	7.271	1	106	.008
4	.964[e]	.929	.926	.949	.003	4.533	1	105	.036

a. Predictors: SpaceSci Inside Comp Tchrs

b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This CANNOT be compared to R Square for models which include an intercept.

c. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Outside Comp Tchrs

d. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Outside Comp Tchrs, SpaceSci Worksheets

e. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Outside Comp Tchrs, SpaceSci Worksheets, Astro Outside Comp Students

f. Dependent Variable: Self Appraisal of Preparedness as Instructor

g. Linear Regression through the Origin

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1205.893	1	1205.893	1080.338	.000[c]
	Residual	120.552	108	1.116		
	Total	1326.444[d]	109			
2	Regression	1220.953	2	610.477	619.209	.000[e]
	Residual	105.491	107	.986		
	Total	1326.444[d]	109			
3	Regression	1227.725	3	409.242	439.422	.000[f]
	Residual	98.720	106	.931		
	Total	1326.444[d]	109			
4	Regression	1231.810	4	307.953	341.684	.000[g]
	Residual	94.634	105	.901		
	Total	1326.444[d]	109			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

c. Predictors: SpaceSci Inside Comp Tchrs

d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

e. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Outside Comp Tchrs

f. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Outside Comp Tchrs, SpaceSci Worksheets

g. Predictors: SpaceSci Inside Comp Tchrs, SpaceSci Outside Comp Tchrs, SpaceSci Worksheets, Astro Outside Comp Students

Appendix Q. Elementary School Teachers Multiple Regressions, Page 32

Coefficients[a,b]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	SpaceSci Inside Comp Tchrs	1.735	.053	.953	32.868	.000	1.000	1.000
2	SpaceSci Inside Comp Tchrs	1.195	.147	.657	8.143	.000	.114	8.753
	SpaceSci Outside Comp Tchrs	.760	.194	.315	3.908	.000	.114	8.753
3	SpaceSci Inside Comp Tchrs	.847	.192	.466	4.406	.000	.063	15.907
	SpaceSci Outside Comp Tchrs	.674	.192	.280	3.516	.001	.111	9.002
	SpaceSci Worksheets	.469	.174	.236	2.696	.008	.092	10.919
4	SpaceSci Inside Comp Tchrs	.684	.204	.376	3.351	.001	.054	18.521
	SpaceSci Outside Comp Tchrs	.542	.198	.225	2.733	.007	.100	9.970
	SpaceSci Worksheets	.410	.173	.207	2.367	.020	.089	11.203
	Astro Outside Comp Students	.448	.211	.179	2.129	.036	.096	10.460

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Linear Regression through the Origin

There was a strong positive correlation between
RESOURCES and ABILITY INSTRUCTOR PREPAREDNESS

Model 1 (r=.953, N= 109) R^2 = .909, F (1, 108) =1080.338, P=.000 (highly significant)
Model 2 (r=.959, N= 109) R^2 = .920, F (2, 107) =619.209, P=.000 (highly significant
Model 3 (r=.962, N= 109) R^2 = .926, F (3, 106) =439.422, P=.000 (highly significant)
Model 4 (r=.964, N= 109) R^2 = .929, F (4, 105) =341.684, P=.000 (highly significant

Models 1, 2,3,4 are highly predictive

Appendix Q. Elementary School Teachers Multiple Regressions, Page 33.

APPENDIX R.

MULTIPLE REGRESSIONS

MIDDLE-SCHOOL TEACHERS

Independent Variable: **A. EXPERIENCE** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: Variables Entered
All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.407[a]	.165	.085	.71555	.165	2.046	9	93	.043

a. Predictors: (Constant), Yrs Teaching Math, Yrs Teaching Life Sci, Yrs Teaching Technolgy, Yrs Teaching Astronomy, Total Years Teaching, Yrs Teaching Space Sci, Years Teaching ESS, Yrs Teaching Phys Sci, Yrs Teaching Earth Sci

b. Dependent Variable: ABILITY Average

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.429	9	1.048	2.046	.043[b]
	Residual	47.618	93	.512		
	Total	57.047	102			

a. Dependent Variable: ABILITY Average

b. Predictors: (Constant), Yrs Teaching Math, Yrs Teaching Life Sci, Yrs Teaching Technolgy, Yrs Teaching Astronomy, Total Years Teaching, Yrs Teaching Space Sci, Years Teaching ESS, Yrs Teaching Phys Sci, Yrs Teaching Earth Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.292	.195		16.863	.000		
	Total Years Teaching	-.005	.071	-.010	-.069	.945	.439	2.277
	Yrs Teaching Earth Sci	.045	.190	.085	.236	.814	.070	14.345
	Years Teaching ESS	.255	.151	.463	1.688	.095	.120	8.368
	Yrs Teaching Space Sci	.091	.129	.163	.707	.481	.170	5.899
	Yrs Teaching Astronomy	.012	.089	.021	.132	.895	.357	2.799
	Yrs Teaching Phys Sci	.003	.145	.006	.021	.983	.121	8.255
	Yrs Teaching Life Sci	-.229	.152	-.434	-1.505	.136	.108	9.279
	Yrs Teaching Technolgy	-.059	.137	-.053	-.428	.670	.585	1.709
	Yrs Teaching Math	-.064	.098	-.078	-.649	.518	.622	1.607

a. Dependent Variable: ABILITY Average

There was a moderate correlation between
EXPERIENCE and ABILITY AVERAGE

Model 1 (r=.407, N= 102) R^2 = .091, F (1, 101) =10.158, P=.002, <.01 (highly significant)

Models 1 is predictive

Appendix R. Middle-School Teachers Multiple Regressions, Page 2

Independent Variable: **A. EXPERIENCE** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY SUBJECT CONTENT KNOWLEDGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.302[a]	.091	.082	.799	.091	10.158	1	101	.002

a. Predictors: (Constant), Years Teaching ESS

b. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.487	1	6.487	10.158	.002[b]
	Residual	64.503	101	.639		
	Total	70.990	102			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Years Teaching ESS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.059	.156		19.548	.000		
	Years Teaching ESS	.186	.058	.302	3.187	.002	1.000	1.000

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate correlation between
EXPERIENCE and ABILITY SUBJECT CONTENT KNOWLEDGE

Model 1 (r=.302, N= 102) R^2 = .909, F (9, 93) =2.046, P=.043, <.05 (significant)

Models 1 is predictive

Appendix R. Middle-School Teachers Multiple Regressions, Page 3

Independent Variable: **A. EXPERIENCE** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **2. ABILITY SUBJECT KNOWLEDGE CURRENCY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.203[a]	.041	.032	.916	.041	4.326	1	101	.040
2	.299[b]	.089	.071	.897	.048	5.305	1	100	.023

a. Predictors: (Constant), Yrs Teaching Space Sci
b. Predictors: (Constant), Yrs Teaching Space Sci, Yrs Teaching Phys Sci
c. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.628	1	3.628	4.326	.040[b]
	Residual	84.708	101	.839		
	Total	88.337	102			
2	Regression	7.895	2	3.948	4.907	.009[c]
	Residual	80.441	100	.804		
	Total	88.337	102			

a. Dependent Variable: How Current Knowledge of Subject
b. Predictors: (Constant), Yrs Teaching Space Sci
c. Predictors: (Constant), Yrs Teaching Space Sci, Yrs Teaching Phys Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.137	.179		17.497	.000		
	Yrs Teaching Space Sci	.141	.068	.203	2.080	.040	1.000	1.000
2	(Constant)	3.266	.184		17.718	.000		
	Yrs Teaching Space Sci	.315	.101	.453	3.132	.002	.436	2.293
	Yrs Teaching Phys Sci	-.221	.096	-.333	-2.303	.023	.436	2.293

a. Dependent Variable: How Current Knowledge of Subject

There was a weak to moderate correlation between
EXPERIENCE and ABILITY SUBJECT KNOWLEDGE CURRENCY

Model 1 (r=.203, N= 102) R^2 = .041, F (1, 101) =4.326, P=.040, <.05 (significant)
Model 2 (r=.299, N= 102) R^2 = .089, F (2, 100) =4.907, P=.009, <.01 (highly significant)

Models 1 is predictive
Models 2 is highly predictive

Independent Variable: **A. EXPERIENCE** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.279[a]	.078	.069	.845	.078	8.513	1	101	.004
2	.351[b]	.123	.106	.828	.046	5.211	1	100	.025

a. Predictors: (Constant), Years Teaching ESS
b. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci
c. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.078	1	6.078	8.513	.004[b]
	Residual	72.112	101	.714		
	Total	78.190	102			
2	Regression	9.650	2	4.825	7.040	.001[c]
	Residual	68.540	100	.685		
	Total	78.190	102			

a. Dependent Variable: How Adequate Instructional Methodolgy
b. Predictors: (Constant), Years Teaching ESS
c. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.173	.165		19.176	.000		
	Years Teaching ESS	.180	.062	.279	2.918	.004	1.000	1.000
2	(Constant)	3.283	.169		19.409	.000		
	Years Teaching ESS	.368	.102	.570	3.602	.000	.350	2.856
	Yrs Teaching Life Sci	-.222	.097	-.361	-2.283	.025	.350	2.856

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak to moderate correlation between
EXPERIENCE and ABILITY SUBJECT KNOWLEDGE CURRENCY

Model 1 (r=.279, N= 102) R^2 = .078, F (1, 101) =8.513, P=.004, <.01 (highly significant)
Model 2 (r=.351, N= 102) R^2 = .123, F (2, 100) =7.040, P=.001, <.01 (highly significant)

Models 1,2 are highly predictive

Independent Variable: **A. EXPERIENCE** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.279[a]	.078	.069	.845	.078	8.513	1	101	.004
2	.351[b]	.123	.106	.828	.046	5.211	1	100	.025

a. Predictors: (Constant), Years Teaching ESS
b. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci
c. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.078	1	6.078	8.513	.004[b]
	Residual	72.112	101	.714		
	Total	78.190	102			
2	Regression	9.650	2	4.825	7.040	.001[c]
	Residual	68.540	100	.685		
	Total	78.190	102			

a. Dependent Variable: How Adequate Instructional Methodolgy
b. Predictors: (Constant), Years Teaching ESS
c. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.173	.165		19.176	.000		
	Years Teaching ESS	.180	.062	.279	2.918	.004	1.000	1.000
2	(Constant)	3.283	.169		19.409	.000		
	Years Teaching ESS	.368	.102	.570	3.602	.000	.350	2.856
	Yrs Teaching Life Sci	-.222	.097	-.361	-2.283	.025	.350	2.856

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak to moderate correlation between
EXPERIENCE and ABILITY SUBJECT KNOWLEDGE CURRENCY

Model 1 (r=.279, N= 102) R^2 = .078, F (1, 101) =8.513, P=.004, <.01 (highly significant)
Model 2 (r=.351, N= 102) R^2 = .123, F (2, 100) =7.040, P=.001, <.01 (highly significant)

Models 1,2 are highly predictive

Appendix R. Middle-School Teachers Multiple Regressions, Page 6

Independent Variable: **A. EXPERIENCE** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise

(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.299[a]	.089	.080	.761	.089	9.898	1	101	.002
2	.356[b]	.127	.109	.749	.038	4.310	1	100	.040

a. Predictors: (Constant), Years Teaching ESS

b. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci

c. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.734	1	5.734	9.898	.002[b]
	Residual	58.511	101	.579		
	Total	64.245	102			
2	Regression	8.152	2	4.076	7.267	.001[c]
	Residual	56.093	100	.561		
	Total	64.245	102			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), Years Teaching ESS

c. Predictors: (Constant), Years Teaching ESS, Yrs Teaching Life Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.146	.149		21.107	.000		
	Years Teaching ESS	.175	.056	.299	3.146	.002	1.000	1.000
2	(Constant)	3.237	.153		21.150	.000		
	Years Teaching ESS	.329	.092	.563	3.566	.001	.350	2.856
	Yrs Teaching Life Sci	-.183	.088	-.328	-2.076	.040	.350	2.856

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak to moderate correlation between
EXPERIENCE and ABILITY INSTRUCTOR PREPAREDNESS

Model 1 (r=.299, N= 102) R^2 = .089, F (1, 101) =9.898, P=.002, <.01 (highly significant)
Model 2 (r=.356, N= 102) R^2 = .127, F (2, 100) =7.267, P=.001, <.01 (highly significant)

Models 1,2 are highly predictive

Independent Variable: **B. EDUCATION MIDDLE-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**
Method: Enter
Model: All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.230[a]	.053	.004	.74631	.053	1.085	5	97	.374

a. Predictors: (Constant), NonCredTraining in Last 5 years, Highest Degree Earned, Major, Education Training, Most Recent Training

b. Dependent Variable: ABILITY Average

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.021	5	.604	1.085	.374[b]
	Residual	54.026	97	.557		
	Total	57.047	102			

a. Dependent Variable: ABILITY Average

b. Predictors: (Constant), NonCredTraining in Last 5 years, Highest Degree Earned, Major, Education Training, Most Recent Training

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.974	.386		7.707	.000		
	Highest Degree Earned	-.039	.076	-.052	-.511	.611	.926	1.080
	Major	.157	.088	.185	1.787	.077	.908	1.101
	Education Training	.091	.166	.057	.546	.586	.908	1.101
	Most Recent Training	.076	.054	.148	1.410	.162	.890	1.124
	NonCredTraining in Last 5 years	.088	.157	.058	.561	.576	.906	1.103

a. Dependent Variable: ABILITY Average

There was a weak correlation between EDUCATION and ABILITY AVERAGE

Model 1 (r=.230, N= 102) R^2 = .053, F (5, 97) =1.085, P=.374, >.05 (not significant)

Models 1 is not predictive

Appendix R. Middle-School Teachers Multiple Regressions, Page 8

Independent Variable: **B. EDUCATION** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **2. Ability SUBJECT KNOWLEDGE**

Method: Stepwise
(Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.281[a]	.079	.070	.804	.079	8.685	1	101	.004
2	.384[b]	.148	.131	.778	.069	8.043	1	100	.006
3	.442[c]	.196	.171	.759	.048	5.910	1	99	.017

a. Predictors: (Constant), Major

b. Predictors: (Constant), Major, Most Recent Training

c. Predictors: (Constant), Major, Most Recent Training, NonCredTraining in Last 5 years

d. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.621	1	5.621	8.685	.004[b]
	Residual	65.369	101	.647		
	Total	70.990	102			
2	Regression	10.487	2	5.244	8.667	.000[c]
	Residual	60.503	100	.605		
	Total	70.990	102			
3	Regression	13.896	3	4.632	8.032	.000[d]
	Residual	57.094	99	.577		
	Total	70.990	102			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Major

c. Predictors: (Constant), Major, Most Recent Training

d. Predictors: (Constant), Major, Most Recent Training, NonCredTraining in Last 5 years

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.004	.183		16.403	.000		
	Major	.266	.090	.281	2.947	.004	1.000	1.000
2	(Constant)	2.650	.217		12.232	.000		
	Major	.306	.088	.323	3.456	.001	.975	1.025
	Most Recent Training	.153	.054	.265	2.836	.006	.975	1.025
3	(Constant)	2.423	.231		10.481	.000		
	Major	.275	.087	.291	3.149	.002	.955	1.047
	Most Recent Training	.185	.054	.320	3.406	.001	.918	1.089
	NonCredTraining in Last 5 years	.388	.160	.230	2.431	.017	.911	1.097

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a weak to moderate correlation between EDUCATION and ABILITY SUBJECT KNOWLEDGE

Model 1 (r=.281, N= 102) R^2 = .079, F (1, 101) =8.685, P=.004, <.01 (highly significant)
Model 2 (r=.384, N= 102) R^2 = .148, F (2, 100) =8.667, P=.000, <.01 (highly significant)
Model 3 (r=.442, N= 102) R^2 = .196, F (3, 99) =8.032, P=.000, <.01 (highly significant)

Models 1,2,3 are highly predictive

Independent Variable: **B. EDUCATION** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY KNOWLEDGE CURRENCY**

Method: Enter
Model: All variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.194[a]	.038	-.012	.936	.038	.761	5	97	.580

a. Predictors: (Constant), NonCredTraining in Last 5 years, Highest Degree Earned, Major, Education Training, Most Recent Training

b. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.335	5	.667	.761	.580[b]
	Residual	85.001	97	.876		
	Total	88.337	102			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), NonCredTraining in Last 5 years, Highest Degree Earned, Major, Education Training, Most Recent Training

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.195	.484		6.601	.000		
	Highest Degree Earned	-.033	.095	-.036	-.346	.730	.926	1.080
	Major	.090	.110	.085	.818	.415	.908	1.101
	Education Training	.012	.209	.006	.056	.955	.908	1.101
	Most Recent Training	.109	.068	.170	1.606	.111	.890	1.124
	NonCredTraining in Last 5 years	-.066	.197	-.035	-.336	.738	.906	1.103

a. Dependent Variable: How Current Knowledge of Subject

There was a weak correlation between EDUCATION and ABILITY KNOWLEDGE CURRENCY

Model 1 (r=.194, N= 102) R^2 = .038, F (5, 97) =.761, P=.580, >.05 (not significant)

Models 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: **B. EDUCATION** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTOR PREPAREDNESS**
Method: Enter
Model: All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.222[a]	.049	.000	.793	.049	1.008	5	97	.418

a. Predictors: (Constant), NonCredTraining in Last 5 years, Highest Degree Earned, Major, Education Training, Most Recent Training

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

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ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.172	5	.634	1.008	.418[b]
	Residual	61.073	97	.630		
	Total	64.245	102			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), NonCredTraining in Last 5 years, Highest Degree Earned, Major, Education Training, Most Recent Training

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.173	.410		7.735	.000		
	Highest Degree Earned	-.043	.080	-.055	-.534	.594	.926	1.080
	Major	.151	.094	.168	1.613	.110	.908	1.101
	Education Training	.001	.177	.001	.008	.994	.908	1.101
	Most Recent Training	.069	.058	.126	1.203	.232	.890	1.124
	NonCredTraining in Last 5 years	.134	.167	.083	.801	.425	.906	1.103

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak correlation between EDUCATION and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 (r=.222, N= 102) R^2 = .049, F (5, 97) =1.008, P=.416, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix R. Middle-School Teachers Multiple Regressions, Page 11

Independent Variable: **C. COMMUNITY SUPPORT MIDDLE-SCHOOL TEACHERS**
Dependent Variable 1. **ABILITY AVERAGE**

Method: Enter
Model: All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.213[a]	.045	-.036	.76110	.045	.560	8	94	.808

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

b. Dependent Variable: ABILITY Average

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.595	8	.324	.560	.808[b]
	Residual	54.451	94	.579		
	Total	57.047	102			

a. Dependent Variable: ABILITY Average

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.511	.192		18.325	.000		
	Degree of Support from District	-.105	.076	-.156	-1.376	.172	.788	1.269
	Degree of Support from Local Teachers	.023	.078	.033	.300	.765	.857	1.167
	Degree of Support from Teachers Out of Dist	.136	.088	.169	1.548	.125	.848	1.179
	Degree of Support from Coleges	.024	.092	.031	.263	.793	.711	1.406
	Degree of Support from Museums	-.060	.108	-.076	-.557	.579	.550	1.817
	Degree of Support from Community SME	.058	.108	.065	.532	.596	.672	1.488
	Degree of Support from Internet SME	-.020	.078	-.029	-.261	.795	.822	1.216
	Degree of Support from Grants	-.050	.128	-.045	-.389	.698	.765	1.307

a. Dependent Variable: ABILITY Average

There was a weak correlation between COMMUNITY SUPPORT and ABILITY AVERAGE

Model 1 (r=.213, N= 102) R^2 = .045, F (8, 94) =.560, P=.808, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: **C. COMMUNITY SUPPORT MIDDLE-SCHOOL TEACHERS**
Dependent Variable 2. **ABILITY SUBJECT KNOWLEDGE**

Method: Enter
Model: All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.291[a]	.085	.007	.831	.085	1.086	8	94	.380

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

b. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.005	8	.751	1.086	.380[b]
	Residual	64.985	94	.691		
	Total	70.990	102			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.589	.209		17.145	.000		
	Degree of Support from District	-.110	.083	-.148	-1.329	.187	.788	1.269
	Degree of Support from Local Teachers	-.079	.085	-.098	-.922	.359	.857	1.167
	Degree of Support from Teachers Out of Dist	.082	.096	.092	.859	.393	.848	1.179
	Degree of Support from Coleges	.178	.101	.206	1.764	.081	.711	1.406
	Degree of Support from Museums	-.009	.118	-.011	-.080	.937	.550	1.817
	Degree of Support from Community SME	-.044	.118	-.045	-.372	.711	.672	1.488
	Degree of Support from Internet SME	.021	.085	.027	.252	.802	.822	1.216
	Degree of Support from Grants	-.189	.140	-.152	-1.350	.180	.765	1.307

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a weak correlation between COMMUNITY SUPPORT and ABILITY SUBJECT KNOWLEDGE

Model 1 (r=.291, N= 102) R^2 = .085, F (8, 94) =1.086, P=.380, >.05 (not significant)

Models 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix R. Middle-School Teachers Multiple Regressions, Page 13

Independent Variable: **C. COMMUNITY SUPPORT MIDDLE-SCHOOL TEACHERS**
Dependent Variable 3. **ABILITY KNOWLEDGE CURRENCY**

Method: Enter
Model: All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.163[a]	.027	-.056	.956	.027	.321	8	94	.956

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

b. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.350	8	.294	.321	.956[b]
	Residual	85.987	94	.915		
	Total	88.337	102			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.398	.241		14.115	.000		
	Degree of Support from District	-.051	.096	-.062	-.538	.592	.788	1.269
	Degree of Support from Local Teachers	.018	.098	.020	.179	.858	.857	1.167
	Degree of Support from Teachers Out of Dist	.098	.110	.099	.892	.374	.848	1.179
	Degree of Support from Coleges	.093	.116	.097	.800	.426	.711	1.406
	Degree of Support from Museums	-.020	.135	-.021	-.150	.881	.550	1.817
	Degree of Support from Community SME	.065	.136	.060	.481	.632	.672	1.488
	Degree of Support from Internet SME	-.055	.098	-.063	-.564	.574	.822	1.216
	Degree of Support from Grants	-.042	.161	-.031	-.263	.793	.765	1.307

a. Dependent Variable: How Current Knowledge of Subject

There was a weak correlation between COMMUNITY SUPPORT and ABILITY KNOWLEDGE CURRENCY

Model 1 (r=.183, N= 102) R^2 = .027, F (8, 94) =321, P=.956, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix R. Middle-School Teachers Multiple Regressions, Page 14

Independent Variable: **C. COMMUNITY SUPPORT MIDDLE-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Enter
Model: All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.252[a]	.063	-.016	.883	.063	.796	8	94	.607

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.961	8	.620	.796	.607[b]
	Residual	73.229	94	.779		
	Total	78.190	102			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Community SME, Degree of Support from District, Degree of Support from Coleges, Degree of Support from Museums

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.540	.222		15.930	.000		
	Degree of Support from District	-.127	.088	-.162	-1.444	.152	.788	1.269
	Degree of Support from Local Teachers	.072	.090	.086	.795	.429	.857	1.167
	Degree of Support from Teachers Out of Dist	.193	.102	.206	1.897	.061	.848	1.179
	Degree of Support from Coleges	-.058	.107	-.064	-.541	.590	.711	1.406
	Degree of Support from Museums	-.019	.125	-.020	-.149	.882	.550	1.817
	Degree of Support from Community SME	-.005	.125	-.005	-.040	.968	.672	1.488
	Degree of Support from Internet SME	.007	.090	.009	.077	.939	.822	1.216
	Degree of Support from Grants	-.016	.149	-.012	-.105	.917	.765	1.307

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak correlation between COMMUNITY SUPPORT and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 (r=.252, N= 102) R^2 = .063, F (8, 94) =.796, P=.607, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: **C. COMMUNITY SUPPORT MIDDLE-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.212[a]	.045	.036	.779	.045	4.767	1	101	.031

a. Predictors: (Constant), Degree of Support from District

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

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ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.895	1	2.895	4.767	.031[b]
	Residual	61.350	101	.607		
	Total	64.245	102			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), Degree of Support from District

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.753	.120		31.195	.000		
	Degree of Support from District	-.151	.069	-.212	-2.183	.031	1.000	1.000

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak correlation between
COMMUNITY SUPPORT and ABILITY INSTRUCTOR PREPAREDNESS

Model 1 (r=.212, N= 102) R^2 = .045, F (1, 101) =.4.767, P=.031, <.05 (significant)

Model 1 is not predictive

Appendix R. Middle-School Teachers Multiple Regressions, Page 16

Independent Variable: **D. CURRICULUM_ MIDDLE-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Stepwise Model: (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). All requested variables entered.

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.337[a]	.113	.104	.70771	.113	12.899	1	101	.001

a. Predictors: (Constant), How Establishd Space Sci Curric

b. Dependent Variable: ABILITY Average

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.461	1	6.461	12.899	.001[b]
	Residual	50.586	101	.501		
	Total	57.047	102			

a. Dependent Variable: ABILITY Average

b. Predictors: (Constant), How Establishd Space Sci Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.766	.213		13.015	.000		
	How Establishd Space Sci Curric	.246	.069	.337	3.592	.001	1.000	1.000

a. Dependent Variable: ABILITY Average

There was a moderate correlation between CURRICULUM and ABILITY AVERAGE

Model 1 (r=.337, N= 102) R^2 = .113, F (1, 101) =12.899, P=.001, <.01 (highly significant)

Model 1 is highly predictive

Appendix R. Middle-School Teachers Multiple Regressions, Page 17

Independent Variable: **D. CURRICULUM_ MIDDLE-SCHOOL TEACHERS**
Dependent Variable **2. ABILITY SUBJECT CONTENT KNOWLEDGE**

Stepwise Model: (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.324[a]	.105	.096	.793	.105	11.852	1	101	.001

a. Predictors: (Constant), How Establishd Earth Sci Curric

b. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.456	1	7.456	11.852	.001[b]
	Residual	63.534	101	.629		
	Total	70.990	102			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), How Establishd Earth Sci Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.496	.299		8.347	.000		
	How Establishd Earth Sci Curric	.287	.083	.324	3.443	.001	1.000	1.000

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate correlation between

CURRICULUM and ABILITY SUBJECT CONTENT KNOWLEDGE

Model 1 (r=.324, N= 102) R^2 = .105, F (1, 101) =11.852, P=.001, <.01 (highly significant)

Model 1 is highly predictive

Independent Variable: **D. CURRICULUM_ MIDDLE-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY KNOWLEDGE CURRENCY**

Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.344[a]	.118	.110	.878	.118	13.548	1	101	.000

a. Predictors: (Constant), How Establishd Space Sci Curric

b. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.448	1	10.448	13.548	.000[b]
	Residual	77.889	101	.771		
	Total	88.337	102			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), How Establishd Space Sci Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.542	.264		9.639	.000		
	How Establishd Space Sci Curric	.313	.085	.344	3.681	.000	1.000	1.000

a. Dependent Variable: How Current Knowledge of Subject

There was a moderate correlation between

CURRICULUM and ABILITY KNOWLEDGE CURRENCY KNOWLEDGE

Model 1 (r=.344, N= 102) R^2 = .118, F (1, 101) =13.548, P=.000, <.01 (highly significant)

Model 1 is highly predictive

Independent Variable: **D. CURRICULUM_ MIDDLE-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.224[a]	.050	.041	.857	.050	5.345	1	101	.023

a. Predictors: (Constant), How Establishd Earth Sci Curric

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.930	1	3.930	5.345	.023[b]
	Residual	74.260	101	.735		
	Total	78.190	102			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), How Establishd Earth Sci Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.868	.323		8.872	.000		
	How Establishd Earth Sci Curric	.208	.090	.224	2.312	.023	1.000	1.000

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak correlation between

CURRICULUM and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 (r=.224, N= 102) R^2 = .050, F (1, 101) =5.345, P=.023, <.05 (significant)

Model 1 is predictive

Independent Variable: **D. CURRICULUM_ MIDDLE-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
Model: All requested variables entered.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.233[a]	.054	.045	.776	.054	5.776	1	101	.018

a. Predictors: (Constant), How Establishd Earth Sci Curric

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.475	1	3.475	5.776	.018[b]
	Residual	60.770	101	.602		
	Total	64.245	102			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), How Establishd Earth Sci Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.873	.292		9.822	.000		
	How Establishd Earth Sci Curric	.196	.081	.233	2.403	.018	1.000	1.000

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak correlation between

CURRICULUM and ABILITY INSTRUCTOR PREPAREDNESS

Model 1 (r=.233, N= 102) R^2 = .054, F (1, 101) =5.776, P=.018, <.05 (significant)

Model 1 is predictive

Appendix R. Middle-School Teachers Multiple Regressions, Page 21

Independent Variable: **E. RESOURCES** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Model: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.552[a]	.304	-.075	.77549	.304	.802	36	66	.762

a. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

b. Dependent Variable: ABILITY Average

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.355	36	.482	.802	.762[b]
	Residual	39.692	66	.601		
	Total	57.047	102			

a. Dependent Variable: ABILITY Average

b. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.873	.292		9.822	.000		
	How Establishd Earth Sci Curric	.196	.081	.233	2.403	.018	1.000	1.000

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a moderate correlation between RESOURCES and ABILITY AVERAGE

Model 1 (r=.562, N= 102) R^2 = .304, F (35, 66) =.802, P=.762, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix R. Middle-School Teachers Multiple Regressions, Page 22

Independent Variable: **E. RESOURCES** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **2. ABILITY CONTENT KNOWLEDGE**

Model: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.543[a]	.295	-.090	.871	.295	.766	36	66	.806

a. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

b. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.918	36	.581	.766	.806[b]
	Residual	50.072	66	.759		
	Total	70.990	102			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.680	1.515		3.090	.003		
	EarthSci Use Text	-.353	.439	-.203	-.804	.424	.167	5.971
	EarthSci Use Written	.178	.387	.098	.460	.647	.237	4.218
	EarthSci Use Worksheet	.542	.445	.269	1.217	.228	.219	4.571
	EarthSci Inside Comp Teachers	.529	.601	.149	.881	.382	.374	2.676
	EarthSci Inside Comp Students	.164	.523	.094	.313	.755	.117	8.521
	EarthSci Outside Comp Teachers	-.587	.496	-.340	-1.183	.241	.130	7.702
	EarthSci Outside Comp Students	.287	.361	.163	.794	.430	.253	3.949
	EarthSci Digital	.264	.506	.149	.521	.604	.130	7.681
	EarthSci Recorded	-.229	.375	-.106	-.611	.543	.354	2.829
	SpaceSci Text	1.188	.538	.675	2.206	.031	.114	8.751
	Space Sci Written	-.655	.408	-.355	-1.607	.113	.219	4.569
	SpaceSci Worksheets	-.931	.499	-.429	-1.866	.067	.202	4.951
	SpaceSci Inside Comp Tchrs	.916	.858	.213	1.067	.290	.269	3.717
	SpaceSci Inside Comp Students	-.589	.559	-.329	-1.054	.296	.110	9.101
	SpaceSci Outside Comp Tchrs	.550	.738	.310	.745	.459	.062	16.148
	SpaceSci Outside Comp Students	.535	.719	.294	.743	.460	.068	14.606
	SpaceSci Digital	-.676	.622	-.383	-1.087	.281	.086	11.644
	SpaceSci Recorded	-.392	.777	-.173	-.504	.616	.091	11.030
	SS Use Text	-.153	.487	-.089	-.314	.755	.132	7.559
	SS Use Written	.234	.421	.130	.555	.580	.196	5.090
	SS Use Worksheet	-.102	.419	-.049	-.243	.809	.263	3.803
	SS Inside Comp Teachers	-1.940	1.053	-.451	-1.842	.070	.178	5.610
	SS Inside Comp Students	.242	.566	.140	.428	.670	.100	10.002
	SS Outside Comp Teachers	.107	.681	.062	.157	.875	.068	14.654
	SS Outside Comp Students	-.457	.432	-.262	-1.057	.294	.174	5.745
	SS Digital	.094	.630	.055	.149	.882	.080	12.568
	SS Recorded	.075	.773	.032	.097	.923	.100	9.992
	Astro Use Text	-.758	.509	-.409	-1.489	.141	.141	7.074
	Astro Use Written	.215	.336	.114	.641	.524	.338	2.957
	Astro Use Worksheet	.406	.409	.206	.992	.325	.249	4.019
	Astro Inside Comp Teachers	-.254	.633	-.065	-.402	.689	.404	2.478
	Astro Inside Comp Students	.262	.465	.141	.565	.574	.171	5.860
	Astro Outside Comp Teachers	.167	.473	.090	.354	.724	.167	6.004
	Astro Outside Comp Students	-.615	.615	-.325	-1.000	.321	.101	9.902
	Astro Digital	.578	.440	.311	1.314	.193	.190	5.256
	Astro Recorded	.669	.666	.286	1.005	.318	.133	7.545

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate correlation between RESOURCES and ABILITY CONTENT KNOWLEDGE

Model 1 (r=.543, N= 102 R^2 = .295, F (36, 66) =.766, P=.806, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Independent Variable: **E. RESOURCES** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY KNOWLEDGE CURRENCY**
Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[c]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.219[a]	.048	.038	.913	.048	5.081	1	101	.026
2	.301[b]	.091	.073	.896	.043	4.712	1	100	.032

a. Predictors: (Constant), Astro Recorded

b. Predictors: (Constant), Astro Recorded, Astro Digital

c. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.231	1	4.231	5.081	.026[b]
	Residual	84.105	101	.833		
	Total	88.337	102			
2	Regression	8.016	2	4.008	4.990	.009[c]
	Residual	80.321	100	.803		
	Total	88.337	102			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), Astro Recorded

c. Predictors: (Constant), Astro Recorded, Astro Digital

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	2.425	.468		5.185	.000		
	Astro Recorded	.572	.254	.219	2.254	.026	1.000	1.000
2	(Constant)	1.759	.552		3.185	.002		
	Astro Recorded	.595	.250	.227	2.383	.019	.998	1.002
	Astro Digital	.429	.198	.207	2.171	.032	.998	1.002

a. Dependent Variable: How Current Knowledge of Subject

There was a moderate correlation between
RESOURCES and ABILITY CONTENT KNOWLEDGE
Model 1 r=.219, N= 102 R^2 = .219, F (1,101) =5.081, P=.026, <.05 (significant)
Model 2 r=.301, N= 102 R^2 = .301, F (2, 100) =4.990, P=.009, <.01 (highly significant)

Model 1 is predictive
Model 1 is highly predictive

Independent Variable: **E. RESOURCES** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.602[a]	.362	.014	.869	.362	1.040	36	66	.435

a. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28.309	36	.786	1.040	.435[b]
	Residual	49.881	66	.756		
	Total	78.190	102			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5.380	1.512		3.559	.001		
	EarthSci Use Text	.107	.438	.059	.245	.807	.167	5.971
	EarthSci Use Written	.138	.387	.072	.356	.723	.237	4.218
	EarthSci Use Worksheet	1.003	.444	.474	2.257	.027	.219	4.571
	EarthSci Inside Comp Teachers	-.322	.600	-.086	-.537	.593	.374	2.676
	EarthSci Inside Comp Students	-.360	.522	-.198	-.689	.493	.117	8.521
	EarthSci Outside Comp Teachers	-.299	.495	-.165	-.604	.548	.130	7.702
	EarthSci Outside Comp Students	-.329	.361	-.178	-.913	.365	.253	3.949
	EarthSci Digital	-.048	.505	-.026	-.095	.924	.130	7.681
	EarthSci Recorded	-.377	.375	-.166	-1.006	.318	.354	2.829
	SpaceSci Text	.577	.537	.313	1.075	.287	.114	8.751
	Space Sci Written	-.752	.407	-.388	-1.849	.069	.219	4.569
	SpaceSci Worksheets	-.756	.498	-.332	-1.518	.134	.202	4.951
	SpaceSci Inside Comp Tchrs	1.632	.857	.361	1.904	.061	.269	3.717
	SpaceSci Inside Comp Students	-.248	.558	-.132	-.445	.658	.110	9.101
	SpaceSci Outside Comp Tchrs	.874	.737	.469	1.186	.240	.062	16.148
	SpaceSci Outside Comp Students	.009	.718	.005	.013	.990	.068	14.606
	SpaceSci Digital	-.560	.621	-.302	-.901	.371	.086	11.644
	SpaceSci Recorded	.211	.776	.089	.271	.787	.091	11.030
	SS Use Text	-.111	.486	-.062	-.228	.820	.132	7.559
	SS Use Written	.066	.420	.035	.157	.876	.196	5.090
	SS Use Worksheet	-.317	.418	-.146	-.759	.450	.263	3.803
	SS Inside Comp Teachers	-1.370	1.051	-.303	-1.303	.197	.178	5.610
	SS Inside Comp Students	1.070	.565	.589	1.894	.063	.100	10.002
	SS Outside Comp Teachers	.004	.680	.002	.006	.995	.068	14.654
	SS Outside Comp Students	-.205	.432	-.112	-.474	.637	.174	5.745
	SS Digital	.194	.629	.108	.309	.759	.080	12.568
	SS Recorded	-.476	.772	-.192	-.617	.539	.100	9.992
	Astro Use Text	-.804	.508	-.414	-1.583	.118	.141	7.074
	Astro Use Written	.732	.335	.369	2.184	.032	.338	2.957
	Astro Use Worksheet	-.451	.408	-.218	-1.104	.274	.249	4.019
	Astro Inside Comp Teachers	-1.014	.631	-.248	-1.605	.113	.404	2.478
	Astro Inside Comp Students	-.066	.464	-.034	-.142	.888	.171	5.860
	Astro Outside Comp Teachers	-.609	.472	-.311	-1.292	.201	.167	6.004
	Astro Outside Comp Students	.262	.614	.132	.427	.670	.101	9.902
	Astro Digital	.714	.439	.366	1.625	.109	.190	5.256
	Astro Recorded	.979	.664	.398	1.474	.145	.133	7.545

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a moderate correlation between
RESOURCES and ABILITY CONTENT KNOWLEDGE

Model 1 r=.602, N= 102 R^2 = .362, F (36,66) =1.040, P=.435, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix R. Middle-School Teachers Multiple Regressions, Page 27

Independent Variable: **E. RESOURCES** **MIDDLE-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Method: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.476[a]	.227	-.195	.868	.227	.537	36	66	.977

a. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.563	36	.405	.537	.977[b]
	Residual	49.682	66	.753		
	Total	64.245	102			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), Astro Recorded, Astro Inside Comp Teachers, Astro Digital, SpaceSci Inside Comp Students, EarthSci Outside Comp Students, SpaceSci Worksheets, EarthSci Use Written, EarthSci Inside Comp Teachers, SpaceSci Outside Comp Tchrs, SS Use Text, Astro Use Written, SpaceSci Inside Comp Tchrs, SS Use Worksheet, EarthSci Recorded, EarthSci Digital, SS Outside Comp Students, Astro Use Worksheet, Space Sci Written, EarthSci Use Worksheet, Astro Inside Comp Students, SS Use Written, EarthSci Use Text, SS Recorded, Astro Use Text, Astro Outside Comp Teachers, EarthSci Inside Comp Students, Astro Outside Comp Students, SS Inside Comp Teachers, EarthSci Outside Comp Teachers, SpaceSci Digital, SpaceSci Text, SS Inside Comp Students, SpaceSci Recorded, SS Digital, SpaceSci Outside Comp Students, SS Outside Comp Teachers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5.077	1.509		3.365	.001		
	EarthSci Use Text	-.267	.437	-.162	-.611	.544	.167	5.971
	EarthSci Use Written	.512	.386	.295	1.328	.189	.237	4.218
	EarthSci Use Worksheet	.655	.444	.342	1.476	.145	.219	4.571
	EarthSci Inside Comp Teachers	.157	.598	.046	.262	.794	.374	2.676
	EarthSci Inside Comp Students	-.310	.521	-.188	-.594	.554	.117	8.521
	EarthSci Outside Comp Teachers	-.453	.494	-.276	-.917	.362	.130	7.702
	EarthSci Outside Comp Students	.012	.360	.007	.032	.975	.253	3.949
	EarthSci Digital	.062	.504	.037	.123	.903	.130	7.681
	EarthSci Recorded	-.236	.374	-.115	-.631	.530	.354	2.829
	SpaceSci Text	.681	.536	.407	1.270	.208	.114	8.751
	Space Sci Written	-.701	.406	-.400	-1.728	.089	.219	4.569
	SpaceSci Worksheets	-.647	.497	-.313	-1.301	.198	.202	4.951
	SpaceSci Inside Comp Tchrs	.347	.855	.085	.406	.686	.269	3.717
	SpaceSci Inside Comp Students	-.443	.557	-.260	-.795	.429	.110	9.101
	SpaceSci Outside Comp Tchrs	.436	.736	.258	.592	.556	.062	16.148
	SpaceSci Outside Comp Students	.628	.716	.363	.877	.384	.068	14.606
	SpaceSci Digital	-.256	.620	-.153	-.413	.681	.086	11.644
	SpaceSci Recorded	.173	.774	.081	.224	.823	.091	11.030
	SS Use Text	-.198	.485	-.122	-.408	.684	.132	7.559
	SS Use Written	-.182	.419	-.106	-.433	.667	.196	5.090
	SS Use Worksheet	-.114	.417	-.057	-.272	.786	.263	3.803
	SS Inside Comp Teachers	-.481	1.049	-.117	-.458	.648	.178	5.610
	SS Inside Comp Students	1.254	.564	.761	2.224	.030	.100	10.002
	SS Outside Comp Teachers	-.062	.679	-.038	-.092	.927	.068	14.654
	SS Outside Comp Students	-.252	.431	-.152	-.585	.561	.174	5.745
	SS Digital	-.169	.627	-.103	-.269	.789	.080	12.568
	SS Recorded	-.560	.770	-.249	-.727	.470	.100	9.992
	Astro Use Text	-.404	.507	-.229	-.797	.428	.141	7.074
	Astro Use Written	.395	.335	.220	1.180	.242	.338	2.957
	Astro Use Worksheet	-.162	.408	-.086	-.397	.693	.249	4.019
	Astro Inside Comp Teachers	-.788	.630	-.213	-1.250	.216	.404	2.478
	Astro Inside Comp Students	-.462	.463	-.261	-.998	.322	.171	5.860
	Astro Outside Comp Teachers	.167	.471	.094	.354	.724	.167	6.004
	Astro Outside Comp Students	-.402	.612	-.224	-.657	.513	.101	9.902
	Astro Digital	.532	.438	.301	1.214	.229	.190	5.256
	Astro Recorded	.797	.663	.357	1.202	.234	.133	7.545

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a moderate correlation between
RESOURCES and ABILITY CONTENT KNOWLEDGE

Model 1 r=.476, N= 102 R^2 = .227, F (36,66) =.537, P=.977, >.05 (not significant)

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix R. Middle-School Teachers Multiple Regressions, Page 29.

APPENDIX S.

MULTIPLE REGRESSIONS

HIGH-SCHOOL TEACHERS

Independent Variable: **A. EXPERIENCE HIGH-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.346[a]	.120	.110	.900	.120	12.130	1	89	.001

a. Predictors: (Constant), Years Teaching ESS

b. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.824	1	9.824	12.130	.001[b]
	Residual	72.079	89	.810		
	Total	81.902	90			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Years Teaching ESS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.864	.184		15.558	.000		
	Years Teaching ESS	.291	.083	.346	3.483	.001	1.000	1.000

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate correlation between
RESOURCES and ABILITY CONTENT KNOWLEDGE

Model 1 r =.346, N= 90 R^2 = .120, F (1, 89) =12.130, P=.001, <.01 (highly significant)

Models 1 is highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 2

Independent Variable: **A. EXPERIENCE HIGH-SCHOOL TEACHERS**
DEPENDENT VARIABLE **3. ABILITY SUBJECT KNOWLEDGE CURRENCY**
Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.327[a]	.107	.097	.909	.107	10.671	1	89	.002
2	.402[b]	.162	.142	.886	.054	5.716	1	88	.019

a. Predictors: (Constant), Yrs Teaching Astronomy
b. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci
c. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.813	1	8.813	10.671	.002[b]
	Residual	73.508	89	.826		
	Total	82.321	90			
2	Regression	13.297	2	6.648	8.476	.000[c]
	Residual	69.024	88	.784		
	Total	82.321	90			

a. Dependent Variable: How Current Knowledge of Subject
b. Predictors: (Constant), Yrs Teaching Astronomy
c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.837	.183		15.545	.000		
	Yrs Teaching Astronomy	.305	.093	.327	3.267	.002	1.000	1.000
2	(Constant)	3.173	.227		13.995	.000		
	Yrs Teaching Astronomy	.341	.092	.365	3.693	.000	.974	1.026
	Yrs Teaching Life Sci	-.152	.064	-.236	-2.391	.019	.974	1.026

a. Dependent Variable: How Current Knowledge of Subject

There was a moderate correlation between
RESOURCES and ABILITY KNOWLEDGE CURRENCY

Model 1 r =.327, N= 90 R^2 = .107, F (1, 89) =10.671, P=.002, <.01 (highly significant)
Model 2 r =.402, N= 90 R^2 = .162, F (2, 88) =8.476, P=.000, <.01 (highly significant)

Models 1 is highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 3

Independent Variable: **A. EXPERIENCE HIGH-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.299[a]	.090	.079	.902	.090	8.749	1	89	.004

a. Predictors: (Constant), Yrs Teaching Astronomy

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.116	1	7.116	8.749	.004[b]
	Residual	72.390	89	.813		
	Total	79.506	90			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), Yrs Teaching Astronomy

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.679	.181		14.790	.000		
	Yrs Teaching Astronomy	.274	.093	.299	2.958	.004	1.000	1.000

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a moderate correlation between
RESOURCES and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 r = .299, N= 90 R^2 = .090, F (1, 89) =8.749, P=.004, <.01 (highly significant)

Models 1 is highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 4

Independent Variable: **A. EXPERIENCE HIGH-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.295[a]	.087	.077	.931	.087	8.486	1	89	.005
2	.362[b]	.131	.111	.913	.044	4.437	1	88	.038

a. Predictors: (Constant), Yrs Teaching Astronomy

b. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci

c. Dependent Variable: Self Appraisal of Preparedness as Instructor

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ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.353	1	7.353	8.486	.005[b]
	Residual	77.117	89	.866		
	Total	84.469	90			
2	Regression	11.054	2	5.527	6.625	.002[c]
	Residual	73.415	88	.834		
	Total	84.469	90			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), Yrs Teaching Astronomy

c. Predictors: (Constant), Yrs Teaching Astronomy, Yrs Teaching Life Sci

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Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.819	.187		15.082	.000		
	Yrs Teaching Astronomy	.279	.096	.295	2.913	.005	1.000	1.000
2	(Constant)	3.125	.234		13.363	.000		
	Yrs Teaching Astronomy	.311	.095	.329	3.269	.002	.974	1.026
	Yrs Teaching Life Sci	-.138	.066	-.212	-2.106	.038	.974	1.026

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

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There was a weak to moderate correlation between
RESOURCES and ABILITY INSTRUCTOR PREPAREDNESS
Model 1 r = .295, N= 90 R^2 = .090, F (1, 89) =8.749, P=.004, <.01 (highly significant)
Model 2 r = .362, N= 90 R^2 = .090, F (1, 89) =8.749, P=.004, <.01 (highly significant)
Models 1 and 2 are highly predictive

Independent Variable: **B. EDUCATION HIGH-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Method: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.220[a]	.048	.037	.86085	.048	4.505	1	89	.037

a. Predictors: (Constant), Education Training

b. Dependent Variable: ABILITY AVERAGE

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.339	1	3.339	4.505	.037[b]
	Residual	65.955	89	.741		
	Total	69.293	90			

a. Dependent Variable: ABILITY AVERAGE

b. Predictors: (Constant), Education Training

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.638	.309		8.545	.000		
	Education Training	.468	.221	.220	2.123	.037	1.000	1.000

a. Dependent Variable: ABILITY AVERAGE

There was a weak correlation between EDUCATION and ABILITY AVERAGE

Model 1 r = .220, N= 90 R^2 = .048, F (1, 89) =4.505, P=.037, >.05 (significant)

Model 1 is predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix S. High-School Teachers Multiple Regressions, Page 6

Independent Variable: **B. EDUCATION HIGH-SCHOOL TEACHERS**
Dependent Variable **2. ABILITY SUBJECT KNOWLEDGE**

Method: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.346[a]	.120	.068	.921	.120	2.317	5	85	.050

a. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Highest Degree Earned, Most Recent Training, Major

b. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.825	5	1.965	2.317	.050[b]
	Residual	72.078	85	.848		
	Total	81.902	90			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Highest Degree Earned, Most Recent Training, Major

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.234	.538		4.154	.000		
	Highest Degree Earned	-.114	.089	-.139	-1.283	.203	.882	1.134
	Major	.158	.128	.141	1.227	.223	.787	1.270
	Education Training	.601	.265	.259	2.265	.026	.791	1.264
	Most Recent Training	.108	.061	.189	1.752	.083	.894	1.119
	NonCredTraining in Last 5 years	.241	.200	.127	1.207	.231	.936	1.069

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a modest correlation between EDUCATION and ABILITY SUBJECT KNOWLEDGE

Model 1 r = . 346, N= 90 R^2 = .020, F (5, 85) =2.317, P=.050, (significant)

Models 1 is predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix S. High-School Teachers Multiple Regressions, Page 7

Independent Variable: **B. EDUCATION HIGH-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY KNOWLEDGE CURRENCY**

Method: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.220[a]	.049	-.007	.960	.049	.868	5	85	.506

a. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Highest Degree Earned, Most Recent Training, Major

b. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.999	5	.800	.868	.506[b]
	Residual	78.322	85	.921		
	Total	82.321	90			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Highest Degree Earned, Most Recent Training, Major

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.632	.561		4.695	.000		
	Highest Degree Earned	.031	.092	.038	.338	.736	.882	1.134
	Major	.027	.134	.024	.202	.840	.787	1.270
	Education Training	.424	.277	.182	1.534	.129	.791	1.264
	Most Recent Training	-.059	.064	-.103	-.923	.358	.894	1.119
	NonCredTraining in Last 5 years	.233	.208	.123	1.120	.266	.936	1.069

a. Dependent Variable: How Current Knowledge of Subject

There was a weak correlation between
EDUCATION and ABILITY KNOWLEDGE CURRENCY

Model 1 r = . 220, N= 90 **R^2 = .049, F (5, 85) =.868, P=.506, >.05 (not significant)**

Models 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix S. High-School Teachers Multiple Regressions, Page 8

Independent Variable: **B. EDUCATION HIGH-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.226[a]	.051	.040	.921	.051	4.796	1	89	.031

a. Predictors: (Constant), Education Training

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.065	1	4.065	4.796	.031[b]
	Residual	75.441	89	.848		
	Total	79.506	90			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), Education Training

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.444	.330		7.402	.000		
	Education Training	.517	.236	.226	2.190	.031	1.000	1.000

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak correlation between
EDUCATION and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 **r = .** 226, **N= 90** **R^2 = .051, F (1, 89) =4.796, P=.031, <.05 (significant)**

Models 1 is predictive

Appendix S. High-School Teachers Multiple Regressions, Page 9

Independent Variable: **B. EDUCATION HIGH-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Method: ENTER
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.175[a]	.031	-.026	.981	.031	.538	5	85	.747

a. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Highest Degree Earned, Most Recent Training, Major

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.593	5	.519	.538	.747[b]
	Residual	81.876	85	.963		
	Total	84.469	90			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), NonCredTraining in Last 5 years, Education Training, Highest Degree Earned, Most Recent Training, Major

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.886	.573		5.034	.000		
	Highest Degree Earned	-.031	.094	-.038	-.333	.740	.882	1.134
	Major	-.010	.137	-.009	-.072	.943	.787	1.270
	Education Training	.344	.283	.146	1.217	.227	.791	1.264
	Most Recent Training	-.029	.065	-.050	-.445	.657	.894	1.119
	NonCredTraining in Last 5 years	.200	.213	.104	.941	.349	.936	1.069

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak correlation between
EDUCATION and ABILITY INSTRUCTOR PREPAREDNESS

Model 1 r = .175**, N= 90 R^2 = .031, F (5, 85) =.538, P=.747, >.05 (not significant)**

Models 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix S. High-School Teachers Multiple Regressions, Page 10

Independent Variable: **C. COMMUNITY HIGH-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.219[a]	.048	.037	.86093	.048	4.488	1	89	.037
2	.312[b]	.097	.077	.84321	.049	4.780	1	88	.031
3	.400[c]	.160	.131	.81778	.063	6.558	1	87	.012

a. Predictors: (Constant), Degree of Support from Grants

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Teachers Out of Dist

c. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Teachers Out of Dist, Degree of Support from Coleges

d. Dependent Variable: ABILITY AVERAGE

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.327	1	3.327	4.488	.037[b]
	Residual	65.967	89	.741		
	Total	69.293	90			
2	Regression	6.725	2	3.363	4.730	.011[c]
	Residual	62.568	88	.711		
	Total	69.293	90			
3	Regression	11.111	3	3.704	5.538	.002[d]
	Residual	58.182	87	.669		
	Total	69.293	90			

a. Dependent Variable: ABILITY AVERAGE

b. Predictors: (Constant), Degree of Support from Grants

c. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Teachers Out of Dist

d. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Teachers Out of Dist, Degree of Support from Coleges

Appendix S. High-School Teachers Multiple Regressions, Page 11

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.143	.107		29.369	.000		
	Degree of Support from Grants	.238	.113	.219	2.119	.037	1.000	1.000
2	(Constant)	3.326	.134		24.795	.000		
	Degree of Support from Grants	.317	.116	.291	2.735	.008	.904	1.107
	Degree of Support from Teachers Out of Dist	-.205	.094	-.233	-2.186	.031	.904	1.107
3	(Constant)	3.122	.153		20.461	.000		
	Degree of Support from Grants	.255	.115	.234	2.216	.029	.863	1.158
	Degree of Support from Teachers Out of Dist	-.307	.099	-.348	-3.090	.003	.760	1.317
	Degree of Support from Coleges	.241	.094	.290	2.561	.012	.754	1.326

a. Dependent Variable: ABILITY AVERAGE

There was a weak to moderate correlation between COMMUNITY and ABILITY AVERAGE

Model 1 r = .215, N= 90 **R^2 = .048, F (1, 89) =4.488, P=.037, <.05 (significant)**
Model 2 r = .312, N= 90 **R^2 = .097, F (2, 88) =4.730, P=.011, <.05 (significant)**
Model 3 r = .400, N= 90 **R^2 = .0160, F (3, 87) =5.538, P=.002, <.01 (highly significant)**

Models 1,2 are predictive; Model 3 is highly predictive.

Independent Variable: **C. COMMUNITY HIGH-SCHOOL TEACHERS**
Dependent Variable **2. ABILITY SUBJECT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[c]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.300[a]	.090	.080	.915	.090	8.777	1	89	.004
2	.441[b]	.194	.176	.866	.105	11.426	1	88	.001

a. Predictors: (Constant), Degree of Support from Coleges

b. Predictors: (Constant), Degree of Support from Coleges, Degree of Support from Teachers Out of Dist

c. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.352	1	7.352	8.777	.004[b]
	Residual	74.551	89	.838		
	Total	81.902	90			
2	Regression	15.919	2	7.960	10.615	.000[c]
	Residual	65.983	88	.750		
	Total	81.902	90			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), Degree of Support from Coleges

c. Predictors: (Constant), Degree of Support from Coleges, Degree of Support from Teachers Out of Dist

Appendix S. High-School Teachers Multiple Regressions, Page 13

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	3.025	.163		18.586	.000		
	Degree of Support from Coleges	.271	.091	.300	2.963	.004	1.000	1.000
2	(Constant)	3.187	.161		19.762	.000		
	Degree of Support from Coleges	.422	.097	.467	4.334	.000	.789	1.267
	Degree of Support from Teachers Out of Dist	-.349	.103	-.364	-3.380	.001	.789	1.267

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate correlation between
COMMUNITY and ABILITY SUBJECT KNOWLEDGE

Model 1 **r = .**300**, N= 90** **R^2 = .090, F (1, 89) =8.777, P=.004, <.01 (highly significant)**

Model 2 **r = .**441**, N= 90** **R^2 = .194, F (2, 88) =10.615, P=.000, .01 (highly significant)**

Models 1,2 are highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 14

Independent Variable: **C. COMMUNITY HIGH-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY KNOWLEDGE CURRENCY**
Method: Enter
All variables Entered

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.429[a]	.184	.104	.905	.184	2.311	8	82	.027

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Museums , Degree of Support from District, Degree of Support from Community SME, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Coleges

b. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.147	8	1.893	2.311	.027[b]
	Residual	67.174	82	.819		
	Total	82.321	90			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Museums , Degree of Support from District, Degree of Support from Community SME, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Coleges

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Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	3.454	.223		15.499	.000		
	Degree of Support from District	-.019	.095	-.022	-.196	.845	.803	1.246
	Degree of Support from Local Teachers	-.105	.104	-.112	-1.011	.315	.810	1.235
	Degree of Support from Teachers Out of Dist	-.287	.119	-.299	-2.420	.018	.650	1.538
	Degree of Support from Coleges	.211	.136	.234	1.556	.123	.442	2.263
	Degree of Support from Museums	.083	.126	.084	.659	.512	.616	1.623
	Degree of Support from Community SME	.129	.115	.132	1.124	.264	.719	1.391
	Degree of Support from Internet SME	-.149	.118	-.165	-1.260	.211	.578	1.730
	Degree of Support from Grants	.223	.131	.188	1.701	.093	.816	1.226

a. Dependent Variable: How Current Knowledge of Subject

There was a moderate correlation between
COMMUNITY and ABILITY KNOWLEDGE CURRENCY
Model 1 r = .429**, N= 90** **R^2 = .184, F (8, 82) =2.311, P=.027, <.05 (significant)**
Models 1 is predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix S. High-School Teachers Multiple Regressions, Page 15

Independent Variable: **C. COMMUNITY HIGH-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**
Method: Enter
All variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.375[a]	.140	.056	.941	.140	1.672	8	82	.118

a. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Museums , Degree of Support from District, Degree of Support from Community SME, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Coleges

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.849	8	1.481	1.672	.118[b]
	Residual	72.620	82	.886		
	Total	84.469	90			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), Degree of Support from Grants, Degree of Support from Local Teachers, Degree of Support from Museums , Degree of Support from District, Degree of Support from Community SME, Degree of Support from Teachers Out of Dist, Degree of Support from Internet SME, Degree of Support from Coleges

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.230	.232		13.941	.000		
	Degree of Support from District	.101	.098	.117	1.028	.307	.803	1.246
	Degree of Support from Local Teachers	-.147	.108	-.155	-1.359	.178	.810	1.235
	Degree of Support from Teachers Out of Dist	-.295	.123	-.303	-2.386	.019	.650	1.538
	Degree of Support from Coleges	.057	.141	.063	.406	.685	.442	2.263
	Degree of Support from Museums	.027	.131	.027	.205	.838	.616	1.623
	Degree of Support from Community SME	.133	.119	.134	1.111	.270	.719	1.391
	Degree of Support from Internet SME	.047	.123	.052	.386	.701	.578	1.730
	Degree of Support from Grants	.213	.136	.177	1.563	.122	.816	1.226

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a moderate correlation between
COMMUNITY and ABILITY INSTRUCTOR PREPAREDNESS
Model 1 r = .375, N= 90 **R^2 = .140, F (8, 82) =1.672, P=.118, >.05 (not significant)**

Model 1 is not predictive
Note: when positive results were not identified using *STEPWISE* method, *ENTER* was used.

Appendix S. High-School Teachers Multiple Regressions, Page 16

Independent Variable: **D. CURRICULUM** **HIGH-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.298[a]	.089	.078	.87223	.089	8.082	1	83	.006

a. Predictors: (Constant), How Establishd ESS Curric

b. Dependent Variable: ABILITY AVERAGE

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.149	1	6.149	8.082	.006[b]
	Residual	63.145	83	.761		
	Total	69.293	84			

a. Dependent Variable: ABILITY AVERAGE

b. Predictors: (Constant), How Establishd ESS Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.620	.246		10.661	.000		
	How Establishd ESS Curric	.244	.086	.298	2.843	.006	1.000	1.000

a. Dependent Variable: ABILITY AVERAGE

There was a moderate correlation between CURRICULUM and ABILITY AVERAGE

Model 1 r = .298, N= 84 R^2 = .089, F (1, 83) =8.082, P=.006, <.01 (highly significant)

Models 1 is highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 17

Independent Variable: **D. CURRICULUM HIGH-SCHOOL TEACHERS**
Dependent Variable **2. ABILITY SUBJECT CONTENT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.271[a]	.074	.062	.956	.074	6.592	1	83	.012

a. Predictors: (Constant), How Establishd Astronomy Curric

b. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.026	1	6.026	6.592	.012[b]
	Residual	75.876	83	.914		
	Total	81.902	84			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), How Establishd Astronomy Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.867	.237		12.095	.000		
	How Establishd Astronomy Curric	.212	.083	.271	2.568	.012	1.000	1.000

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate correlation between

CURRICULUM and ABILITY SUBJECT CONTENT KNOWLEDGE

Model 1 r = .271, N= 84 R^2 = .074, F (1, 83) =6.592, P=.012, <.05 (significant)

Models 1 is predictive

Appendix S. High-School Teachers Multiple Regressions, Page 18

Independent Variable: **D. CURRICULUM HIGH-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY KNOWLEDGE CURRENCY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.279[a]	.078	.067	.956	.078	7.014	1	83	.010

a. Predictors: (Constant), How Establishd ESS Curric

b. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.415	1	6.415	7.014	.010[b]
	Residual	75.906	83	.915		
	Total	82.321	84			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), How Establishd ESS Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.687	.269		9.971	.000		
	How Establishd ESS Curric	.249	.094	.279	2.648	.010	1.000	1.000

a. Dependent Variable: How Current Knowledge of Subject

There was a weak correlation between

CURRICULUM and ABILITY KNOWLEDGE CURRENCY

Model 1 r = .271, N= 84 R^2 = .078, F (1, 83) =7.014, P=.010, (highly significant)

Models 1 is highly predictive

Independent Variable: **D. CURRICULUM HIGH-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.334[a]	.112	.101	.923	.112	10.425	1	83	.002

a. Predictors: (Constant), How Establishd ESS Curric

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.872	1	8.872	10.425	.002[b]
	Residual	70.634	83	.851		
	Total	79.506	84			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), How Establishd ESS Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.361	.260		9.083	.000		
	How Establishd ESS Curric	.293	.091	.334	3.229	.002	1.000	1.000

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a moderate correlation between

CURRICULUM and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 r = .334, N= 84 R^2 = .112, F (1, 83) =10.425, P=.002, <.01 (highly significant)

Models 1 is highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 20

Independent Variable: **D. CURRICULUM HIGH-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.265[a]	.070	.059	.973	.070	6.277	1	83	.014

a. Predictors: (Constant), How Establishd ESS Curric

b. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.939	1	5.939	6.277	.014[b]
	Residual	78.530	83	.946		
	Total	84.469	84			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), How Establishd ESS Curric

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.650	.274		9.669	.000		
	How Establishd ESS Curric	.240	.096	.265	2.505	.014	1.000	1.000

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a weak correlation between

CURRICULUM and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 r = .265, N= 84 **R^2 = .070, F (1, 83) =6.277, P=.014, <.05 (significant)**

Models 1 is predictive

Appendix S. High-School Teachers Multiple Regressions, Page 21

Independent Variable: **E. RESOURCES** **HIGH-SCHOOL TEACHERS**
Dependent Variable **1. ABILITY AVERAGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). All requested variables Entered

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.414[a]	.171	.161	.83173	.171	17.168	1	83	.000
2	.504[b]	.254	.236	.79407	.082	9.060	1	82	.003

a. Predictors: (Constant), Astro Digital

b. Predictors: (Constant), Astro Digital, SS Recorded

c. Dependent Variable: ABILITY AVERAGE

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.876	1	11.876	17.168	.000[b]
	Residual	57.417	83	.692		
	Total	69.293	84			
2	Regression	17.589	2	8.794	13.947	.000[c]
	Residual	51.705	82	.631		
	Total	69.293	84			

a. Dependent Variable: ABILITY AVERAGE

b. Predictors: (Constant), Astro Digital

c. Predictors: (Constant), Astro Digital, SS Recorded

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.936	.333		5.808	.000		
	Astro Digital	.907	.219	.414	4.143	.000	1.000	1.000
2	(Constant)	.783	.498		1.572	.120		
	Astro Digital	.758	.215	.346	3.526	.001	.946	1.057
	SS Recorded	.766	.255	.295	3.010	.003	.946	1.057

a. Dependent Variable: ABILITY AVERAGE

There was a moderate correlation between

RESOURCES and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 r = .414, N= 84 **R^2 = .171, F (1, 83) =17.168, P=.000, <.01 (highly significant**
Model 2 r = .504, N= 84 **R^2 = .254, F (2, 82) =13.947, P=.000, <.01 (highly significant)**

Models 1 and 2 are highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 22

Independent Variable: **E. RESOURCES HIGH-SCHOOL TEACHERS**
Dependent Variable **2. ABILITY CONTENT KNOWLEDGE**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). All requested variables Entered

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.424[a]	.180	.170	.899	.180	18.229	1	83	.000
2	.507[b]	.257	.239	.862	.077	8.469	1	82	.005
3	.546[c]	.298	.272	.842	.041	4.774	1	81	.032

a. Predictors: (Constant), EarthSci Recorded

b. Predictors: (Constant), EarthSci Recorded, Astro Digital

c. Predictors: (Constant), EarthSci Recorded, Astro Digital, SpaceSci Text

d. Dependent Variable: Adequacy in Knowlege of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.749	1	14.749	18.229	.000[b]
	Residual	67.154	83	.809		
	Total	81.902	84			
2	Regression	21.035	2	10.517	14.169	.000[c]
	Residual	60.867	82	.742		
	Total	81.902	84			
3	Regression	24.423	3	8.141	11.472	.000[d]
	Residual	57.480	81	.710		
	Total	81.902	84			

a. Dependent Variable: Adequacy in Knowlege of Subject

b. Predictors: (Constant), EarthSci Recorded

c. Predictors: (Constant), EarthSci Recorded, Astro Digital

d. Predictors: (Constant), EarthSci Recorded, Astro Digital, SpaceSci Text

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.082	.555		1.951	.054		
	EarthSci Recorded	1.304	.305	.424	4.270	.000	1.000	1.000
2	(Constant)	.483	.570		.848	.399		
	EarthSci Recorded	1.080	.303	.351	3.570	.001	.935	1.069
	Astro Digital	.682	.235	.286	2.910	.005	.935	1.069
3	(Constant)	1.352	.685		1.974	.052		
	EarthSci Recorded	1.028	.297	.335	3.466	.001	.929	1.076
	Astro Digital	.732	.230	.307	3.176	.002	.926	1.080
	SpaceSci Text	-.554	.253	-.205	-2.185	.032	.987	1.013

a. Dependent Variable: Adequacy in Knowlege of Subject

There was a moderate correlation between

RESOURCES and ABILITY CONTENT KNOWLEDGE

Model 1 r = .424, N= 84 R^2 = .180, F (1, 83) =18.229, P=.000, <.01 (highly significant)
Model 2 r = .507, N= 84 R^2 = .257, F (2, 82) =14.169, P=.806, <.01 (highly significant)
Model 3 r = .546, N= 84 R^2 = .298, F (3, 81) =11.472, P=.806, <.01 (highly significant)

Models 1, 2 and 3 are highly predictive

Independent Variable: **E. RESOURCES** **HIGH-SCHOOL TEACHERS**
Dependent Variable **3. ABILITY KNOWLEDGE CURRENCY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
All requested variables Entered

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.219[a]	.048	.038	.913	.048	5.081	1	101	.026
2	.301[b]	.091	.073	.896	.043	4.712	1	100	.032

a. Predictors: (Constant), Astro Recorded

b. Predictors: (Constant), Astro Recorded, Astro Digital

c. Dependent Variable: How Current Knowledge of Subject

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.404	1	16.404	20.655	.000[b]
	Residual	65.917	83	.794		
	Total	82.321	84			
2	Regression	25.899	2	12.949	18.819	.000[c]
	Residual	56.422	82	.688		
	Total	82.321	84			

a. Dependent Variable: How Current Knowledge of Subject

b. Predictors: (Constant), Astro Digital

c. Predictors: (Constant), Astro Digital, Astro Inside Comp Teachers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.783	.357		4.993	.000		
	Astro Digital	1.066	.235	.446	4.545	.000	1.000	1.000
2	(Constant)	.063	.570		.110	.912		
	Astro Digital	.863	.225	.361	3.834	.000	.941	1.063
	Astro Inside Comp Teachers	1.104	.297	.350	3.715	.000	.941	1.063

a. Dependent Variable: How Current Knowledge of Subject

There was a weak to moderate correlation between

RESOURCES and ABILITY KNOWLEDGE CURRENCY

Model 1 r = .219, N= 84 R^2 = .199, F (1,83) =20.655, P=.000, <.01 (highly significant)
Model 2 r = .301, N= 84 R^2 = .315, F (2, 82) =18.819, P=.000, <.01 (highly significant)

Models 1 and 2 are highly predictive

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Independent Variable: **E. RESOURCES** **HIGH-SCHOOL TEACHERS**
Dependent Variable **4. ABILITY INSTRUCTIONAL METHODOLOGY**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). All requested variables Entered

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.329[a]	.108	.097	.924	.108	10.041	1	83	.002

a. Predictors: (Constant), Astro Recorded

b. Dependent Variable: How Adequate Instructional Methodolgy

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.581	1	8.581	10.041	.002[b]
	Residual	70.926	83	.855		
	Total	79.506	84			

a. Dependent Variable: How Adequate Instructional Methodolgy

b. Predictors: (Constant), Astro Recorded

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.059	.663		1.597	.114		
	Astro Recorded	1.115	.352	.329	3.169	.002	1.000	1.000

a. Dependent Variable: How Adequate Instructional Methodolgy

There was a weak to moderate correlation between

RESOURCES and ABILITY INSTRUCTIONAL METHODOLOGY

Model 1 r = . 329, N= 84 R^2 = .108, F (1,83) =10.041, P=.002, <.01 (highly significant)

Models 1 is highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 25

Independent Variable: **E. RESOURCES** **HIGH-SCHOOL TEACHERS**
Dependent Variable **5. ABILITY INSTRUCTOR PREPAREDNESS**

Method: Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100). All requested variables Entered

Model Summary[c]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.376[a]	.141	.131	.935	.141	13.627	1	83	.000
2	.430[b]	.185	.165	.916	.044	4.384	1	82	.039

a. Predictors: (Constant), Astro Digital

b. Predictors: (Constant), Astro Digital, Astro Inside Comp Teachers

c. Dependent Variable: Self Appraisal of Preparedness as Instructor

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.913	1	11.913	13.627	.000[b]
	Residual	72.556	83	.874		
	Total	84.469	84			
2	Regression	15.595	2	7.798	9.284	.000[c]
	Residual	68.874	82	.840		
	Total	84.469	84			

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

b. Predictors: (Constant), Astro Digital

c. Predictors: (Constant), Astro Digital, Astro Inside Comp Teachers

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	1.952	.375		5.211	.000		
	Astro Digital	.909	.246	.376	3.692	.000	1.000	1.000
2	(Constant)	.881	.630		1.399	.166		
	Astro Digital	.782	.249	.323	3.144	.002	.941	1.063
	Astro Inside Comp Teachers	.688	.328	.215	2.094	.039	.941	1.063

a. Dependent Variable: Self Appraisal of Preparedness as Instructor

There was a moderate correlation between

RESOURCES and ABILITY INSTRUCTOR PREPAREDNESS

Model 1 r = . 376, N= 84 R^2 = .141, F (1,83) =13.627, P=.000, <.01 (highly significant)
Model 2 r = . 430, N= 84 R^2 = .185, F (2,82) =9.284, P=.000, <.01 (highly significant)

Models 1 and 2 are highly predictive

Appendix S. High-School Teachers Multiple Regressions, Page 26.

APPENDIX T

INTERVIEW QUESTIONS

EARTH & SPACE SCIENCE AND ASTRONOMY

Interview Questions

Time: _________ Room: _________ Older/Newer school: __________

Rural/city: _________ Size of school: ________ Grades in school:____________

Socio-economic profile: ___________

What does the classroom and areas surrounding the classroom look like: displays, posters, materials, experiments, tools?

If the interview takes place during the school day, is the teacher hurried and busy continuously?

Is the interview taking place before, during, after a class; during a free-period?

1. Would you prefer that your name, school or affiliations remain

A. Confidential – name, school, affiliation recorded but not revealed in any fashion

B. Anonymous – no connection recorded between responses and your name, school or affiliation

Interviewee name:____

School: ____

2. What courses are you currently teaching?

3. What grade level are the typical students?

4. How many classes/sections of this course are you teaching?

5. How long is each class period?

Appendix S. Interview Questions, Page 1

6. How many times per week?

7. How many students are in each class?

8. Are there additional sections/classes in the same school

9. Are there additional sections/classes in the same district

   Answers are recorded for each individual class/subject.

(Usually most teachers teach 1 or 2 subjects; teaching more than 2 subjects is less typical)

Class/subject   Grade level # sections length #/wk   # std/class   addl school   addl in district

A.4._____ 5.__________ 6._______ 7.___ 8.____ 9.____ 10. Y/N #__ 11. Y/N #__

B. 4. ____ 5.__________ 6._______ 7.____ 8.____ 9. ____ 10. Y/N #__ 11. Y/N #__

C. 4._ ___ 5.__________ 6._______ 7.____ 8.____ 9.____ 10. Y/N #__ 11. Y/N #__

D. 4. ____ 5.__________ 6._______ 7.____ 8.____ 9.____ 10. Y/N #__ 11. Y/N #__

10. What is the background of the students in the class?

    What science courses have they had previously?

    How knowledgeable are they when they come in?

    How interested are they?

    Did they sign up for this specific course as one alternative among several?

    Are they interested in specific topics?

11. Do you have a specific set of topics you cover for the course (try to get a syllabus or class schedule). Have you used the same topics and syllabus every year you have taught the course?

    If you have changed the course, why did you change it?

Appendix S. Interview Questions, Page 2

12. Do you have a typical teaching method?

- Lecture
- Reading
-
- Labs
- Library visits
- Computer work

13. What are your principal sources and resources for the course?

Do they have/use a text? Is it up-to-date? Other written materials?

Videos?

Pre-packaged educational units?

14. Do you use a specific set of ‘instruments’, tools or technology?

Telescopes

Globes

Computers/Computer programs

Model rockets

Other?

15. Are there specific activities you try to do, try to cover in the class?

- Constellations
- Celestial globes
- Model rockets
- Labs
- Other?

16. Do you have an adequate number of labs and activities?

Appendix S. Interview Questions, Page 3

17. Does your class ever go on field trips?
    Museums?   Space Center?   Other?

18. Is there a budget ?

    for procuring ?

- Tools - source material - supplies - other resources

    for field trips?

19. Where do you get the funds to support your activities?

- grants ?

    if so, what is the source of some of their grants?

20. Do you find you are competing for scarce resources with other courses? Instructors?
    Or are there essentially no resources available from year-to-year?

21. Do you students have access to computers

- In school
- Outside of school

22. Do your students do homework?
    How often is homework assigned?
    -if students do not do homework, is this:
    because of school requirements?
    Because it is anticipated students will not do the assigned work?

Appendix S. Interview Questions, Page 4

23. Have you had an opportunity for any professional development in these areas?

If so-

Can you identify specific

- activities
- classes
- conferences
- sponsors/hosts

24. How are your expenses associated with professional development covered?

- There are no expenses
- Professional development takes place in the school/district
- School/district provides resources
- External organization provides resources
- Professional development is offered by the host organization at no cost to the teacher/school

25. Which would you prefer or alternatively not take part in:

- Working with other teachers in the district or locally on your own time
- Working with others with similar interest on-line
- Professional development activities during in-service periods in the school/district
- Short classes/lectures
  - At conferences
  - 1-2 day, or week-end activities
  - week-long activities
  - local
  - travel
  - during vacation period (summer, winter break)

Appendix S. Interview Questions, Page 5

26. Are there specific needs that you are having difficulty locating, using, procuring?
- On-line
- Written materials
- Labs
- Lecturers from outside
- In-class activities
- Professional development
- Specific topics

27. Do you have a ‘support network’ for these subjects?
- Local teachers
- On-line
- Other local people
- Organizations
- Your department, school, district
- Regional resources
- State resources
- National resources
  - NASA?
  - USGS
  - Universities
  - Others?

28. How much ‘guidance’ do you get from you department, school, district, for what you must cover; how you must conduct activities?

29. Are there other subjects you believe I did not cover adequately that you would like to address?

Appendix S. Interview Questions, Page 6

30. Is there something specific you think would be helpful in better understanding your statements?

- Classroom logs
- Syllabus
- Schedules
- Activity sheets
- Student materials

Interview Questions

- Can you provide a copy of your class syllabus or outline of topics?
- Have you changed your syllabus or the order of topics from one year to the next?
- If so, why?
- Can you identify specific resources used for individual topics?
- Can you identify specific difficulties in presenting/assessing particular topics?
- What types of resources do you need but do not now have access to?

Can you recommend how the course can be taught more effectively

Appendix S. Interview Questions, Page 7.

APPENDIX U

LISTING OF KNOWN REPRESENTED SCHOOL DISTRICTS

1. Aldine
2. Alief
3. Allen
4. Allison
5. Alvin
6. Anderson
7. Anson
8. Anton
9. Arlington
10. Azle
11. Bastrop
12. Bay City
13. Beaumont
14. Blackwell
15. Brooks County
16. Brownsboro
17. Brownsville
18. Bryan
19. Burnham Wood
20. Burton
21. Channelview
22. Chapel Hill
23. Cleveland
24. Coleman
25. College Station
26. Conroe
27. Cornal
28. Corpus Christi
29. CY Fair
30. Dalhart
31. Dallas
32. Darrouzett
33. Delvalle
34. Dickinson
35. Donna
36. Duncanville
37. Eagle Mountain - Saginaw
38. Elkhart
39. Evarman
40. Forney
41. Fort Bend
42. Fort Elliott
43. Fort Worth
44. Frisco
45. Galveston
46. Garland
47. Gatesville
48. Godley
49. Grand Prairie
50. Harlandale
51. Harlingen
52. High Island
53. Highland Park
54. Houston
55. Humble
56. Hutto
57. Irving
58. Joshua
59. Judson
60. Killeen
61. Krum
62. La Joya
63. Leander
64. Little Elm
65. Loraine
66. Lovejoy
67. Lytle
68. McAllen
69. McLeod
70. Midland
71. Midlothian
72. Mullin
73. New Home
74. Normangee
75. North Zulch
76. Paradise
77. Pasadena
78. Pflugerville
79. Pharr San Juan
80. Alamo
81. Poteet
82. Prosper
83. Raymondville
84. Richardson
85. River Road
86. Robstown
87. Roosevelt
88. Rosebud Lott
89. Round Rock
90. Sabinal ISD
91. San Angelo
92. San Antonio
93. Sealy
94. Shallowater
95. Shamrock
96. So San Antonio
97. Spring
98. Spur
99. Tyler
100. Vidor
101. Waco
102. Washington Twp
103. Wells
104. Whitehouse
105. Wimberly

Note: respondents were free to not provide identifying information therefore only those districts identified by respondents are reflected.

Appendix U. Listing of known represented school districts

VITA

Gary H. Kitmacher grew up in Pittsfield, Massachusetts, the son of Albert Kitmacher and Pearl Harris Kitmacher. His father had been a slave laborer in Hitler's NAZI Germany, working for a time in missile and aircraft factories; the rest of his father's family were murdered by the NAZIs during World War II. His mother had been a US Navy WAVE during WWII.

Gary H. Kitmacher became interested in everything about space flight and aviation at an early age, growing up with the US and Russian space programs. He was active in the Boy Scouts and the Civil Air Patrol, which provided him with a scholarship for flight training that afforded him the opportunities to experience zero-G and to solo before he had a driver's license. He was an avid reader, space memorabilia collector, amateur photographer, amateur astronomer, scale modeler and radio control modeler. As a teenager he put on programs in the schools of Pittsfield, Massachusetts and for the Boy Scouts, demonstrating how men would one day walk on the moon.

As an undergraduate at the University of Massachusetts, he studied planetary geology and worked at the Amherst College Bassett Planetarium. After graduation he worked at the Smithsonian Einstein Spacearium and the Smithsonian Center for Earth and Planetary Study during the inaugural year of the Air and Space Museum. Later he took a position as a Planetarium Director and taught college and high school astronomy, physics and earth science.

Kitmacher joined the staff of the NASA Johnson Space Center in Houston, Texas in 1981. He served as a subsystem manager for the Space Shuttle. His Master's Thesis at the University of Houston, Clear Lake, included development of a financial model used to identify prospective companies to sponsor payloads that would fly on the Shuttle. Later he was responsible for the development and integration of payloads on the commercial Spacehab. From 1993-2000 he led NASA operations and integration on the Russian Mir orbital station, leading negotiation of the contracts and international agreements that established the program and subsequently leading redesign of the Russian Priroda module to house US astronauts and equipment. As the Man-Systems architect for the space station he helped to define the design of the station's inhabited modules. He established the initial design and began development of the International Space Station Cupola observation deck, often called the astronauts' favorite place in space because of its expansive views. Kitmacher authored and illustrated the Reference Guide to the International Space Station; it has served as a primary text for astronauts and the public and was nominated for the Eugene Emme Astronautical Literature award. The website based on the book won the 2007 Adobe Max international award.

EDUCATION

D.Ed., University of Houston, Education, Curriculum and Instruction; Advisor, B.R.Robin.
M.B.A., University of Houston-Clear Lake, Management and Marketing; Advisor, O.W.Baskin.
B.S., University of Massachusetts, Geology, minors: Astronomy, Education; Advisor, G.E.McGill

HONORS AND AWARDS

Smithsonian Certificate of Appreciation, 2008
Adobe MAX Award. 2007.
NASA Exceptional Achievement Medal, 2007
National Nomination, American Astronautical Society, Emme Award in Literature
NASA Achievement Award, 2005
Performance Awards. 1985-2009
NASA/Mir Achievement Award. 1998.
NASA Silver Snoopy Award. 1997.
NASA Special ACT/Service Award for Program Management, 1997.
NASA Distinguished Service Award,1996.
NASA Commendation for Leadership.1996.
NASA Certificate of Commendation, (NASA-Mir Program Management). 1996.
NASA Expeditionary Award. 1996.
NASA Superior Achievement Award. 1996.
NASA Special Award. 1996.
NASA Certificate of Commendation. (Spacehab-Space Commercialization). 1994.
NASA Special Service Award. 1994.
NASA Group Achievement Awards
Research and Technology Development Report. 2008.
NASA/Mir. 1998.
Spacehab Commercial Middeck Augmentation Module. 1994.
Space Exploration Initiative. 1991.
Space Station. 1988.
Strategic Planning. 1987.
Space Shuttle Configuration Management. 1985.
Management Systems. 1984.
Shuttle Orbiter Flight Test Program. 1984.
NASA Outstanding Speaker Award. 1991.
NASA Distinguished Lecturer Award. 1992, 1990, 1989, 1988.1987, 1986.
NASA Sustained Superior Performance Awards. 1987-1990.
Presidential Commission on Investigation of the Challenger Accident, Certificate, 1986.
Skylab Student Experimenter Certificate, 1972.
Space Shuttle crew personal awards: many missions.

Academic Honors

M.B.A. awarded magna cum laude
B.S. awarded cum laude

Chairmanships and Leadership Positions

Principal Investigator, SDTO 27001-u: PhotoSynth International Space Station Test. (2007).
Chairman, Communications Education and Outreach Working Group (2001-2003).
Subsystem Manager, Space Station Crew Health Care and Exercise Systems. (2000-2001).

Chairman, Trash and Waste Integration Group. Space Station Program. (1999-2000).
Chairman, Hardware Acceptance Review Panel, Space Station Program. (1998-1999).
Chairman, Chair, NASA-Mir Operations and Integration Working Group. (1996-1999).
Manager, Priroda Project; Chairman, Configuration Control Board. (1993-1996).
Mission Manager, STS-57, Spacehab-1; STS-60, Spacehab-2. (1992-1994).
Utilization Planning Manager, Spacehab Commercial Middeck Module. (1991-1993).
Deputy Chairman, Man-Systems Configuration Control Board. (1988-1990).
Systems Architect, Space Exploration Initiative Man-Systems. (1989-1991).
Systems Architect. Space Station Man-Systems. (1986-1989).
Manager, Space Station Man-Systems Architectural Control Document. (1986-1989).
Subsystem Manager, Space Shuttle Crew Equipment and Stowage. (1985-1986).
Secretary, Space Shuttle Program Requirements Change Board. (1981-1984).

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Science Teachers Association of Texas, 2013, 2012.
Texas Earth Science Teachers Association. 2013.
University of Houston, Health and Human Performance Department, 2007-2013.
Houston ExxonMobil Club, 2010.
University of Houston. College of Education. Human Performance Department. 2009.
Dallas/Ft. Worth Aerospace Forum, 2009.
Irving Central Library, 2009.
University of Texas-Arlington, 2009.
Victoria Public Library, 2009.
University of Houston-Clear Lake, Space Center Lecture Series.
Strategic Air and Space Museum, Nebraska.
Kearney, Nebraska Boy Scouts, 2008.
Smithsonian Institution, 2008.
German ‘Space Day’, New Brandenberg, Germany, 2007.
Experimental Aircraft Association AirVenture, Oshkosh, WI, 2007, 2003, 2001.
Panola College, 2005.
Houston Science Café, 2005.
Mars Society, Houston, 2005.
Wesleyan University Astronomical Society. 2005.
Parks College, St. Louis University. 2004.
Engineering in Extreme Environments Conference. 2004.
Wright Brothers 100^{th} Anniversary, Kill Devil Hill, NC. 2003.
Wright Brothers 100^{th} Anniversary, Dayton, Ohio. 2003.
American Chemical Society, Chicago. 2003.
World Space Congress. 2002.
US Air Force Museum. 2002.
Kansas Cosmosphere. 2000, 2001, 2002
Johnson County Community College, Kansas. 2001.
University of Michigan. 2000.
Massachusetts Institute of Technology. 1999.
University of Texas-Lubbock, 1996.

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Spacecraft Design, Hardware and Renderings

Priroda Laboratory Module design and lay-out, Mir
Crew On-Orbit Support System (COSS)
Priroda Utilization Panel (PUP)
Priroda Stowage Lockers
Mir Priroda Tranfer Bag
Cargo Transfer Bag (CTB)
Soft Stowage systems for Mir and ISS
Cupola, ISS
New Initiatives Habitability Concepts for Lunar and Planetary Missions

Pressurized Lunar Rover, 1990.	Design Rendering and Study
Lunar Habitat. 1990.	Design Rendering and Study
First Lunar Outpost, 1989.	Design Rendering and Study
Mars Lander Crew Station. 1989.	Design Rendering and Study

Employment

National Aeronautics and Space Administration (1985 – Present)

Liaison, University of Houston and NASA Johnson Space Center

Manager, Communications and Education, International Space Station Program

Manager, Space and Life Sciences Directorate Spaceflight Safety, Johnson Space Center

Manager Crew Health Care Systems, Space and Life Sciences Directorate, Johnson Space Center

Manager, Operations and Integration, NASA-Mir Program, Johnson Space Center

Manager,Priroda Integration, NASA-Mir Program, Johnson Space Center

Manager, Spacehab 1 (STS-57) and Spacehab 2 (STS-60), New Initiatives Office

Manager, Utilization Planning, Spacehab Commercial Module Project, New Initiatives Office

System Architect, Lunar & Planetary Systems, Space Exploration Initiative, New Initiatives Office

System Architect, Man-Systems, Space Station Program, Space and Life Sciences Directorate, Johnson Space Center

Subsystem Manager, Crew Equipment and Stowage, Space Shuttle Program

Rockwell International Space Shuttle Orbiter Division (1981-1985)

Commercialization and Utilization Planning Manager, Customer Service Office, Space Shuttle Program

Configuration Management and Management Communications, Management Integration Office, Space Shuttle Program

Northrop International Corporation (1981)

Research Assistant, Lunar Sample Laboratory

Smithsonian Institution, National Air and Space Museum (1976)

Research Assistant, Center for Earth and Planetary Studies

Academic Employment

University of Houston, Texas (2002-2003, 2008-present)

Adjunct Professor, Instructor and Lecturer: Management, Spacecraft Design, Space Project Management ‘

Macomb County Community College, Warren, Michigan (1977-1979).

Adjunct Professor, Physics and Astronomy

Cranbrook Institute of Science, Bloomfield Hills, Michigan (1978-1979).

City of Taunton, Massachusetts (1979-1981).

Planetarium Director

Warren Public Schools, Michigan (1976-1979).

Planetarium Director

Deerfield Academy, Deerfield, Masschusetts (1974-75).

Instructor

Amherst College. Amherst, Massachusetts (1973-76)

Planetarium Instructor

Professional Societies

American Astronautical Society

American Institute of Aeronautics and Astronautics

International Planetarium Management Society

Pi Sigma Epsilon