COMPARISON OF AGRICULTURE BIOLOGY AND GENERAL BIOLOGY TESTING OUTCOMES IN UTAH

by

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COMPARISON OF AGRICULTURE BIOLOGY AND GENERAL BIOLOGY TESTING OUTCOMES IN UTAH

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Abstract

Agriculture education can take scientific topics to higher levels, emphasize scientific concepts, involve hands-on learning, and develop interrelationships with the other sciences, thus making the living and non-living world around them relevant for students. Prior to 1996, agriculture education was not considered adequate to prepare Utah high school students to meet state biology requirements. The appropriateness of making that equalizing decision in 1996 was not tested until this 2014 study, comparing student test scores on the state biology test for general biology and agriculture biology students. The 2008-2012 data were collected from the Utah Department of Education Data and Statistics, utilizing a descriptive comparative post-test only analysis. As seen in this study, not only did B/AS students tend to score lower than their General Biology counterparts, in multiple cases this difference was significant ($p \leq .05$). This contrary finding challenges the theoretical foundation of this study. As a result of this study three implications were made; (a) the Utah CRT-Biology test is not a reliable gauge of academic achievement in agriculture biology, (b) agriculture students in the sample population have not been taught with rigorous biology standards, and (c) biology standards taught in agricultural biology classes are not aligned with content tested by the biology portion of the Utah CRT-Biology test standards. The results of this study indicate to stakeholders that there is a gap occurring within the B/AS education, and the need to reevaluate the biology curriculum delivery to its population may possibly be in need of immediate action.

Dedication

I dedicate this work to the most Important, without Him nothing is possible, my Lord and Savior. Next, to the most important individuals in my life, Cheryl my beautiful wife and eternal companion who has been patient, longsuffering, spent innumerable late evenings alone. My thanks and gratitude goes beyond measure to her and our four wonderful children Magdalena, Morgan, Croyden, and Morley. I promise we will now go camping and fishing.

I cannot express in word the appreciation and love I have for my parents. My Dad, who has always been my hero, gave advice and support along the way that was always welcomed and helpful. I will always remember to put a pencil and paper to "it" before I make any decision.

I want to thank the Mendenhall Brothers, Paul and Robert, for teaching and instilling in me a hard work ethic, to never give up, and always be honest, while giving me the opportunities and experiences of a lifetime that I will never forget.

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Table of Contents

List of Tables

List of Figures

CHAPTER 1: INTRODUCTION

As early as 1988, it was clear that the national agriculture education curricula were becoming outdated, being based primarily on production agriculture (National Research Council, 2009). As a consequence of these findings, the State of Utah incorporated a biology curriculum into agriscience courses (Warnick, 1998) to prepare agriculture students for their Utah Basic Skills Competency Test (Utah State Office of Education, 2012). However, prior to 1996, Utah high school agriculture students were required to take a separate traditional biology course (Warnick, 1998), as well as the Biology-Agriculture and Technology (B-AST) course (Warnick, 1998), to meet the state requirements and to earn one biology credit. Modern 21st century agriculture is a science that includes biology (Baird, Lazarowitz, & Allman, 2006; Myers & Dyer, 2004), which led agriculture supporters to urge the Utah State Board of Education to change the requirement. The argument was that both the B-AST course and General Biology course followed the same standards and were designed to equally prepare students for their biology competency exams. As a result of this argument (Warnick, 1998), the 1996 Board of Education agreed, considering the B-AST course equivalent to General Biology, meaning that agriculture students were no longer required to enroll into a separate traditional biology course, in addition to their agriculture curriculum (Warnick, 1998). A name change occurred in 2000, with the B-AST course officially becoming Biology/Agricultural Science (B/AS) (Utah State Office of Education, 2012), the name used throughout this study unless specifically noted for clarity.

The Utah Agriculture Education Department supported the 1996 change (Warnick, 1998), joining the Utah State Board of Education (Utah State Office of Education, 2012), in believing that since agriculture includes biology along with other sciences, agriculture students should not be required to take an additional general biology course. However, nearly two decades later in 2014, the supposition that high school agriculture students taking the B/AS course would score as well on the Utah State Core Requirements Test in Biology (Utah CRT-Biology) as high school students taking a general biology course had not been verified (Utah State Office of Education, 2012). The purpose of this study was to for the first time assess Utah high school student performance on the Utah CRT-Biology to determine if agriculture students were scoring as well as their general biology student counterparts. The premise of the study was that if results indicated that agriculture students were scoring as well as general biology students, then the 1996 decision (Utah State Office of Education, 2012; Warnick, 1998) was well founded and the B/AS curriculum was successfully preparing agriculture students. If, however, agriculture students were determined to not be scoring as well as their general biology student counterparts, the 1996 decision could need to be reconsidered.

Background of the Problem

In 2009, the National Research Council, in *Transforming Agriculture Education: New Directions* for Education reported that since 1998, the content of many agricultural education programs had become outdated and was based primarily upon production agriculture. Recommendations for improving agricultural education in the *Transforming Agriculture Education* report included revising the agriculture curriculum to include the application of concepts from the physical and biological sciences (National Research Council, 2009). The report also referred to what would become known as integrated agriculture education; an approach Wilson and Curry (2011) suggested as a solution for the national concern over inadequate science education in the United States.

Utah has taken the lead in this approach by supporting agriculture coursework as meeting general biology requirements (Utah State Office of Education, 2012). Enderlin and Osborne (1992, as cited in Nolin & Parr, 2013) reported that agriculture students received higher test scores in biology than students in other classes. According to Nolin and Parr (2013) and Bishop-Clark et al. (2010), the integration of science into Career and Technical Education (CTE) and agriculture classes was initially introduced early in the 20th century. However, the approach has experienced a revitalization of interest among agriculture educators as the second decade of the 21st century begins. Questions still arise if the imposed curricular changes in agriculture, moving it from production-based to science-based, have been effective (Nolin & Parr, 2013). According to the United States Department of Education (2012):

> The 1994 reauthorization of the Elementary and Secondary Education Act (ESEA) established a requirement that each state set standards defining what their students should know and be able to do in critical subjects and assess whether students were mastering those standards. (p. 3)

Doerfert (2011) responded by suggesting that the field of agricultural education has undergone many changes in recent decades and subsequently the focus of agricultural education research has followed suit. Doerfert (2011) suggested that with increases in accountability for academics, industry credentialing, and post-secondary training as mandated by the Carl D. Perkins Act (Perkins II) (Clark, 2012), CTE educators must produce empirical evidence of compliance (Doerfert, 2011). Despite the 1996 change in Utah policy that established agriculture as equivalent to biology in preparing students for the Utah CRT-Biology exam (Utah State Office of Education, 2012; Warnick, 1998), as of 2014 there has been no analysis of test results to determine if agriculture education was preparing students to pass the exam as proficiently at students enrolled in general biology (Utah State Office of Education, 2012). This oversight is critical, particularly given the No Child Left Behind Act of 2001 (NCLB) mandate that states be held accountable for academic achievement of their students (Clark, 2012). This study was intended to address the missing accountability factor and also provided statistical evidence in a descriptive, longitudinal, comparative analysis (Christensen, Johnson, & Turner, 2011) to determine if Utah high school agriculture students were performing as well as their general biology counterparts on the Utah CRT-Biology exam using data provided by the Utah State Office of Education (2012).

Statement of the Problem

This descriptive, longitudinal, comparative study (Christensen, et al., 2011) was designed to address the problem of lack of evidence regarding the Utah premise that the B/AS curriculum prepares students for the Utah CRT-Biology exam (Utah State Office of Education, 2012) as well as the general biology approach does. By comparing the test scores of 37.2% of students taking agriculture and 37.2% of students taking general biology, across the 2008 through 2012 years, Neuman (2006) suggested the study would generate a 99% confidence level (Neuman, 2006) regarding the results, enabling a resolution of this issue of accountability that has, in 2014, existed for nearly two decades (Utah State Office of Education, 2012).

Purpose of the Study

In 1996, the State of Utah aligned the biology curriculum so that high school agriculture teachers were allowed to teach agriculture students the B/AS course (Warnick, 1998). This meant that agriculture students could meet their biology curriculum requirement through enrollment in the B/AS course without having to take an additional biology course (Utah State Office of Education, 2012; Warnick, 1998). However, no study has reexamined whether this decision of having agriculture instructors teach the B/AS course was effective in preparing students for the Utah CRT-Biology. Even though all Utah biology students must take the Utah CRT-Biology (Utah State Office of Education, 2012), there has been no documented evidence supporting the wisdom of the decision to allow agriculture students to take the B/AS course rather than the general biology curriculum (Utah State Office of Education, 2012).

Table 1

Individual Standards of the Utah CRT-Biology Exam

Standard	Short Title	Full Description
1	Environmental Interaction	Living organisms interact with one another & their environment
2	Molecular Biology	Organisms composed of one or more cells that are made of molecules… & perform life functions
3	Structure & Function	Relationship between structure & function of organs & organ systems
4	Genetics	Understand the importance of the genetic information coded in DNA
5	Evolutionary Diversity	Biological diversity is a result of the evolutionary processes
6	Science & Thinking	Use science process and thinking skills
7	Science Concepts	Demonstrate understanding of science concepts, principles & systems
8	Communication	Communicate effectively using science language and reasoning
9	Science Awareness	Demonstrate an awareness of social & historical aspects of science
10	Nature of Science	Demonstrate understanding of the nature of science

Note. Short titles were used in subsequent tables for brevity.

The purpose of this study was to determine if biology students and B/AS students scored at a similar level on the Utah CRT-Biology (Utah State Office of Education, 2012). The Utah CRT-Biology scores of students in grades 10 through 12 from years 2008-2012 were analyzed, with the Utah State Office of Education providing access to the data provided (see Appendix A). To ensure statistical reliability of the analysis, the recommendation of Neuman (2006) was followed, with a representative sample equal to 37.2% of the total population used to a 99% level of confidence in study results. Further exploration resolved whether there were differences in Utah CRT-Biology assessment scores between general biology students and students taking a B/AS course for the 10 individual standard scores that comprise the CRT-Biology overall score, as shown in Table 1.

Significance of the Problem

Nearly two decades have passed since the 1996 decision by the Utah State Office of Education (2012) to approve B/AS as being the curricular equivalent of General Biology in preparing high school students for the Utah CRT-Biology. As of 2014, no statistical verification of this equivalency has been ascertained (Utah State Office of Education, 2012). Given the national mandates of educational accountability (Clark, 2012; NCLB Act of 2001; United States Department of Education, 2012), the data on the Utah CRT-Biology needed to be analyzed across both agriculture and general biology students to verify if there was curricular equivalency of B/AS and General Biology, and if not, take the appropriate steps to resolve the curricular discrepancy.

The significance of this descriptive comparative study (Christensen et al., 2011) study was to determine how effectively biology was being taught in the agriculture classroom. This study examined the Utah CRT-Biology results (Utah State Office of Education, 2012) of high school students in general biology courses compared to agricultural students who had taken a B/AS course that integrated biology.

Significance of the Study

According to the Utah State Office of Education (2012), this study was the first attempt in retrieving historical data to compare the Utah CRT-Biology results of the two different approaches to teaching biology in Utah schools at the high school level, the general approach and the biology enhanced agriculture approach. By analyzing the Utah CRT-Biology scores between the two populations of the general curriculum biology students and B/AS curriculum students, this study attempted to examine comparable test score evidence to determine if the 1996 implementation of an B/AS curriculum with an enhanced focus on biology was well founded (Utah State Office of Education, 2012). This effort was made possible by the decision in 2011 by the Utah State Office of Education to grant licensed Utah educators access to information, including testing data, through the Utah Education Facts campaign (Utah Education Network, 2012). The IBM Corporation Cognos® database and reporting software application (Utah Education Network, 2012) is used in Utah to precisely measure student development and to help educators pursue professional development opportunities (A Summary of Core Components, 2012).

Significance of the Study to Leadership

In 1996, the State of Utah formally incorporated biology into agriscience courses allowing a modified agricultural curriculum (Warnick, 1998) with an enhanced focus on biology to prepare agriculture students for success on their Utah CRT-Biology (Utah State Office of Education, 2012). The amended stipulation no longer required agriculture students to take a separate traditional biology course in addition to their agricultural curriculum (Warnick, 1998). The agriculturally supported view was that since agriculture courses include biology along with other sciences, students taking B/AS would be expected to score as well as students taking traditional biology courses (Baird et al., 2006; Utah State Office of Education, 2012; Warnick, 1998).

The Utah Agricultural Education Pathways were based on national skills standards and the national cluster pathways for agricultural education (Utah State Office of Education, 2012). By taking the B/AS course, students are expected learn to value and understand the vital role of agriculture, food, fiber, and natural resources systems. This vital role was demonstrated by the Utah State B/AS course description:

> Provide students with an appreciation for living systems as applied to the science of food and fiber production and food processing. This course also describes and applies the principles and practices of biotechnology research and production, and will prepare individuals to apply this knowledge and skill as a solution to practical agricultural problems. (Utah State Office of Education, 2012, Agriculture Education Course Information, para. 1)

The Utah State Office of Education (2012) indicated that there has been no utilization of historical data to compare the Utah CRT-Biology results of the two different approaches to teaching biology, leaving open the question of whether the premise of the 1996 change (Utah State Office of Education, 2012; Warnick, 1998) was valid. Ascertaining whether or not agriculture students, with an enhanced agriculture emphasize in their courses, were as well prepared for and consequently perform as well on the Utah CRT-Biology as students taking a general biology course, seemed a critical oversight noting the dramatic changes that have occurred in the workplace during the last half of the 20th century (Urman & Roth, 2010; Utah State Office of Education, 2012). Education has sometimes been accused of not adapting to meet these changes (Urman & Roth, 2010). The 1996 change (Warnick, 1998) in

Utah of incorporating more biology into agriculture curriculums (Utah State Office of Education, 2012), was one factor demonstrating the considerable effort and resources that were being applied to revising and updating programs and creating new programs to meet the skill and workplace requirements of post-secondary education (Rojewski, Asunda, & Kim, 2008; Warnick, 1998).

Investigating the Utah CRT-Biology results (Utah State Office of Education, 2012) determined if the decision to allow a modified agricultural curriculum with an enhanced focus on biology rather than requiring agriculture students to take a separate traditional biology course, in addition to their agricultural curriculum, was well-founded (Warnick, 1998). If the quantitative results support the assertion that agriculture was a well-rounded and an integrated biology inclusive program, the results would justify the 1996 decision (Utah State Office of Education, 2012; Warnick, 1998) to enable agriculture students to take an agriculture biology course without having to take a general biology course. Furthermore, the agriculture biology effort could also lead to additional enhanced agriculture programs that meet other learning outcomes. However, if the results do not support this equivalency assertion, then the 1996 decision (Utah State Office of Education, 2012; Warnick, 1998) may need to be reconsidered, perhaps by strengthening the B/AS curriculum.

Nature of the Study

This study correlated how effectively biology was being taught in the Utah high school agriculture classroom vs. the general biology curriculum by comparing Utah CRT-Biology scores of students in general biology courses with those of students taking a B/AS course (Utah State Office of Education, 2012), using a descriptive, quantitative methodology with correlational design. The variables studied in this project were the Utah CRT-Biology results of 10th through 12th grade Utah students (Utah State Office of Education, 2012), comparing those enrolled in the B/AS course with those enrolled in general biology courses. The data were collected from the Utah State Office of Education statistical database (see Appendix A) and analyzed using a *t-test* (Gall, Gall, & Borg, 2007) to evaluate levels of significant difference. With multiple year data available from 2008 through 2012, ANOVA (Steinberg, 2008) was developed to monitor the increase or decrease of agriculture student Utah CRT-Biology results (Utah State Office of Education, 2012) compared to the test outcome results of general biology students over a five-year longitudinal time frame (Gall et al., 2007).

Overview of the Research Method

In keeping with national mandates of educational accountability (Clark, 2012; NCLB Act of 2001; United States Department of Education, 2012), a qualitative approach was not considered for this study. Qualitative methods enable a deep understanding of an experience (Creswell, 2012); focusing primarily on the instructional forms of data, including interviewing, observation, and employing verbal descriptions and explanations to social research (Hammersley, 1989). However, this neglects the necessity and use of quantifiable data that meet the nationally mandated accountability standards (Clark, 2012; NCLB Act of 2001; United States Department of Education, 2012). Furthermore, qualitative methods often involve an emphasis on process rather than structure, with a devotion to the study of small-scale situations in preference to analysis at the societal or the psychological levels (Litchman, 2013). Although, Hammersley (1989) claimed that qualitative methods may be useful in gaining insight that statistics and numbers may not yield, Litchman (2013) suggested that quantitative data provide greater the rigor and structure, elements important in accountability efforts. Thus, this study necessitated a quantitative approach to determine if the B/AS course that incorporates biology embedded agricultural focused curriculum was as effective as the traditional general biology curriculum in preparing Utah high school students for their subsequent Utah CRT-Biology (Utah State Office of Education, 2012).

Overview of the Design Appropriateness

Within the realm of quantitative methodology, multiple research designs were considered. According to Gall et al. (2007), descriptive research measures the characteristics of a population on prespecified variables, an aspect that is appropriate when the purpose is to create a detailed, quantitatively based description of a phenomenon in which there was no attempt to influence the population being studied. While a descriptive design would describe the Utah CRT-Biology test results for each group (B/AS and General Biology) factually and accurately (Nolin & Parr, 2013), a more comparative nature was desired to assess curricular equivalency. In addition, given that multiple years of data were available; this also provided the opportunity to add a developmental or longitudinal component to the study (Mertler & Vannatta, 2010).

An experimental design was not appropriate as this study did not control or manipulate the independent variable, nor were random assignment of study subjects to the intervention or control group carried out (Cantrell, 2011).This study employed a non-experimental (Moriba & Edwards, 2013) descriptive comparative methodology (Christensen et al., 2011). This method involved a systematic collection of data that were evaluated, described, and explained factually and accurately through quantitative measures (Splan, Porr, & Broyles, 2011). This study compared differences among groups of students who participated in the Utah CRT-Biology exam, and also considered the possibility of longitudinal change (Neuman, 2006; Steinberg, 2008) in Utah CRT-Biology scores among general biology students and B/AS students.

Specifically, this study utilized a descriptive comparative *within-participants posttest-only design* (Christensen et al., 2011) since there was no intervention, with all participants taking either the General Biology or B/AS curriculum, with the Utah CRT-Biology serving as the post-test for all participants. This approach enabled determination of the relationship among variables, traditional biology taught students as the independent variable or control group vs. those taught with an agriculture emphasis as the dependent variable or test group (Christensen et al., 2011). The analysis also considered the 10 individual standard scores (see Table 1) represented in the Utah CRT-Biology (Utah State Office of Education, 2012). Furthermore, the inclusion of students across years from 2008 through 2012 enabled investigation of more than a single snapshot of evidence, with the opportunity to identify longitudinal change (Christensen et al., 2011; Neuman, 2006; Steinberg, 2008). *T*-tests and ANOVA were utilized to measure the difference between the two populations, general biology students and B/AS taught students, on a longitudinal basis (Christensen et al., 2011; Neuman, 2006; Steinberg, 2008) to counterbalance any potential basic linear carry over effect (Christensen et al., 2011).

Research Questions

Evidence shared by Roegge and Russell (1990) and Rosentrater (2005) supported the underlying premise of the 1996 decision by the Utah State Office of Education (2012) to equate student learning outcomes of traditional biology and B/AS programs. However, despite nearly two decades of use, this premise has not been validated (Utah State Office of Education, 2012; Warnick, 1998). This study was conducted to determine if that the premise was valid by comparing the Utah CRT-Biology scores, overall and by individual standards (see Table 1), of the two students groups (Utah State Office of Education, 2012). ANOVA was used to analyze the longitudinal test scoring to examine any trends in Utah CRT-Biology scoring differences (Christensen et al., 2011).

Research Question 1

To what extent is there a difference in Utah CRT-Biology results from students in traditional biology programs compared to students in B/AS programs?

$H1_0$: No significant ($p > .05$) difference in Utah CRT-Biology scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

$H1_a$: A significant ($p \leq .05$) difference in Utah CRT-Biology scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

Research Question 2

To what extent is there a difference in the Utah CRT-Biology results in any of the Utah CRT-Biology individual standards (See Table 1) from students enrolled in traditional biology courses compared to students enrolled in B/AS courses?

$H2_0$: No significant ($p > .05$) difference in the Utah CRT-Biology individual standard scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

$H2_a$: A significant ($p \leq .05$) difference in the Utah CRT-Biology individual standard scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

Research Question 3

To what extent has any difference in Utah CRT-Biology scores between students taught biology using the traditional approach compared to those students taught using the B/AS approach varied during the five-year time period from 2008 through 2012?

$H3_0$: Any gap in Utah CRT-Biology scores between students taught biology using the traditional approach compared to those students taught using the B/AS approach has narrowed ($p \leq .05$) during the five-year time period from 2008 through 2012.

$H3_a$: Any gap in Utah CRT-Biology scores between students taught biology using the traditional approach compared to those students taught using the B/AS approach has widened ($p \leq .05$) or not changed ($p > .05$) during the five-year time period from 2008 through 2012.

Theoretical Framework

The underlying philosophy of this study was since agriculture courses include biology along with other sciences (Manley & Price, 2011), students taking agriculture should be expected to score as well as students taking general biology courses (Clark, 2012; Roegge & Russell, 1990; Rosentrater, 2005; Thompson & Warnick, 2007; Utah State Office of Education, 2012; Warnick, 1998; Wilson & Curry, 2011). However, this philosophy had not been verified since the 1996 decision in Utah (Utah State Office of Education, 2012; Warnick, 1998) to allow high school agriculture students to take only an integrated agriculture biology course rather than having to take a general biology course.

Warnick (1998) asserted that the reconstructive and reorganized effort of the Utah State Office of Education decision of 1996 was needed because "philosophical concepts provide direction for curriculum organization and outcomes" (p. 8). Warnick and Straquadine (2005) and Esters and Retallick (2013) claimed that if the basic assumption was accepted that education should prepare students to think and act purposefully, then the curriculum of the classroom should be selected with this end in view. As the agriculture industry becomes more diverse, the industry requires a broader education than does any other vocation or profession (Maguire, Starobin, Laanan, & Friedel, 2012; Warnick & Straquadine, 2005). Nolan (1918, as cited in Warnick, 1998) claimed that the merging of agriculture and science in secondary education has been a topic that has been discussed and debated prior to the passage of the Smith-Hughes Act of 1917 (Anderson & Anderson, 2012), hence the 1996 decision (Utah State Office of Education, 2012; Warnick, 1998;) was perhaps overdue. Warnick (1998) further claimed the B/AS courses were attracting a new group of students enrolling in agriculture education, suggesting these students were enrolling in B/AS classes to learn science (Splinder & Greiman, 2013) by using agriculture applications and the scientific principles valued in agriculture application.

In viewing the enhanced biology curriculum in the B/AS course for agriculture students, Warnick and Straquadine (2005) and Splinder and Greiman (2013) found that it included the principles, objectives, methodology, and organization of reading skills; activities; and both formal and informal influences. The B/AS curriculum offers a course of study and an arrangement of all the materials and learning activities that serve as a guide for the teacher in harmony with the Utah Constitution, Utah legislative mandates, and overall objectives of the Board of Education (Warnick & Straquadine, 2005). Berry (1924, as cited in Warnick & Straquadine, 2005) stated that for effective teaching to lead to effective learning; it must have a known organizational pattern and apparent structure. As agriculture educators become more diverse (Warnick & Straquadine, 2005) their limits decrease and they can potentially offer a scientific basis for teaching students seeking structure, routine, and rhythm by including artful, informal, and qualitative strategies within scientific education (Thoron, Myers, & Abrams, 2011). Furthermore, agriculture education has been a multi-faceted science that provides comparable knowledge attainment with more traditional science approaches (Robinson, Kelsey, & Terry, 2013). For example, agriculture education emphasizes hands-on learning and real-life application of knowledge attained (Warnick, 1998). As a result, students in agriculture education exhibit on-task behaviors and stay focused during learning activities (Thoron et al., 2011; Warnick & Straquadine, 2005).

Warnick (1998) stated that competing theories have been espoused regarding the inclusion of biology into the agriculture classroom and curricula. Johnson and Newman (1993) and Stripling and Roberts (2013) argued that continued success of B/AS courses was dependent upon the perceptions of others, including school administrators, counselors, and traditional science teachers who have been described as being influential in whether the agriculture science courses achieve success. Research findings provide some accusations (Splan et al., 2011) that B/AS educators generally were less prepared and lacked the thorough background needed to be a successful biology instructor (Johnson & Newman, 1993). As Warnick (1998) noted, the agriculture classroom has been viewed by some school counselors as a "dumping ground" (p. 9) for students with lower learning abilities and those who show less of a desire for academic challenges. However, these older views are not reflective of agriculture of the 21st century, a broad-based field of study that goes far beyond the mere producing of crops and livestock for food, but includes discovery and integration of advanced scientific principles (Robinson et al., 2013). However, Warnick's (1998) assertion that traditional science teachers have an important role in determining the acceptance of the B/AS course does need to be considered, and thus becomes an additional factor supporting the significance of this study to demonstrate whether the agriculture students taking the BA/S curriculum perform as well as more traditional students taking the general biology curriculum.

To assess whether or not B/AS students were learning biology principles as well as students in the general biology curriculum, this study focused on a statewide comparison of traditional biology students vs. agriscience students in Utah by comparing student scores on the Utah CRT-Biology, taken by 10th through 12th graders following completion of state-required biology curriculum (Utah State Office of Education, 2012). Beyond just comparing composite scores, this study also compared the 10 individual standard scores (see Table 1), and did so longitudinally for each year of data from 2008 through 2012.

Definition of Terms

Agriculture education. Agriculture education provides students with an appreciation for living systems as applied to the science of food and fiber production, food processing, agriculture business, animal processes, and skilled and technical sciences (Utah State Office of Education, 2012).

Biology/Agriculture science (B/AS). Originally called B-AST until 2000 (Myers & Dyer, 2004), the B/AS course was designed to meet the requirement for biological science credit. The standards and objectives for this course were the same as the standards and objectives for General Biology, with both following the Utah State Standard Biological standards (Utah State Office of Education, 2012). The only difference between B/AS and General Biology was the degree of emphasis placed on agriculture, including additional curriculum based on National FFA Organization (2013) recommendations. Students completing this course were expected to be cognizant of current technologies, methods, and changes in agricultural science and to know and apply the standards outlined in the core curriculum as they relate to the industry of agriculture (Utah State Office of Education, 2012). Both General Biology and B/AS students were assessed upon completing their respective course by taking the same Utah CRT-Biology.

Carl D. Perkins Vocational and Applied Technology Education Act of 1990 (Perkins II). Perkins II was the first major piece of federal legislation encouraging educators to shift away from the traditional job skills orientation of vocational education and move toward the use of vocational education to teach academics and other forms of thinking skills (Strecher et al., 1994).

Carl D. Perkins Vocational and Applied Technology Education Act of 1998 (Perkins III). Included in a final report to the U.S. Congress regarding Perkins III, the United States Department of Education (2012) recommended using curriculum development as a strategy to strengthen student academic performance and to improve vocational program performance.

No Child Left Behind Act of 2001 (NCLB). NCLB was an educational reform act signed into law by President George W. Bush on January 8, 2002. The legislative action held all public schools in the United States accountable by using standardized tests to measure adequate yearly progress (Clark, 2012).

Science, Technology, Engineering, and Mathematics (STEM). The STEM Coalition has worked aggressively to raise awareness in Congress, the Administration, and other organizations about the critical role that STEM education plays in enabling the US to remain the economic and technological leader of the global marketplace of the 21st century.

Members of the STEM Coalition believe that our nation must improve the way our students learn science, mathematics, technology, and engineering (Asunda, 2011).

Utah State Biology Core Requirements Test (Utah CRT-Biology). The Utah CRT-Biology was developed, critiqued, piloted, and revised by a community of Utah science teachers, university science educators, State Office of Education specialists, scientists, expert national consultants, and an advisory committee representing a wide diversity of people from the community (Utah State Office of Education, 2012). The Utah CRT-Biology reflects the current philosophy of science education that was expressed in national documents developed by the American Association for the Advancement of Science and the National Academies of Science (Utah State Office of Education, 2012). The Utah CRT-Biology has the endorsement of the Utah Science Teachers Association (Utah Education Network, 2012).

Vocational education. Vocational education provides learning opportunities and instruction intended to prepare students for industrial or commercial trade occupations. Vocational education can be acquired either formally in trade schools and technical secondary schools, in other job training programs, or more informally by picking up necessary skills during on-the-job training (Myers & Irani, 2011; United States Department of Education, 2012).

Assumptions

The foundational data for this study depended upon provision of data from the Utah State Office of Education through the Utah Education Facts campaign. In 2011, licensed Utah educators were granted access to information including testing data (Utah Education Network, 2012). As a researcher, access to these data has been granted (see Appendix A), however, the data were limited to that pulled by the Utah State Office of Education staff from the IBM Corporation Cognos® database and reporting software application (Utah Education Network, 2012) based on researcher stipulated parameters, inclusions, and exclusions. Thus, the assumption was that the necessary data elements were adequately conveyed to the Utah State Office of Education staff and they delivered the data necessary to complete this study's quantitative statistical approach using a descriptive comparative within-participants posttest-only design (Christensen et al., 2011) with an analysis of variance (Neuman, 2006; Steinberg, 2008). While the Utah Department of Education does not report a reliability estimate for the CRT-Biology instrument, as it is the State's accepted measure of performance, it was assumed to be a reliable testing instrument. Further, it was assumed that the data delivered were adequate to determine with statistical significance ($p < .05$) if the 1996 decision to allow a modified agriculture curriculum with an enhanced focus on biology rather than requiring agriculture students take a separate general biology course in addition to their agriculture curriculum (Utah State Office of Education, 2012) was a well-founded decision.

Scope and Limitations

The scope of this study was confined to test scores of Utah 10^{th} through 12^{th} graders participating in the state-mandated Utah CRT-Biology between 2008 through 2012 after completing their required biology course of either B/AS or General Biology. The testing data results were extracted and scrubbed of personal identifiers by the Utah State Office of Education (see Appendix A) as per the Utah Education Facts campaign stipulations (Utah Education Network, 2012) prior to delivery to the researcher. The data were then analyzed with IBM® SPSS® Statistics software (version 21) to generate the descriptive comparative analysis and perform ANOVA on the testing data. This study was limited by the fact that there was no control of the student population or background of the schools or participants.

Factors such as (a) rural vs. non-rural populations, (b) male vs. female, (c) minority populations and diversity, (d) social and economic backgrounds, and (e) years of educator teaching experience were not considered.

Delimitations

Researcher imposed delimitations of the study were used to narrow the scope of the research (Christensen et al., 2011). In theory, access back to the initial 1996 stipulation of allowing Utah high school agriculture students to bypass the necessity to take an additional traditional biology course in addition to their agriculture curriculum because of the approval of the B-AST, and later B/AS curriculum would be available (Utah State Office of Education, 2012; Warnick, 1998). However, early data were incomplete. This study was intentionally delimited to consider only data collected after 2008. While excluding data from the initial 12 years, it still provided a five-year longitudinal range of complete Utah CRT-Biology testing data, including the 10 individual standard scores (see Table 1) (Utah State Office of Education, 2012). Despite this delimitation, data were adequate not only for the descriptive comparative within-participants posttest-only design (Christensen et al., 2011), but also for the analysis of variance (Neuman, 2006; Steinberg, 2008). The dataset consisted of 37.2% of the total population of comparable gender-stratified random Utah high school students enrolled in traditional biology or B/AS for each year from 2008 through 2012, which generated a 99% confidence level (Neuman, 2006) in the reliability of the results. Validity was further verified in ascertaining that "the two groups participated with the same test in the same year, each year" (J. Baggley, personal communication, July 8, 2014).

Summary

The focus of this descriptive comparative within-participants posttest only design (Christensen et al., 2011) with a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) study examined the agriculturally supported opinion that since agriculture courses include biology along with other sciences (Balschweid, 2002; Conroy & Walker, 1995; Johnson & Newman, 1993; Warnick, 1998), students taking the B/AS course as part of their agriculture education curriculum should be expected to score as well on the Utah CRT-Biology as did students taking a traditional biology course. By analyzing the Utah CRT-Biology scores between the two populations of traditionally taught biology students and B/AS students, this study determined if the 1996 implementation of a biology agricultural science curriculum with an enhanced focus on biology (Utah State Office of Education, 2012; Warnick, 1998) was well founded, not just for the overall Utah CRT-Biology score, but also for the 10 individual standard scores (see Table 1).

Chapter 2 provides an exhaustive review of the literature on factors that led to the belief that an agriculture curriculum would prepare students to achieve a science comprehension comparable to that of students who took a more traditional science curriculum. Chapter 2 includes a discussion of the emergence of integrated vocational curricula that emphasize the application of foundational educational principles. In addition, Chapter 2 also includes literature justifying the selection of a quantitative methodology using a descriptive comparative within-participants posttest only design (Christensen et al., 2011) with a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) in answering the research questions.

CHAPTER 2: REVIEW OF THE LITERATURE

The literature review provides background for this study and was designed to demonstrate the theoretical basis for assuming that Utah high school agriculture students enrolled in B/AS courses comprehend scientific principles on an equal level to comparable students who were enrolled in general taught biology courses (Warnick, 1998), as well as to support the need for this study. Thompson and Warnick (2007) and Martin and Kitchel (2012) found agriculture teachers in agreement that stronger connections were made between science and the agriculture curriculum and that agriculture programs should become more science-based. This chapter also provides literature support for the use of the selected descriptive comparative within-participants posttest only design (Christensen et al., 2011). A five-year analysis of variance (Neuman, 2006; Steinberg, 2008) was used to evaluate the difference in Utah CRT-Biology scores between General Biology and B/AS taught students (Utah State Office of Education, 2012).

Documentation

This research study depended heavily upon a variety of databases as a means to gather pertinent information. The University of Phoenix's library provided access to many of the electronic indexes and databases utilized in this study, most notably ProQuest, EBSCOhost, and ProQuest Dissertation and Thesis sites. Individual word searches, multi-word searches, and Boolean operator searches used the following terms: *biology in the agriculture-classroom, agriculture and biology education, teaching biology in the agriculture-classroom, teaching agriculture science, gender gaps in STEM, STEM education, and STEM in agriculture science*. In addition, the Utah State Office of Education; the Utah State University Agriculture Systems, Technology and Education Department; the Ohio State

University Agriculture, Communication, Education, and Leadership Department; the *Journal of Agriculture Education,* the *Journal of Career and Technical Education,* the *Journal of sTEm Teacher Education,* the *Career and Technical Education Research Journal,* and the *Journal of Economic Literature,* also provided a large amount of the resource material. In total, 112 sources including 75 articles from 44 different journals, 15 electronic resources, 16 EBooks, 3 EMagazines articles, 1 unpublished doctoral dissertation, 1 Master's thesis, 1 textbook, and multiple phone conversations with statistical support sustained the development of the dissertation. The entire literature review represents 98% of the 112 sources used in developing this dissertation, with 55% of the sources being from 2008 (6 years) or more recent.

Agriculture Education Overview

Roegge and Russell (1990) claimed that since 1986, high school agriculture education has been in a delicate position as a result of steady decreases in enrollment and increased graduation requirements for academic credit in the math and science areas. Roegge and Russell (1990) perceived this decline as stemming from the inadequacies of the traditional agriculture curriculum that primarily took a vocational approach. The1984 National Commission on Secondary Vocational Education began to bridge the gap between academic and vocational classes, placing increased emphasis on higher standards in a practical and applicative aspect of agriculture education (Roegge & Russell, 1990).

Taylor and Kauffman (1998) suggested that as early as 1908, academicians were developing curriculum and activities to supplement the need for students to learn science to better interrelate with practical matters. Parr and Edwards (2004) claimed that historically, agriculture education has presented learning in a "hands on" and "minds on" (p. 107) approach in both design and delivery. Agriculture education has been well-grounded and has taught scientific laws, methods, and procedures providing a means for students to learn science and provide the hands- and minds-on experiences to complement scientific theory (Parr & Edwards, 2004).

Even as society continues to move away from the agrarian way of life (Rosentrater, 2005), Hansen (1999), and Martin and Kitchel (2012) pointed out those agrarian traditions were an important part of many lifestyles, a lifestyle that dominated in many ways through the economy and national prominence. Agriculture goes beyond agrarian life, with modern agriculture including scientist and technology, techniques of modern biology, and human intervention (Myers & Irani, 2011; Rosentrater, 2005). It was within this broader view of agriculture that Rosentrater (2005) and Anderson and Anderson (2012) discussed the importance of incorporating scientific ideas into the agriculture curriculum because the science of agriculture involves the use and modification of biological material.

Degenhart et al. (2007) and Thompson and Warnick (2007) stated that students were more likely to experience learning from their accomplishments while engaging in hands-on learning experiences rather than passively listening to lectures. Furthermore, this was where the agriscience curriculum is claimed to excel because of its intrinsic hands-on learning approach (Parr & Edwards, 2004). Furthermore, Degenhart et al. (2007) indicated that because of the hands-on approach student enthusiasm increases for science, as does their belief in their ability to pursue science-related careers. Agriculture education has been viewed as a window to the world of science careers through its hands-on learning approach and the understanding that agriculture is a science, involving far more than the narrow view of crop and livestock production (Thompson & Warnick, 2007). Parr and Edwards (2004) and Morgan, Parr, and Fuhrman (2011) supported this evidence by showing that agriculture education influences what students learn because of how they were taught, and that agriscience students can achieve higher-order thinking skills and problem solving behaviors that encourage them to be interactive and life-long learners (Nolin & Parr, 2013).

Impact of Legislation on Agriculture Education

According to Winter (2003) and Myers and Irani (2011), as early as 1862 the U.S. government began to establish Land-Grant universities and agriculture experimental stations in each state. As the development of agriculture education continued, precursors to current agriculture educations legislative bills also developed, including the 1906 Burkett-Pollard Bill in Nebraska; the 1907 Clay-Livingston Bill in Georgia; and the 1907 Nelson Amendment, an amendment to the Morrell Act of 1890 that provided special provisions opening the door to prepare teachers of agriculture (Winter, 2003). Winter (2003) further suggested the monies established by these early bills were used to provide courses for the special preparation of instructors for teaching the elements of agriculture and the mechanical arts.

Hatch Act of 1887

The United States Department of Agriculture (USDA) (2012) claimed funds appropriated under the Hatch Act of 1887 were used to conduct original research, investigations, and experiments contributing to the establishment and maintenance of a permanent and effective agriculture industry in the United States. The USDA (2012) further stated that additional funds were used for the development and improvement of the rural home and rural life based on the needs and varying conditions of each state. Hillison (1996) suggested that the passage of the Hatch Act of 1887 resulted in a revolution in agriculture and agriculture science, and served as the originator of other Acts to follow that emphasized the addition of strong science content to agriscience curriculum. All students need a basic understanding of scientific concepts, and by teaching an agriscience curriculum, more specific concepts can be incorporated into the curriculum, enabling students to learn science more effectively (Hillison, 1996). In the years following enactment of the Hatch Act of 1887, the agriscience-based curriculum has succeeded in establishing a considerable and thorough curriculum that improved the quality and practical application of scientific knowledge for agriscience students (Hillison, 1996).

Smith Hughes Act of 1917

According the USDA (2012), the Smith-Hughes Act of 1917 began providing funds for teaching vocational agriculture in public schools. Nine schools in West Virginia employed agriculture teachers and began programs in vocational agriculture education in the fall of 1917 (United States Department of Agriculture [USDA], 2012). The Smith-Hughes Act of 1917 provided the basis for funding the special needs of agriculture extension programs and Land-Grant universities (USDA, 2012). The purpose of this funding was to increase the level of agriculture extension activities and reach out to new audiences through agriculture education (USDA, 2012). Nolan (1918) and Warnick (1998) claimed that the merging of agriculture and science in secondary education was a topic of discussion and debate prior to the passage of the Smith-Hughes Act of 1917, however, the Smith-Hughes Act was the first national approval of vocational education including education in the area of agriculture, as well as other trades and industries (Warnick, 1998). Consequently, the 1996 decision in Utah that agriscience coursework provides comparable preparation for the Utah

CRT-Biology as do traditional biology courses (Utah State Office of Education, 2012) was precipitated by the passage of the Smith Hughes Act of 1917, some nearly 80 years prior.

Carl D. Perkins Vocational and Applied Technology Act of 1990 (Perkins II)

The USDA (2012) suggested that Perkins II was established to make the United States more competitive in the world economy by more fully developing the academic and occupational skills of all segments of the U.S. population. The USDA (2012) claimed this was achieved by concentrating resources on improving educational programs leading to academic and occupational skill competencies for work in a technologically advanced society. As the 20^{th} century entered its last decade, Perkins II was crucial in that it encouraged collaboration, integration, and implementation of real-life learning experiences in the agriculture curriculum and classroom (Thompson & Warnick, 2007). This interdisciplinary and interactive approach enabled agriculture teachers to provide students with the knowledge that goes beyond simple agriscience and interactively provides students with real-life learning experiences. As a result, students were well-prepared for advanced study and employment in the changing agriscience industry (Thompson & Warnick, 2007).

Carl D. Perkins Vocational and Technical Act of 1998 (Perkins III)

The Carl D. Perkins Vocational and Technical Act of 1998 (Perkins III) is the current legislation that vocational education operated under in 2014 (USDA, 2012). The purpose of Perkins III was to more fully develop the academic, vocational, and technical skills of secondary students and post-secondary students who enroll in vocational and technical education programs (USDA, 2012). Only eight years after the passage of Perkins II, vocational and technical education was further strengthened in 1998 with Perkins III. The United States Department of Education (2012) looked to Perkins III in recommending using curriculum development as a strategy to strengthen student academic performance and to improve vocational program performance (Clark, 2012). Integration of academic and vocational subjects was a strategy for educational reform conceptualized by educators, supported by business, and articulated by policymakers of the Perkins Amendments (Conroy & Walker, 2000).

No Child Left Behind (NCLB) Act of 2001

The USDA (2012) described the NCLB Act of 2001 and agriculture education as a key component of President George W. Bush's effort to provide an opportunity for students to continue to learn new skills and discover new abilities. NCLB and agriculture education have provided and expanded academic enrichment opportunities by working in collaboration with public agencies, organizations, local businesses, secondary and post-secondary institutions, other scientific and cultural communities, and after school activities (USDA, 2012). Clemens and McElroy (2011) viewed the emergence of the NCLB Act as placing an emphasis on standardized testing as the common thread that has tied together the evaluation of teachers, students, and school performance. Despite the negative views that have been expressed about standardized testing (Herman & Golan, 1993), standardized performance evaluation can be used for mutual benefit (Clemons & McElroy, 2011). The Utah CRT-Biology (Utah State Office of Education, 2012) is a standardized test and is pivotal in showing how integration of NCLB requirements holding schools accountable (Clark, 2012) can be used to demonstrate the value of agriscience.

Clemens and McElroy (2011) suggested the combination of providing biology in agriculture presents a good place for integration where students can capitalize on scientific literacy creating a perfect intersection between disciplines by building ideas and concepts one upon another, thus transcending specific disciplines. When biology and science are combined, students spend more time in research, reading, writing, and analyzing scientific processes (Clemens & McElroy, 2011). This ideology fits well with the thinking behind the 1996 decision (Warnick, 1998) in Utah that agriscience coursework could provide comparable biology preparation for the Utah CRT-Biology (Utah State Office of Education, 2012). This decision served as the foundation for this research study because the validity of this decision had not yet been demonstrated (Utah State Office of Education, 2012).

The Need for Integration of Science into Education

Connors and Elliot (1995) found that science achievement scores in the United States have shown trends of no improvement, with science scores of U.S. 14 year-olds ranking 14th out of 17 countries. Evidence from the Program for International Student Assessment (PISA) test indicated that the math, reading, and science scores of U.S. 15-year olds remained flat while scores of comparable students in other countries soared (Layton, 2013). With U.S. achievement scores not improving while international achievement scores do only worsens the U.S. ranking. As U.S. Department of Education Secretary, Arne Duncan, remarked, the scores were "a 'brutal truth' that 'must serve as a wake-up call' for the country" (Layton, 2013, para. 4). This indication suggested that national science curriculum and science education were in a difficult situation when compared to an international perspective (Robinson et al., 2013). The lower science scores have increased the call for improved science education for American students (Connors & Elliot, 1995). Moore (1993) and Maguire et al. (2012) argued that the current situation facing education was the need to provide education in more appropriate ways. In support, Edwards (2004) claimed that student achievement has been directly linked to the core academic areas, including science, mathematics, and English, while calling for a restructuring of fundamental components and identifying opportunities for systemic improvements within education.

In terms of solving the education dilemma, Moore (1993) and Thoron and Myers (2011) suggested that merely teaching the facts was not enough. Rather, high school students need to build a strong background in science and technology, enabling more depth to the disciplinary sciences and an understanding of the complex relationships between humans and their environment (Moore, 1993). Moore (1993) emphatically discussed the need to reform the education system rather than devoting so much time to experimenting with new models of education, an approach Moore (1993) viewed as exacerbating the problems education faces. In viewing that society has assigned educators the task of educating citizens to be, Moore (1993) and Urman and Roth (2010) emphasized that part of this role must be to ensure that literacy in the sciences and technology pervades all learning to ensure that society understands and “feels at home” (Moore, 1993, p. 782) in the natural and human-made worlds. By increasing the amount of science in the K-6 curriculum, the younger students would be more eager and inquisitive, wanting to know and learn all sorts of things, enabling teachers to encourage them to do their own exploring and learning (Moore, 1993).

The assertions of Connors and Elliot (1995), Edwards (2004), and Moore (1993) suggested education reform needs to be refocused, also emphasizing the need for the curriculum to be integrated rather than isolated. Conroy and Walker (2000) have suggested that those who have studied integration have maintained it can address two criticisms: (a) strengthening student competencies in academic subject areas, critical thinking, and problem solving, and (b) ensuring that students learn academic content in ways that are relevant, or by providing other contexts in which the theory has meaning. The National Science Foundation

(1996) agreed, emphasizing in their report, *Shaping the Future,* the importance that biology must move beyond teaching the facts and in the direction of teaching critical thinking skills. The emphasis on education in science should include processes of discipline, addressing current application and implications on the curriculum being taught, encouraging integration between students, and developing writing and speaking skills (Eisen, 1998).

The Importance of STEM and Science Exposure

The United States has taken pride in being a leader in science and education (Nelson & Wright, 1992). However, maintaining such a status has met challenges in the past. For example, when the Soviets put the first man into space in April 1961 (Sandlin, Murphrey, Linder, & Dooley, 2013), President J. F. Kennedy responded in May 1961 by challenging NASA to put a man on the moon, a feat accomplished in June 1969 (Sandlin et al., 2013). A major message President Kennedy sent was one of urging the United States to rally its intellectual, industrial, and economic resources (Sandlin et al., 2013). Congress and the country responded (Anderson & Anderson, 2012). The wave of activity that followed included an intensive focus on identifying and providing the necessary science and math-focused educational responsibility for elementary, middle, and high school students across the country (Sandlin et al., 2013). These responsibilities included teachers at the Kindergarten to 12th-grade levels receiving intensive training in science and math (Jackson, 2007).

The NCLB of 2001 sought again to challenge education (Rhodes, 2007; Rice, LaVergue, & Gartin, 2011), yet the US has fallen behind other developed countries in math, science, geography, and basic literacy proficiency (Rhodes, 2007: Rice et al., 2011). Concerns about the academic preparedness of our youth have led to stronger pushes for

STEM education (Thoron et al., 2011). Some of the challenges in getting students interested in studying math and science were that it was often perceived as difficult (Ceci & Williams, 2010), not interesting (Ceci & Williams, 2010), and requiring too much schooling (Ceci & Williams, 2010; Jackson, 2007). Agriculture education and STEM (Herschback, 2011) can provide a window to math and science that is engaging, as well as agriculture providing a window that has a far larger female audience that most other sciences (Ceci & Williams, 2010). Furthermore, Johnson, Wardlow, and Franklin (1998) and Aragon, Alfeld, and Hansen (2013) have shown that supporters of hands-on sciences, like agriculture education, claim it has several advantages when compared to more traditional forms of science instruction.

According to Johnson et al. (1998), "the use of hands-on activities makes science vivid, meaningful, and fun for most students" (p. 19), including resulting in higher test scores from female students when participating in both immediate and delayed post-test studies. Aragon et al. (2013) and Moriba and Edwards (2013) also revealed that CTE science-based classes and experiences offer benefits above those offered through general education alone. In addition, female students tend to receive more of the benefits of the CTE and agriscience experience than male students (Aragon et al., 2013; Moriba & Edward, 2013). Aragon et al. (2013) suggested that recent research has shown that CTE education, including agriculture education, can also play a role in student dropout prevention (Shoulders & Myers, 2013), and can increase the amount of higher level math and science courses CTE students were taking compared to their general counterparts (Aragon et al., 2013).

Closing the Gender Gap with STEM and Agriculture

Maguire et al. (2012) and Aragon et al. (2013) suggested females entering STEM majors in college tend to be well qualified and likely to have taken and earned high grades in math and science classes taken in high school, giving them confidence in their STEM abilities. Although females tend to be the majority of college students (Aragon et al., 2013), only 15% of all female college freshman planned to major in a STEM field (American Association of University Women, 2010). According to Legewie and PiPrete (2011) females have made impressive achievements in STEM, but continue to be a minority in many STEM fields. Legewie and PiPrete (2011) have found that CTE- and STEM-related high school courses create environments that support female's achievements and interest in STEM, encouraging more females to pursue careers in STEM vital fields. Given the interest and positive attitude that high school students demonstrate toward hands-on science classes (Aragon et al., 2013; Johnson et al., 1998), agriculture provides an excellent window of opportunity to encourage more females to study STEM career fields (Ceci & Williams, 2010).

MacQuarrie, Applegate, and Lacefield (2008) and Nolan and Parr (2013) reported that schools across the country have mandated and are expected to improve students' skill levels to prepare students for the next stage. Rojewski et al. (2008) suggested using CTE and agriculture education as they integrate STEM into the curricula, providing students with technical skills, knowledge, and the training necessary to succeed in specific occupations and careers. Jackson (2007) and Legewie and PiPrete (2011) insisted on the importance of tapping the new majority of young women and ethnic minority groups, both of whom are underrepresent in STEM professions.

According to Alesina, Giuliano, and Nunn (2013), historically and traditionally agriculture has had lower female participation in agriculture activities. Furthermore, Peterman, Behrman, and Quisumbing (2011) warned that the failure to recognize the roles, differences, and inequities between men and women presents a threat to the effectiveness of agriculture development. In a report on the status of women in the College of Agriculture at Iowa State University (2000), undergraduate women in the College of Agriculture have been increasing, going from 20% of students in the academic year 1980-81 to 37% in 1997-98, showing an increasing trend of female participation within agriculture education. Jackson (2007) claimed that if the Nation was going to succeed in filling the emerging gap in engineering and science talent, the United States cannot continue to ignore the 30% of the population represented by ethnic minorities in this country. Nor can the United States ignore women who, together with minorities, comprise the underrepresented majority of the STEM workforce. Engaging the complete talent pool must be a top priority (Jackson, 2007).

Integration of Science into Agriculture Education

Agriculture education provides an opportunity to address the U.S. educational concerns expressed by Splinder and Greiman, (2013), Connors and Elliot (1995), Edwards (2004), and Moore (1993). The US must take advantage of the integrative approach of Conroy and Walker (2000) to strengthen student competencies in academic subject areas, critical thinking, and problem solving and to ensure that students learn academic content in ways that are relevant and have meaning. For example, an understanding of the sciences and major technologies helps students find importance in understanding the biotechnical and agriculture industries (Hodge & Lear, 2011; Moore, 1993). Agriscience can take scientific topics to higher levels, emphasize scientific concepts, involve hands-on learning, and develop interrelationships with the other sciences, thus making the living and non-living world around them relevant for students (Hodge & Lear, 2011; Moore, 1993). Likewise, Edwards (2004) and Nolin and Parr (2013) pointed out that student achievement in an era of "high stakes testing" (Edwards, 2004, p. 227) should support the integration of science into the agriculture curriculum. Agriscience courses place the science disciplines at the forefront of instructional emphasis (Nolin & Parr, 2013), constantly encouraging students to think critically, objectively, and analytically, supporting a continual growth in critical thinking skills throughout the agriscience curriculum (Taylor & Kauffman, 1983). Dormody (1992) took this even one step further, recommending that not only should agriculture teachers continue teaching the more applied agriscience curriculum, but also work closely with traditional science teachers. This combined approach of sharing and developing strategies that promote positive attitudes toward student learning could demonstrate student achievement among both agriscience and traditional science students.

Providing a Bountiful Harvest Within Agriculture Education

The National Research Council (2009) suggested that all students, beginning with Kindergarten and continuing through 12th grade should receive agriculture instruction providing students with higher academic achievement and agriscience knowledge. This approach reflects on the assertion by Rosentrater (2005) that "when tillage begins; other arts will follow" (p. 320). Agriculture education can thus offer a bountiful harvest of educational possibilities for classroom connections (Pense, Leising, Portillo, & Igo, 2005). Parr and Edwards (2004) claimed that it is widely accepted that student learning should take place as a process, linked with opportunities for students to make connections and associations, and to make meaning of their learning as it happens. Inquiry-based learning has been deeply practiced in science education as an active approach to learning (Parr & Edwards, 2004). Furthermore, in schools where active learning methods take place, students demonstrated significantly higher achievement scores (National Research Council, 2009).

Rekindling the Interest in Science Education

The Committee on Agriculture Education in the Secondary Schools, part of the National Academy of Sciences (1998), claimed that science has been portrayed as depressing, citing evidence that large numbers of American students avoid science in both secondary and higher education. A major effort within agriculture education has been to re-stimulate interest in science education (Thompson, 1998). Dailey, Conroy, and Shelly-Tolbert (2001) proposed that agriculture education could provide new student interest in science by offering integrated agriscience courses and presenting topics related to floral design; machinery operation and repair; and knowledge about animal, livestock, and food qualities. The real-world opportunity that the agriscience curriculum offers to students provides the knowledge and structure needed to rekindle science programs within high schools (Dailey et al., 2001). Thompson (1998) stated that policy makers, educators, administrators, scholars, and social critics have advocated that agriculture education and its approach of integrating scientific academic content in the curriculum has improved the image and quality of high school agriculture programs by meeting the needs and demands of a changing educational system.

French and Balschweid (2009) reiterated the call from the National Academy of Sciences (1998) and the “Gary plan” (Kaluf & Rogers, 2011, p. 14) that there is a need for enhanced science instruction at the secondary level. French and Balschweid (2009) and Kaluf and Rogers (2011) claimed that as agriculture education continues to integrate science into the curriculum, students become capable of learning dynamic scientific inquiries. French and Balschweid (2002) further claimed that as agriculture students enter the classroom and are presented with scientific inquiry-based facilitating, students learn important life skills and become actively engaged with their learning. Since the 1980s, the National Commission on Excellence in Education (1983) and Kaluf and Rogers (2011) have supported the concept of integrating science into agriculture education programs. Research by Balschweid (2002) supported this view, showing that integration of science into agriculture courses has been a more effective way to teach science as demonstrated by higher achievement than students taught by traditional approaches. When students focus and understand the nature of science rather than focusing on what they know about science, it offers multiple opportunities to think scientifically and apply scientific reasoning to every day, complex problems (Balschweid, 2002).

Further, since 1988, the USDA (2012) has funded grants that strengthen agriculture education in preparing students to pursue careers by incorporating science, business, and consumer education into an agriscience curriculum. In considering the results of the USDA (2012) grants, Balschweid (2002) and Splan et al. (2011) found that students learn better when shown connections between what was required of them to learn and how to use the connection in real life applications. An integrated agriscience curriculum creates authentic learning experiences that develop connections to motivate, enhance academic performance, and promote student learning (Balschweid & Thompson, 2002).

Positive Impacts Found Within Agriculture Education

Connors and Elliot (1995) reviewed research studies showing that agriscience taught students have performed equally to or better than students in traditionally taught science courses. In fact, at comparable grade levels, agriscience students were leading state science standards compared with students in traditional science classes (Connors & Elliot, 1995). More than just attaining equal learning, Connors and Elliot (1995) claimed that science knowledge differs between students who receive traditional science instruction and those who received agriscience-based instruction. In addition, new and innovative methods of presenting scientific methods in the agriscience approach improve students' achievement and enthusiasm for learning science.

Taylor and Kauffman (1998) have suggested that the demand created for quality instruction and more accountability has been a part of the philosophical rhetoric that has been ongoing since at least the 1930s. As Taylor and Kauffman (1998) noted, even in the 1930s, educators were called upon to create objective approaches to teaching, developing curriculum, and helping plan and place students into a career. Taylor and Kauffman (1998) claimed that by adding science into the agriculture curriculum there has been an increase in computer integration, more hands-on experiences, improved communication skills, integration of business and economics skills, and new discoveries, as well as rediscoveries of old approaches that continue to motivate students to learn and think.

Mowen, Wingenbach, Roberts, and Harlin (2007) suggested the majority of agriculture teachers agree that secondary schools should require more science to be integrated into the agriculture education curriculum to improve the academic content, as well as to help students adequately prepare for science related careers. Conroy and Walker (2000), claimed that when sciences were added into secondary agriculture education it met the need for basic instruction and the concepts required of workers in technical jobs. The added benefits to students enrolled in an agriscience course were that the agriscience approach allowed for further gains in knowledge, information, and understanding of agriculture (Mowen, Wingenbach et al., 2007). Mowen et al. (2007) stated, "agriculture education was the premier vehicle for contextualized teaching and learning within any community setting, and should be meeting both the demands of the agriculture industry, as well as students" (p. 107). Mowen et al. (2007) implied that agriculture teachers must be able to assess and evolve to meet the demands of their environments and students' needs. Through agriscience education, students achieve positive learning impacts and retain high levels of knowledge (Mowen et al., 2007).

Integration of Biology into Agriculture Education

The American Association for the Advancement of Science (1990) suggested that the agriscience curriculum had been taught by integrating scientific principles with agriculture, and that equal achievements can be obtained by agriscience students, and students taught traditional biology. Dormody's (1992) research suggested that agriculture and biology were natural partners in the classroom. Connors and Elliot (1995) suggested that agriculture provides an amazing means for teaching biological concepts where real examples and hands-on experiences become part of the classroom experimentation and observation. Dormody (1992) stated, "biology in agriculture involves the application of chemistry, biology, and zoology concepts and principles in studies such as agronomy, crop science, animal science, forestry, natural resources, poultry science and horticulture" (p. 23). Dormody (1992) further suggested that it was logical for agriculture teachers to teach biology in their curriculum because of the importance of biology in promoting the agriculture literacy development of their students. Rosentrater (2005) supported the observation that by infusing agriculture curricula with scientific knowledge and skills improves student understanding of biological sciences and their scientific literacy.

Jungwirth and Dreyfus (1973) supported the effectiveness of combining biological principles and agriculture application in meeting the need for student achievement by improving student habits in inductive thinking. In addition, agriculture biology courses provide the means to develop positive attitudes toward the study of biological topics and situations (Jungwirth & Dreyfus, 1973). The agriculture biology approach not only helps emphasize the scientific nature of modern agriculture, but it also helps demonstrate the vast potential of prospective careers that the agriculture industry provides (Roegge & Russell, 1990).

Packer (2009) demonstrated the effectiveness of hands-on learning projects in biology courses, noting that students can learn more academic content because they become interested in how biological issues connect to them and their interests. Students can better understand the importance of biological principles when given the chance to apply these principles to real-world experiences (Packer, 2009). This hands-on focus was a critical aspect of the success because agriscience courses tend to emphasize the hands-on and applied aspects of learning (Dormody, 1992). Packer (2009) claimed that the intent of incorporating science into the agriculture curriculum was to impress upon the students that science is more than a collection of facts; it is an approach to thinking about the world.

Eisen (1998) discussed the importance of students not only having the capacity to learn the fundamental knowledge required of biology students, but also how to present scientific information and the aptitude to see and make connections among the crucial themes of biology. Knobloch (2008) confirmed that students need a continuation of genuine learning involvement to motivate them into developing inquiry skills, applying academic content, and connecting their learning further than the perspective of the classroom. Knobloch (2008) argued that by changing attitudes and connecting biology to agriscience, the integrated topics and activities enhance student learning and their understanding of scientific principles. The agriscience curriculum has provided students hands-on, real-life opportunities to be engaged in experiential learning and connecting content to real-world relevance (Knobloch, 2008). Knobloch (2008) stressed that the interdisciplinary education was the means to foster students into profound thinking about agriculture systems, biology, and their role in society.

The Role of Agriculture in Biology/Agriculture Education

Klein (2012) professed that agriscience programs bring life to math, reading, and the sciences for many students. Klein (2012) further claimed that agriscience students were very thirsty and the integrated approach provides them an opportunity to drink, thus giving the students a three-dimensional learning process and proving that students respond better with hands-on learning. Klein (2012) suggested that agriculture education prepares students to work, students who learn how to work become better citizens, and better citizens are those who think critically.

Dreyfus (1987) discussed the importance of understanding the role and potential role of agriculture in science teaching. The potential roles stem from the diversity of agriculture's components and intellectual and practical activities that embrace the elements of modern science teaching (Dreyfus, 1987). Agricultural science thus adds a combination of educational opportunities based on tradition, science, and technology. For example, Connors and Elliot (1995) stated that agriculture education has called for new and innovative approaches to teaching science, resulting in student acquisition of science knowledge that differs from those students who receive traditional science instruction. However, while agriculture education was recognized as a curriculum for several decades and the potential role of agriculture education was fairly well understood, the potential role of teaching science in agriculture has seemed to be a neglected issue (Dreyfus, 1987). Whether incorporating biology into the agriculture classroom has been viable and whether doing so produces biology knowledge comparable to traditional biology curricula remains unproven (Dormody, 1992). Historical trends and information from agriculture programs that have incorporated biology must be evaluated before passing judgment regarding the ability of biology-infused agriculture curriculum to substitute for traditional biology programs, an important step in defending continued efforts in providing agriscience in the agriculture classroom (Dormody, 1992).

Ricketts, Duncan, and Peake (2006) described the accomplishments of agriscience students taking the science portion of the Georgia High School Graduation Test, finding that agriscience students compared favorably with other students. Rather than focusing on individual facts, teaching biology in the agriculture classroom promoted the use of contextual learning through agriscience and demonstrated that agriscience education programs exemplify the necessary factors of constructive pedagogy; providing real, relevant, reflective, and multiple venues for understanding science in the agriscience classroom (Ricketts et al., 2006). Parr and Edwards (2004) also supported the claim that agriculture education encourages students to think creatively and critically, as well as facilitating a deeper understanding of scientific concepts, developing positive attitudes toward scientific learning, and cultivating students with advanced reasoning skills. Furthermore, enrolment in high school agriscience courses has provided a means to develop positive attitudes toward the study of biological topics and situations (Stephens & Latif, 2005).

Stephens and Latif (2005) discussed the need for students to become better prepared to pursue careers related to the agriscience-based industry. Stephens and Latif (2005) noted tremendous advances were being made in biotechnology discoveries and applications such as health; industrial technology programs; foods and nutrition; and other categories of jobs relevant to the biotechnology industry including agriculture, pharmacy, and science. As a result, there are increasing demands and services that continue to develop, while at the same time, there were projected shortages of employees who have the requisite knowledge and skills necessary in the growing agriscience industry (Stephens & Latif, 2005). The agriscience field thus offers many emerging opportunities based on life-science, products, and processes with a growing career potential that should be attractive those who do not typically consider agriculture as a career (Stephens & Latif, 2005).

Holding Agriculture Educators Accountable

In 1990, Perkins II was the first major piece of federal legislation encouraging educators to shift away from the traditional job skills orientation of vocational education and move toward the use of vocational education to teach academics and other forms of thinking skills (Strecher et al., 1994). One of the key guidelines of the Perkins II initiative was the integration of vocational and academic curriculum (Strecher et al., 1994). In the final report to the U.S. Congress regarding the 1998 Perkins III, the United States Department of Education recommended using curriculum development as a strategy to strengthen student academic performance and to improve vocational program performance (Clark 2012).

As a result of the NCLB Act of 2001, which President George W. Bush signed into law on January 8, 2002, states were required to be held accountable for the academic achievement of their students (Clark, 2012). Consequently, educators became more focused on academic performance and techniques to improve test scores (Nolan & Parr, 2013). For example, in Utah, secondary education students were required to pass three science courses – one life/biological science, one physical science, and one elective science – (Warnick, 1998), and all three science sections of the Utah Basic Skills Competency Test (Utah State Office of Education, 2012).

NCLB holds academic, career, and technology educators across the nation accountable for student achievement in the core academic subjects by 2014 (Clark, 2012). In addition, science educators recommend that scientific principles must be taught in elective courses to bridge the gap from educational settings to authentic applications (Israel, Myers, Lamm, & Galindo-Gonzales, 2012; Thompson & Warnick, 2007). One suggested technique was to connect agriculture education to academic subjects to reiterate academic course objectives (Clark, 2012).

In response to connecting agriculture curriculum to academic subjects, in 1998, two years after the initial decision of allowing biology into the agriculture classroom (Utah State Office of Education, 2012; Warnick, 1998), the Utah State Office of Education, and Agricultural Education Department implemented Utah Performance Standards for agricultural education courses and cross-referenced science, social studies, English, and mathematics (Anderson & Anderson, 2012). In addition, biological standards were incorporated into each agricultural education standard in the B/AS curriculum (Utah State Office of Education, 2012). As a result, the Utah B/AS course was designed to meet the requirement for one biological science credit (Utah State Office of Education, 2012; Warnick, 1998). The standards and objectives for the Utah B/AS course were the same as the standards and objectives for the General Biology course, with the only difference being the degree of emphasis on agriculture (Utah State Office of Education, 2012). With agriculture education teaching methods including hands-on activities, problem solving and inquiry-based opportunities were promoted for students to apply and reflect on educational standards (Morgan et al., 2011; Parr & Edwards, 2004). Students completing the Utah B/AS course were expected to be cognizant of the core curriculum, including individual standards (see Table 1), current technologies, methods and changes in agricultural science, and were expected to know and apply the standards outlined in the core curriculum as they relate to the industry of agriculture (Utah State Office of Education, 2012).

Applied and Contextual Combinations in Agriculture Education

Dailey et al. (2001) noted that past research studies indicated that students lacked understanding of science and mathematics in traditional classrooms because of both a lack of knowledge and disconnect in being able to utilize or transfer skills to real-world situations. Dailey et al. (2001) claimed that when science is applied to the agriculture curriculum, a culmination of principles of physical, chemical, and biological sciences cause positive and drastic changes in agriculture education. These changes, involving the integration of the sciences, include opportunities for deeper learning and understanding, reinforcement of classroom instruction in mathematics and science, and improving the acquisition of basic processing skills of students (Dailey et al., 2001). Dailey et al. (2001) also showed that student achievement in science and mathematics were higher as a result of participation in agriculture, leading Daily et al. (2001) to claim that when integration of science and agriculture happens, students' attitudes change, personal learning skills improve, and students become involved in their learning.

Whent (1994) highlighted that agriculture education may be unknown to many traditional educators. In fact, it is not uncommon for agriculture teachers to teach at a high school for many years without knowing other teachers, or what they are teaching. Likewise, Warnick (1998) reported that before, since, and after the 1996 decision in Utah to enable students to take B/AS instead of traditional biology, agriculture educators have often been considered and tolerated as a "step child" of the biological science community (p. 26). In relating agriculture to the growing of knowledge, not just crops, Knobloch (2008) suggested that those teachers who do not value agriculture have little knowledge and misconceived ideas about agriculture, thus failing to see the benefits of integrating biology into the agriculture curriculum. However, as 21st century educational trends move toward integration, collaboration, and cross-departmental participation, this may provide new fertile ground for these endeavors to happen and better integrate agriculture teachers with their other teaching colleagues (Whent, 1994).

Justification of Descriptive Comparative Design with Analysis of Variance

Considerable research provides theoretical support for the inclusion of science into the agriculture classroom (Balschweid, 2002; Clark, 2012; Conroy & Walker, 2000; Dreyfus, 1987; Hillison, 1997; Rosentrater, 2005; Thompson, 1998; Warnick, 1998). However, much of this research results in non-quantifiable claims that agriscience programs bring life to math, reading, and the sciences for many students (Klein, 2012) and providing biology in agriculture education has created a perfect intersection between disciplines (Clemens & McElroy, 2011). Whether incorporating biology into the agriculture classroom or not

(Dormody, 1992), only a single statistical comparative study done in Georgia has been completed to make comparisons (Ricketts et al., 2006). Despite the passage of nearly two decades since the 1996 decision by the Utah State Office of Education (2012) approving the B/AS course as being the curricular equivalent of General Biology in preparing high school students for the Utah CRT-Biology, as of 2014, no statistical verification of this equivalency has been ascertained (Utah State Office of Education, 2012). To properly assess whether the 1996 Utah decision (Utah State Office of Education, 2012) was justified requires statistical rigor in keeping with the national mandate of accountability standards (Clark, 2012; NCLB Act of 2001; United States Department of Education, 2012). The purpose of this study was to address the missing accountability and provide statistical evidence in a rigorous descriptive, longitudinal, comparative analysis that determined if Utah high school agriculture students were performing as well as their general biology counterparts on the Utah CRT-Biology exam by using data provided by the Utah State Office of Education (2012).

In determining the most appropriate quantitative research design to address this study's research questions, a descriptive, comparative within-participants posttest only design (Christensen et al., 2011) with a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) was used. A descriptive comparative quantitative study was an appropriate approach for this statistical study because it involved within-participants only serving as their own control by participating in all of the experimental conditions, with all variables and prior experience remaining constant over the duration of the study (Christensen et al., 2011). Christensen et al. (2011) claimed that having the participants serve as their control has been a powerful technique of control because they were thus evenly matched in the treatment conditions, which in turn increases the sensitivity of the experiment optimizing the participant's sensitivity to the effects of the test group or independent variable. Christensen et al. (2011) cautioned that when using the within-participants only design a sequencing effect can occur when participants become involved in more than one treatment condition. However, this was not a factor in this study as no participant was enrolled in both the general biology and BA/S course in preparation for the posttest CRT-Biology (Utah State Office of Education, 2012). Further, the within-participants posttest only design and use of representative sampling was recommended, particularly when there was no possibility of administering a pre-test to the research participants (Christenson et al., 2011), such as there was not in this study.

To ensure statistical reliability of the analysis, the recommendation of Neuman (2006) was to use a representative sample equal to 37.2% of the total population to produce a 99% confidence level in the reliability of the results. Consequently, this study involved the examination of test scores on the Utah CRT-Biology (Utah State Office of Education, 2012) from 37.2% comparably gender-stratified random Utah high school students taking B/AS, and tests scores of 37.2% comparably gender-stratified random Utah high school students taking general biology for each year from 2008 through 2012. The data were provided in a data file that was scrubbed of personal identifiers by the Utah State Office of Education (see Appendix A) as per the Utah Education Facts campaign stipulations (Utah Education Network, 2012), with support for the study from the State Director of Agriculture Education and the State Director of Biology Education (see Appendix A).

The descriptive comparative within-participants posttest-only design (Christensen et al., 2011) was conducted utilizing an independent *t*-test (University of California Los Angeles, 2013) for correlated means to determine whether there was a statistically observed difference of $p \leq .05$ between the two populations (general biology and BA/S) on the posttest variable (Utah CRT-Biology score). In addition to considering the *t-test* (University of California Los Angeles, 2013) comparison for the overall Utah CRT-Biology score, the 10 individual standard scores (see Table 1) were also compared via independent *t* test analysis (University of California Los Angeles, 2013). The *t*-test (University of California Los Angeles, 2013) comparative means analysis was conducted for each of the five years of data from 2008 through 2012. Any environmental difference between the five consecutive years were negligible as the students took the same standardized CRT-Biology and were taught either general biology or B/AS with both courses adhering to the same biology standards and objectives as established by the Utah State Office of Education (2012).

In addition, since five consecutive years of data were available for this study, a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) was undertaken to explore any gap trend in the scores between traditional biology and BA/S students (see Table 12). While the intent was not to verify the validity of the assumption that there was no environmental difference between the five consecutive years of data, this provided an opportunity to see if any gap in performance between students in the general biology curriculum compared to the BA/S curriculum has widened, narrowed, or remained constant (see Table 10). If a gap change existed, it may provide insight that can be subsequently investigated to understand and address causative factors (Christensen et al., 2011) as the State of Utah continues to demonstrate accountability of its educational efforts, both for self-improvement needs (Utah Education Network, 2012; Utah State Office of Education, 2012), and to meet the mandates established by the NCLB Act of 2001 (Clark, 2012).

Conclusions

With science scores of U.S. 14-year-olds ranking 14th out of 17 developed countries (Connors & Elliot, 1995) and results not improving with the release of results from an internationally comparative 2012 PISA test (Layton, 2013), there is an obvious concern for science education in the US. Dailey et al. (2001) suggested that students lack understanding of science and mathematics in traditional classrooms in part because of not being able to utilize or transfer skills to real-world situations. However, when science and mathematics become integrated in an applied program, such as agriscience, student attitudes change, their learning skills improve, and students become involved in their learning (Dailey et al., 2001).

Agriculture teachers agreed that stronger connections were made between science and the agriculture curriculum, and that agriculture programs should become more science-based (Thompson & Warnick, 2007). While this assertion suggested promise for the future development of an integrated agriscience curriculum, it also suggested a potential doubt in the wisdom of allowing Utah high school students to take agriscience BA/S rather than a general biology curriculum (Utah State Office of Education, 2012). This study explored if there were differences in student learning testing outcomes from general and agriculture biology programs by evaluating the difference in Utah CRT-Biology scores (Utah State Office of Education, 2012) for students who completed a traditional biology course compared to those who selected the BA/S alternative. For the first time in nearly two decades since the 1996 Utah decision (Utah State Office of Education, 2012) was made, this study provided quantitative evidence via a descriptive comparative within-participants posttest-only design with an analysis of variance to answer the question of whether the Utah BA/S curriculum has meet general biology learning outcomes. A positive result could lead to additional enhanced agriculture programs whereas a negative result could point to areas where the BA/S curriculum needs improvement.

Summary

Connors and Elliot (1995) have presented one possible solution to the challenge that has been plaguing science education; a solution that involves increasing the student's interest in science by incorporating agriculture based curriculum, resources, and concepts to teach science. An underlying assumption and expectation (Conroy & Walker, 2000) was that broadening the scope of agriculture education with an increased science curricular focus will help improve interest in agriculture, and result in better student achievement in the sciences (Roegge & Russell, 1990). This approach fits well with the intent of this study's perspective of determining if students enrolled in B/AS courses comprehend science principles on a level equal to students who were enrolled in traditionally taught biology and other science courses.

The purpose of Chapter 3 is to spotlight the study's descriptive comparative within-participants posttest only design (Christensen et al., 2011) with a five-year analysis of variance (Neuman, 2006; Steinberg, 2008). The study examined the agriculturally supported perspective that since agriculture courses include biology along with other sciences (Balschweid, 2002; Conroy & Walker, 1995; Johnson & Newman, 1993; Warnick, 1998), students taking the B/AS course as part of their agriculture education curriculum should be expected to score as well on the Utah CRT-Biology (Utah State Office of Education, 2012) as students taking a general biology course. This quantitative comparison of comparable student cohorts who were expected to be equally prepared and achieve the same standardized testing results finally determined the validity of 1996 decision in Utah to consider the BA/S curriculum equal preparation to that of the general biology curriculum (Utah State Office of Education, 2012).

CHAPTER 3: METHOD

The purpose of this descriptive comparative quantitative study using within-participants posttest-only design (Christensen et al., 2011) with a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) was to determine if general biology students and B/AS students were scoring at a similar level on the Utah CRT-Biology (Utah State Office of Education, 2012) as premised, but not yet tested nearly two decades since the 1996 State of Utah approval (Warnick, 1998) for students to take B/AS without an additional biology course requirement (Utah State Office of Education, 2012; Warnick, 1998). By analyzing the CRT-Biology scores, both composite and for the 10 individual standards (see Table 1), between the two populations, evidence has demonstrated whether the 1996 decision (Utah State Office of Education, 2012) to implement a B/AS curriculum with an enhanced focus on biology was well-founded.

Research Method and Design Appropriateness

A descriptive comparative quantitative study was an appropriate approach for this statistical study involving within-participants only who serve as their own control by participating in all of the experimental conditions, with all variables and prior experience remaining constant over the duration of the study (Christensen et al., 2011). Further, no sequencing effect (Christensen et al., 2011) occurred as no participant took both the general biology and BA/S course in preparation for the posttest CRT-Biology (Utah State Office of Education, 2012). In addition, since five consecutive years of data were available for this study, a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) was undertaken to explore any gap trend in the scores between traditional biology and BA/S students.

The descriptive comparative within-participants posttest-only design (Christensen et al., 2011) was conducted utilizing an independent *t*-test (University of California Los Angeles, 2013) for correlated means to determine whether there was a statistically observed difference of $p \leq .05$ between the two populations (general biology and BA/S) on the posttest variable (Utah CRT-Biology score) for each of the five years of data from 2008 through 2012. In addition to considering the *t*-test (University of California Los Angeles, 2013), comparison for the overall Utah CRT-Biology score, the 10 individual standard scores (see Table 1) were also compared via independent *t-testing*, prior to conducting the five-year analysis of variance (Neuman, 2006; Steinberg, 2008).

Research Questions

This study determined if any statistically significant ($p \leq .05$) differences in student learning outcomes existed between traditional biology and B/AS programs by evaluating the difference in Utah CRT-Biology results (Utah State Office of Education, 2012) among students taking the respective biology preparatory courses as 10^{th} through 12^{th} graders from 2008 through 2012.

Research Question 1

To what extent is there a difference in Utah CRT-Biology results from students in traditional biology programs compared to students in B/AS programs?

$H1_0$: No significant ($p > .05$) difference in Utah CRT-Biology scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

$H1_a$: A significant ($p \leq .05$) difference in Utah CRT-Biology scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

Research Question 2

To what extent is there a difference in the Utah CRT-Biology results, in any of the Utah CRT-Biology individual standards (See Table 1) from students enrolled in traditional biology courses compared to students enrolled in B/AS courses?

$H2_0$: No significant ($p > .05$) difference in the Utah CRT-Biology individual standard scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

$H2_a$: A significant ($p \leq .05$) difference in the Utah CRT-Biology individual standard scores exists between students taught biology using the traditional approach compared to those students taught using the B/AS approach.

Research Question 3

To what extent has any difference in Utah CRT-Biology scores between students taught biology using the traditional approach compared to those students taught using the B/AS approach varied during the five-year period from 2008 through 2012?

$H3_0$: Any gap in Utah CRT-Biology scores between students taught biology using the traditional approach compared to those students taught using the B/AS approach has narrowed ($p \leq .05$) during the five-year period from 2008 through 2012.

$H3_a$: Any gap in Utah CRT-Biology scores between students taught biology using the traditional approach compared to those students taught using the B/AS approach has widened ($p \leq .05$) or not changed ($p > .05$) during the five-year period from 2008 through 2012.

Geographic Location

This study was specifically limited to the state of Utah as it sought to provide statistical evidence regarding the performance of 10th to 12th grade Utah high school students on the state-mandated Utah CRT-Biology (Utah State Office of Education, 2012) following completion of the required biology curriculum, either general biology or BA/S. While not intended to be generalizable to other states, the evidence generated by this study, in conjunction with the three other similar analyses done in Georgia (Ricketts et al., 2006), Arizona (Elliot, 2008), and Alabama (Nolin & Parr, 2013) offered some limited insight into the justification for inclusion of agriscience courses in high school curriculums elsewhere.

Population

The population of interest was the complete cadre of 10th to 12th grade students in Utah high schools who took the mandatory Utah CRT-Biology (Utah State Office of Education, 2012) from 2008 through 2012 after having first taken either general biology or the BA/S course. From this population, the recommendation of Neuman (2006) and Christensen et al. (2011) of selecting a representative sample equal to 37.2% of the total population was used, producing a 99% confidence level in the reliability of the study results (Gall et al., 2007).

The total numbers of student test scores were 12,791 test scores of students taking B/AS and 124,898 test scores of students taking general biology. The 37.2% recommended (Neuman, 2006) random, gender-stratified sample used for analysis included 4,758 B/AS student test scores and 46,462 general biology test scores. The data were provided in a data file that was scrubbed of personal identifiers by the Utah State Office of Education (see Appendix A) as per the Utah Education Facts campaign stipulations (Utah Education

Network, 2012) with support for the study from the State Director of Agriculture Education and the State Director of Biology Education (see Appendix A). Other than overall and individual standard CRT-Biology scores, the only additional data provided in the file was the testing year to enable the longitudinal trend aspect of the study (Neuman, 2006; Steinberg, 2008).

Sampling Frame

When sampling, rather than the entire population being utilized, McMillan and Schumacher (2006) emphasized the importance of ensuring that the sample was representative such that it accurately represented the population of interest. Christensen et al. (2011) suggested that the way to represent a population is by using an equal probability of selection method, in which any member of the population has an equal chance of being selected for inclusion in the sample. Particularly with respect to education, Gall et al. (2007, p. 395), viewed "representative sampling is a process for planning an experiment so that [it] accurately reflects both real-life environments in which learning takes place and the natural characteristics of learners." This condition was critical in eliminating any potential bias that was introduced into the Utah CRT-Biology comparative analysis (Christensen et al., 2011).While a variety of factors were not considered due to limited student information, e.g. rural vs. non-rural, ethnicity, socioeconomics, and teacher experience, the sample was equally gender stratified based on composite balance.

The within-participants posttest only representative sample design (Christensen, 2011) provided the ability to enlist a large group sample of participants to test the hypotheses of this study that agriculture biology students perform as equally well as traditionally taught biology students on the Utah CRT-Biology. To ensure statistical reliability of the analysis, this study involved the examination of Utah CRT-Biology scores (Utah State Office of Education, 2012) from 37.2% comparably gender-stratified random Utah high school students taking B/AS, and test scores of 37.2% comparably gender-stratified random Utah high school students taking general biology for each year from 2008 through 2012. Christensen et al. (2011) suggested that the larger the sample size makes it less likely that an effect or relationship was missed that was present in a population. Thus, use of a large representative sample size helped in obtaining a relatively narrow confidence interval (Christensen et al., 2011), specifically the 37.2% of the total population inclusion recommended by Neuman (2006) to generation a 99% confidence interval.

Informed Consent and Confidentiality

This study did not involve actual participant participation, but rather relied on historical test result data from the 2008 through 2012 administration of the Utah CRT-Biology to 10th through 12th grade students after completion of their biology class requirement, either general biology or BA/S. As such, no individual informed consent was sought. Rather, the Utah State Office of Education (see Appendix A), as per the Utah Education Facts campaign stipulations (Utah Education Network, 2012), provided the raw data for analysis, with support for the study from the State Director of Agriculture Education and the State Director of Biology Education (see Appendix A). The data retrieved from the test scores were scrubbed of any personal identifiers prior to researcher access to ensure confidentiality of student test data.

Data Collection, Instrumentation, and Analysis

In 2011the Utah Education Facts campaign (Utah Education Network, 2012), and the Utah State Office of Education (Utah State Office of Education, 2012) granted licensed Utah educators access to educational information, including testing data, making this research effort possible. The instrumentation used throughout this research was the IBM Corporation Cognos® database and reporting software application (Utah Education Network, 2012), which provided the researcher the data necessary to conduct the study in accordance with the intent of Utah in providing access to data to more precisely measure student development and to help educators pursue professional development opportunities (A Summary of Core Components, 2012).

Once the scrubbed data were received from the Utah State Office of Education (see Appendix A), it was analyzed with IBM® SPSS® Statistics version 21 software to generate the descriptive comparative analysis and analysis of variance results. The independent variable was represented by the traditional biology students, effectively the control group against which the BA/S students, representing the test group or dependent variable, were compared. The data were analyzed using an independent *t-test* (Gall et al., 2007; University of California Los Angeles, 2013) to evaluate levels of significant difference. In addition to the composite test scores, each of the 10 individual standard scores (see Table 1) were compared for each year of the 2008 through 2012 longitudinal continuum. With multiple year data available from 2008 through 2012, ANOVA (Neuman, 2006; Steinberg, 2008) was used to monitor the increase or decrease of agriculture student performance on the Utah CRT-Biology (see Table 10) (Utah State Office of Education, 2012) compared to the test outcome results of traditional biology students over the five-year longitudinal period.

Validity and Reliability

The research methodology strengthened this study's validity and reliability by focusing on the selection of the groups, separating traditional biology taught students as the independent variable or control group from those taught with an agriculture emphasis as the dependent variable or test group (Christensen et al., 2011). Christensen et al. (2011) further stated that as long as the focus remained on these two variables, the results acquired from the nonequivalent comparison group design would produce a close approximation to a randomized experimental research design in achieving unbiased results. Further, this approach helped ensure that observed differences between the two groups were not caused by group differences in extraneous variables such as attrition, maturation, operation of instruments, regression to the mean, or reactions to non-treatment events occurring during the five-year period of study (Christensen et al., 2011).

Reliability

Reliability is the degree to which an assessment tool produces stable and consistent results (Christensen et al. 2011). This study utilized parallel forms of reliability (Gall et al., 2007) with a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) for Utah CRT-Biology test result evaluation. According to Gall et al. (2007) and Christensen et al. (2011), parallel forms of reliability are a measure of reliability obtained by administering different versions of delivery containing the same items that probe construct, skill, knowledge base, etc. within a group of individuals. Reliability for this study was established by utilizing the within-participants posttest only design (Christensen et al., 2011) by descriptively comparing the test scores of the two groups, B/AS and general biology, and exploring the differences in student learning outcomes as measured by the results of the Utah CRT-Biology. While the Utah Department of Education does not report a reliability estimate for the CRT-Biology instrument, as it is the State’s accepted measure of performance, it was assumed to be a reliable testing instrument.

Validity

Validity refers to how well a test measures what has been purported to measure (Steinberg, 2008). Christensen et al. (2011) claimed while reliability is necessary, Gall et al. (2007) suggested reliability is not sufficient. For a test to be reliable, Gall et al. (2007) indicated it also needs to be valid.

External validity. Christensen et al. (2011) reported that external validity is the degree to which investigative reports can be generalized to and across targeted and accessible populations, settings, treatments, and outcomes. A key factor in the external validity strength of this study was the random sampling of gender-stratified participants from the targeted population (Christensen et al. 2011). As Christensen et al. (2011) noted, "generalizing to a population through random sampling is especially strong in allowing the investigator to generalize from sample characteristics to population characteristics" (p. 188).

Internal validity. Gall et al. (2007) claimed that the simple design of this research method may exhibit low internal validity, indicating that other factors and influences may not be accounted for or cannot be ruled out. In this study, there was no consideration of the impact of e.g. rural vs. non-rural, ethnicity, socioeconomics, or teacher experience, but the relatively large sample size recommendation by Neuman (2006) and Christensen et al. (2011) of 37.2% of the total population, minimized the internal validity concerns (Gall et al., 2007). Consequently, the results acquired from the nonequivalent comparison group design produced a closer approximation to a randomized experimental research design by achieving unbiased results (Christensen et al., 2011). Further, this approach helped ensure that observed differences between the two groups were not caused by group differences in extraneous variables such as attrition, maturation, operation of instruments, regression to the mean, or reactions to non-treatment events (Christensen et al., 2011). These considerations (Christensen et al., 2011) enabled valid and reliable comparison of the two populations, General Biology students vs. B/AS taught students, for overall and individual standard scores of the Utah CRT-Biology (Utah State Office of Education, 2012) over a five-year longitudinal timeframe from 2008 through 2012.

Summary

The focus of this descriptive, comparative within-participants post-test only study (Christensen et al., 2011) with a five-year analysis of variance (Neuman, 2006; Steinberg, 2008) was to examine the agriculturally supported view (Clark, 2012; Roegge & Russell, 1990; Rosentrater, 2005; Thompson & Warnick, 2007; Utah State Office of Education, 2012; Warnick, 1998; Wilson & Curry, 2011) that since agriculture courses include biology along with other sciences, students taking BA/S should score as well as on the Utah CRT-Biology (Utah State Office of Education, 2012) as students taking a general biology course. A representative sample size of 37.2% of the population of 10^{th} to 12^{th} grade Utah high school students who took the Utah CRT-Biology following completion of their biology core requirement (either general biology or BA/S) from 2008 through 2012 was used, with the large sample size generating a 99% confidence level in the results (Neuman, 2006). By analyzing the Utah CRT-Biology scores between the two populations of traditionally taught biology students and agriculture taught students, this study finally provided the evidence necessary to determine if the nearly two-decades-old 1996 decision in Utah (Utah State Office of Education, 2012; Warnick, 1998) to implement a B/AS curriculum with an enhanced focus on biology rather than requiring agriculture education students to take an additional general biology course was well founded.

The results from the investigation are presented in Chapter 4 and then interpreted in Chapter 5. Chapters 5 also looks at the implication of the findings, as well as providing insight into additional research that may be needed regarding the use of agriculture as an integrated and hands-on method of teaching biology, including its potential to increase student interest in science and science-related careers.

CHAPTER 4: RESULTS

The purpose of this descriptive comparative quantitative study was to determine if General Biology students and B/AS students scored at similar levels on the Utah CRT-Biology (Utah State Office of Education, 2012). The premise been made with the1996 State of Utah approval, not tested until this 2014 study, nearly two decades later (Utah State Office of Education, 2012; Warnick, 1998). By analyzing the CRT-Biology scores, both composite and for the 10 individual test standards (see Table 1) between the two populations, the appropriateness of the 1996 decision (Utah State Office of Education, 2012) to implement a B/AS curriculum with an enhanced focus on biology has finally been determined. Also, guidance has been provided whether the B/AS curriculum should be strengthened or agriscience courses should be used more broadly to prepare students in core subject areas.

This chapter presents results obtained from the research outlined in Chapter 3 that was designed to address the three research questions posed for this study. Descriptive statistics were used to analyze the connection between the independent variable (General Biology) and the dependent variable (B/AS) across all five years of the longitudinal analysis of variance, using an independent *t-test* (University of California Los Angeles, 2013) for each year to determine the statistical difference between General Biology and B/AS study means for CRT-Biology composite and ANOVA each of the 10 individual standard scores. ANOVA was subsequently used to compare alignment and test score differentiation between the General Biology and B/AS student populations across the five-year time frame of the study.

Study Population and Sampling

The Utah State Office of Education complete data set of 2008-2012 CRT-Biology test scores were comprised of a total of 137,689 test scores; 12,791 test scores in the B/AS data set and 124,898 test scores in the General Biology data set. Following the recommendation of Neuman (2006), 37.2% of the gender-stratified population was selected at random from both testing groups to generated a 99% confidence level, resulting in a. sample size of 46,462 General Biology and 4,757 BA/S scores for the CRT-Biology test.

Table 2 provides the General Biology and BA/S sample sizes for each of the five years of data.

Table 2

Number of CRT-Biology Test Scores Analyzed from 2008 through 2012 Testing Periods

	Testing Period				
Student Group	2008	2009	2010	2011	2012
General Biology	9,269	9,350	9,746	9,195	8,902
B/AS	855	991	1,102	905	904

Statistical Findings

Statistical analyses were conducted separately for the three separate research questions and datasets. The scrubbed and gender-stratified 2008-2012 CRT-Biology testing data provided by the Utah State Office of Education (see Appendix A) as per the Utah Education Facts campaign stipulations (Utah Education Network, 2012) was analyzed with IBM® SPSS® Statistics software (version 21) to generate the descriptive comparative analysis and analysis of variance of the testing data. Inferential statistics were used to draw conclusions about the population *t-test* and ANOVA results, which allowed assessment of the relationship between criterion variable and predictor variables (Christensen et al. 2011). This approach was used to compare alignment and test score differentiation between the two student populations under investigation over the five-year longitudinal period of study.

Research Question 1 – Composite CRT-Biology Difference, General Biology vs. B/AS

In analyzing Research Question 1, independent one-tailed *t-tests* (University of California Los Angeles, 2013) were used to compare composite CRT-Biology test score differentiation between the General Biology and B/AS student populations for each of the years across the five-year time frame. Results shown in Table 3 indicate that General Biology scores were higher than those of B/AS students for all five years, with this difference being significant ($p \leq .05$) in two of the five years, 2009 and 2010.

Table 3

Comparison of General Biology and B/AS Student CRT-Biology Test Scores 2008-2012

	Testing Period				
Group	2008	2009	2010	2011	2012
General Biology	66.2%	63.9%	66.2%	64.3%	66.1%
B/AS	62.9%	60.3%	62.8%	62.6%	63.5%
Difference p-value	0.0629	0.0305*	0.0276*	0.8073	0.1136

Note. *$p \leq .05$ significant difference between the student means within the testing years.

Research Question 2 – Individual Standards Difference, General Biology vs. B/AS

Independent one-tailed *t-tests* (University of California Los Angeles, 2013) were used to compare each of the 10 Utah CRT-Biology individual standard test scores (see Table 1) between the General Biology and B/AS student populations for each year of the study. As seen in Tables 4-8, General Biology students achieved higher, though not always statistically so, individual standard CRT-Biology scores than did B/AS students except for 2012 where both groups had the same score for the Genetics standard. It should be noted that Tables 4-8 show an apparent change in 2009 and 2010, with B/AS students performing significantly worse ($p \leq .05$) on both the overall Utah CRT-Biology and most of the 10 standards. No explanation could be found (J. Baggley, personal communication, July 8, 2014) for why there was such a dramatic difference these two years.

Results for 2008 (see Table 4) and 2009 (see Table 5) indicate significant ($p \leq .05$) differences between General Biology and B/AS students for two of the individual CRT-Biology standard scores, Communication and Nature of Science. In 2010 (see Table 6) there was a significant ($p \leq .05$) difference in eight of the standard scores, including seven with a highly significant ($p \leq .01$) difference, with only Environmental Interaction and Genetics not being signification different ($p > .05$). This larger difference continued in 2011 (see Table 7), again with a significant ($p \leq .05$) difference in eight of the standard scores, but only five with a highly significant ($p \leq .01$) difference. Again Genetics was not significantly different ($p > .05$), nor was Science & Thinking. In 2012 (see Table 8), the CRT-Biology individual standard scores between General Biology and B/AS students were more comparable, with only a significant difference ($p \leq .05$) for one of standards, Nature of Science.

Table 4

Comparison of 2008 CRT-Biology Standard Scores: General Biology vs. B/AS Students

Individual Standard	General Biology	B/AS	P-Value
Environmental Interaction	65.3%	63.0%	0.1859
Molecular Biology	61.6%	58.7%	0.1028
Function	64.2%	62.9%	0.4478
Genetics	60.8%	58.5%	0.1894
Evolutionary Diversity	58.8%	56.4%	0.1653
Science & Thinking	66.6%	65.5%	0.5193
Science Concepts	64.4%	63.1%	0.4662
Communication	51.6%	48.0%	0.0477*
Science Awareness	57.7%	56.2%	0.3908
Nature of Science	64.3%	60.6%	0.0306*

Note. See Table 1 for the description of each standard. *$p \leq .05$ significant difference between the student means within individual CRT-Biology standard.

Table 5

Comparison of 2009 CRT-Biology Standard Score: General Biology vs. B/AS Students

Individual Standard	General Biology	B/AS	P-Value
Environmental Interaction	62.9%	60.8%	0.1863
Molecular Biology	57.7%	56.0%	0.3015
Structure & Function	61.4%	60.7%	0.6473
Genetics	59.3%	56.8%	0.1153
Evolutionary Diversity	59.9%	56.1%	0.0214*
Science & Thinking	58.8%	56.6%	0.1801
Science Concepts	62.7%	60.1%	0.1075
Communication	57.4%	54.1%	0.0472*
Science Awareness	59.3%	57.3%	0.2129
Nature of Science	59.8%	56.8%	0.0694

Note. See Table 1 for the description of each standard. *$p \leq .05$ significant difference between the student means within individual CRT-Biology standard.

Table 6

Comparison of 2010 CRT-Biology Standard Scores: General Biology vs. B/AS Students

Individual Standard	General Biology	B/AS	P-Value
Environmental Interaction	69.1%	66.3%	0.0527
Molecular Biology	60.5%	56.2%	0.0052†
Structure & Function	55.9%	51.3%	0.0035†
Genetics	61.1%	58.9%	0.1577
Evolutionary Diversity	64.9%	60.5%	0.0037†
Science & Thinking	65.3%	61.5%	0.0118*
Science Concepts	60.7%	56.6%	0.0076†
Communication	58.9%	53.8%	0.0011†
Science Awareness	64.1%	60.0%	0.0069†
Nature of Science	65.2%	59.9%	0.0004‡

Note. See Table 1 for the description of each standard. *$p \leq .05$ significant, †$p \leq .01$ highly significant, and ‡$p \leq .001$ very highly significant difference between the student means within individual CRT-Biology standard.

Table 7

Comparison of 2011 CRT-Biology Standard Scores: General Biology vs. B/AS Students

Individual Standard	General Biology	B/AS	P-Value
Environmental Interaction	69.4%	65.2%	0.0093†
Molecular Biology	61.2%	55.5%	0.0008‡
Structure & Function	55.4%	51.7%	0.0302*
Genetics	62.7%	60.2%	0.1412
Evolutionary Diversity	63.0%	57.8%	0.0025†
Science & Thinking	65.5%	62.3%	0.0579
Science Concepts	61.5%	57.6%	0.0213*
Communication	60.0%	54.6%	0.0017†
Science Awareness	66.2%	62.7%	0.0338*
Nature of Science	59.9%	55.3%	0.0072†

Note. See Table 1 for the description of each standard. *$p \leq .05$ significant, †$p \leq .01$ highly significant, and ‡$p \leq .001$ very highly significant difference between the student means within individual CRT-Biology standard.

Table 8

Comparison of 2012 CRT-Biology Standard Score: General Biology vs. B/AS Students

Individual Standard	General Biology	B/AS	P-Value
Environmental Interaction	60.5%	59.1%	0.4060
Molecular Biology	62.3%	59.6%	0.1127
Structure & Function	61.9%	60.4%	0.3881
Genetics	66.0%	66.0%	0.9940
Evolutionary Diversity	62.2%	61.3%	0.6056
Science & Thinking	64.1%	62.5%	0.3646
Science Concepts	62.2%	59.4%	0.1031
Communication	60.7%	57.5%	0.0591
Science Awareness	61.0%	61.3%	0.8315
Nature of Science	66.5%	63.2%	0.0469*

Note. See Table 1 for the description of each standard. (*$p \leq .05$ significant difference between the student means within individual CRT-Biology standard.)

Research Question 3 – Analysis of Variance

In analyzing Research Question 3, ANOVA was utilized to allow comparison of all 10 individual CRT-Biology standard scores across all five years of the study (Neuman, 2006;

Steinberg, 2008) to gain a better indication of the emerging trends and indicate whether the gap between General Biology and B/AS student scores was expanding or narrowing.

Table 9 provides the results of the ANOVA analysis of which scores differed significantly ($p \leq .05$) within the five years of analyzed data to determine the differences among all 10 standard means across all five years. There was a very highly significant ($p \leq .001$) between group comparison ($p = .000271$, F criteria = 2.578739), indicating little change in the gap between B/AS and General Biology overall CRT-Biology test scores across the study time range.

Table 9

ANOVA Results

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.965406	4	0.241352	6.649195	0.000271	2.578739
Within Groups	1.633404	45	0.036298			
Total	2.59881	49				

Table 10 expands the longitudinal comparative analysis, using year to year and overall comparisons to determine the difference in General Biology and B/AS study CRT-Biology scores, with no year-to-year significance ($p \leq .05$), demonstrating the consistency of the testing results.

Table 10

Longitudinal Comparison of the General Biology and B/AS CRT-Biology Test Differences

Year-to-Year Comparison	Difference Between Means	Standard Deviation of Difference Between Means	P-Value
2008 versus 2009	0.0033	0.1388	0.4447
2009 versus 2010	-0.0015	0.0661	0.5264
2010 versus 2011	0.0090	0.3830	0.3509
2011 versus 2012	-0.0165	0.6756	0.7504
2008 versus 2012	-0.0057	0.2337	0.5924

Figure 1 graphically examines the relationship between the two groups, General Biology and B/AS, showing the resulting moderate association of a difference between the means (see Figure 1). Figure 1 provided further proof that the performance measures of the two groups can characterize the five-year spectrum of Utah CRT-Biology scores derived from the 10 individual testing standards from all five years 2008-2012. These measures complemented the data of previous findings in providing useful information about the association of a difference between the two different group test results studied.

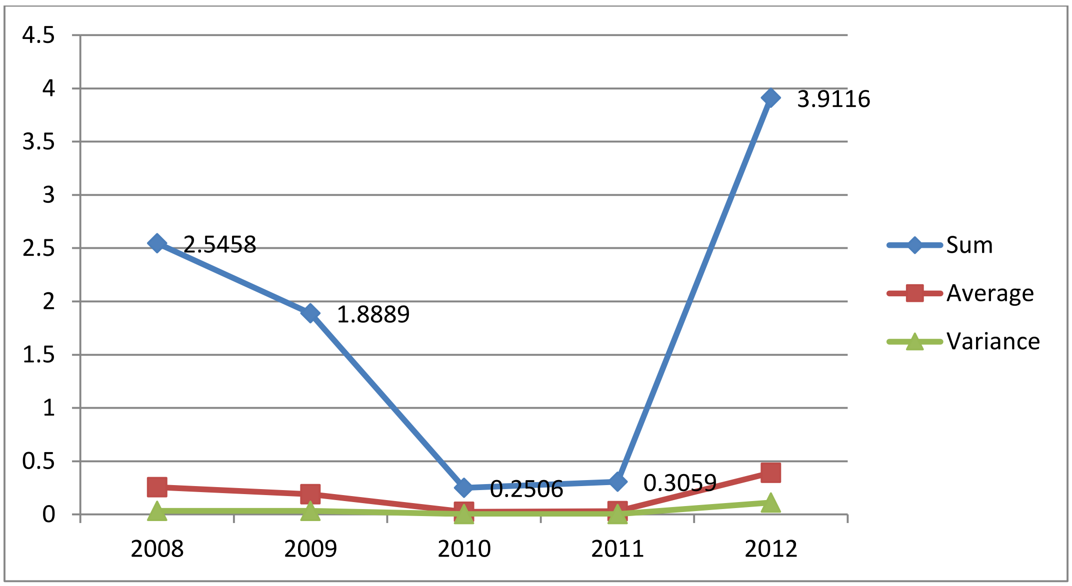

Figure 1. Association of the difference between General Biology and B/AS mean CRT-Biology scores for 2008-2012.

Table 11 summarizes the significant deficiencies for B/AS students compared to General Biology students for each of the 10 individual standards of the Utah CRT-Biology during the entire 2008-2012 study period. B/AS students consistently scored significantly below ($p \leq .05$) General Biology students on two of the individual standards, Communication and Nature of Science, in four of the five years. Referring to Table 1, these standards were to communicate effectively by using science language and reasoning to understand the nature of science. These standards would seem critical deficiencies as they indicate an understanding of the very nature of science and the ability to communicate or explain it (Utah State Office of Education, 2012).

Table 11

Significant B/AS Gap

Individual Standard	2008	2009	2010	2011	2012
Environmental Interaction				0.0093†	
Molecular Biology			0.0052†	0.0008‡	
Function			0.0035†	0.0302*	
Genetics					
Evolutionary Diversity		0.0214*	0.0037†	0.0025†	
Science & Thinking			0.0118*		
Science Concepts			0.0076†	0.0213*	
Communication	0.0477*	0.0472*	0.0011†	0.0017†	
Science Awareness			0.0069†	0.0338*	
Nature of Science	0.0306*		0.0004‡	0.0072†	0.0469*

Note. See Table 1 for the description of each standard. *$p \leq .05$ significant, †$p \leq .01$ highly significant, and ‡$p \leq .001$ very highly significant difference.

The one area where B/AS students did not show any Utah CRT-Biology deficiency compared to General Biology students was in the Genetics standards. The genetics standard measures the student's understanding of the importance of the genetic information coded in DNA (Utah State Office of Education, 2012), a topic often considered more advanced (Wright & Campbell, 2014). While this would seem to indicate a more difficult topic, it is also one that is emphasized in B/AS courses because of the importance of genetics in the breeding of livestock and crops (Elliot, 2008). This would seem to indicated that B/AS students are certainly capable of excelling in the study of biology, though not so indicated in the results in the other CRT-Biology standards where B/AS students demonstrated lower performance, even when not significant ($p > .05$).

Reliability and Statistical Analysis

Gall et al. (2007) explained that reliability for a research instrument has been established when an instrument consistently delivers accurate results repeatedly. Gall et al. (2007) noted that the alpha measure has been one of the most useful indicators of a multiple-item measure's reliability. This study used the suggestion of Christensen et al. (2011) in using an alpha level of .05 to measure the reliability of the Utah CRT-Biology instrument for consistency. As seen in Table 12, with the exception of 2012, the variance among the individual 10 standards was within the alpha of .05. These results suggested a strong reliability in the CRT-Biology instrument as used to provide a consistent assessment of the biology knowledge of Utah high school students.

Table 12

Consistency of CRT-Biology Test for Years 2008-2012

Groups	*Individual Standards*	*Sum*	*Average*	*Variance*
2008	10	2.5458	0.25458	0.033743
2009	10	1.8889	0.18889	0.033103
2010	10	0.2506	0.02506	0.002407
2011	10	0.3059	0.03059	0.001843
2012	10	3.9116	0.39116	0.110392

In terms of internal reliability of the sample population in predicting the findings for the entire population of Utah high school students, this study utilized a large sample size. A representative sample size of 37.2% of the population (see Table 2) of 10th to 12th grade Utah high school students from 2008 through 2012 who took the Utah CRT-Biology test following completion of their biology core requirement (either General Biology or BA/S) was used, which Neuman (2006) asserted a 99% internal reliability confidence level.

Conclusion

Chapter 4 reported the results obtained through the analysis of data using descriptive comparative statistics and ANOVA. Chapter 5 follows with a discussion of the implications, validity of the assumptions, test score analysis, and provides recommendations for future study.

CHAPTER 5: DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

In light of the trends happening in student achievement over the past decades that led to the NCLB Act of 2001, agriculture education has not missed out on the transformation, reform, and recommendations made for improving student education. Roegge and Russell (1990) claimed that agriculture education has been in a delicate situation because of perceived inadequacies of the traditional agriculture curriculum. However, proponents of agriculture education suggested that as early as 1908, academicians were developing curriculum and activities to supplement the need for students to learn scientific principles while claiming that historically, agriculture education has presented learning in a "hands on" and "minds on" approach (Parr & Edwards, 2004, p. 107).

Degenhart et al. (2007) and Thompson and Warnick (2007) stated that students were more likely to experience learning from their accomplishments while engaging in hands-on learning experiences han passively listening to lectures. This was where the agriscience curriculum research had claimed it excels because of its intrinsic hands-on learning approach (Parr & Edwards, 2004). Furthermore, Degenhart et al. (2007) indicated that because of the hands-on approach, student enthusiasm increases for science, as does their belief in their ability to pursue science-related careers. Agriculture education has been seen as the window to a world of science careers through its hands-on learning approach and the understanding that agriculture is a science, involving far more than the narrow view of crop and livestock production (Thompson & Warnick, 2007). Parr and Edwards (2004) and Morgan et al. (2011) supported this evidence by showing that agriculture education influences what students learn because of how they were taught and that agriscience students can achieve higher-order thinking skills and problem solving behaviors that encourage them to be interactive and life-long learners (Nolin & Parr, 2013).

Although the main body of research indicates numerous advantages associated to hands on and minds on learning (Degenhart et al., 2007; Morgan et al., 2011; Nolin & Parr, 2013; Parr & Edwards, 2004; Thompson & Warnick, 2007), there remain many variations in curriculum integration, cross-collaboration, and implementation, thus producing mixed results regarding the impact on student performance (Nolin & Parr, 2013). The general pattern of results (Degenhart et al., 2007; Morgan et al., 2011; Nolin & Parr, 2013; Parr & Edwards, 2004; Thompson & Warnick, 2007) produced from the literature suggested that curriculum integration features higher levels of connections between subjects. For example, Connors and Elliot (1995) reviewed research studies showing that agriscience taught students have performed equally to or better than students in traditionally taught science courses.

While the expectations based on the literature suggested that the 1996 decision (Utah State Office of Education, 2012) to implement a B/AS curriculum with an enhanced focus on biology for Utah high school students was sufficient as an alternative to taking General Biology, the results of this study were to the contrary. This first time effort to evaluate the appropriateness of that decision, taking place nearly two decades post-decision (Utah State Office of Education, 2012), found that B/AS students did not score equal to or better than their General Biology counterparts on the Utah CRT-Biology test, and in fact scored significantly ($p \leq .05$) below the General Biology students in a number of aspects.

Discussion of Data Handling

The random sample provided by the Utah State Office of Education included small, less than 1% each year, subpopulations of students whose possible scores had varying ranges as the Office utilized different pilot tests to consider possible future testing variations. In addition, the Office also collected data from students who, for some reason, registered for but did not take the test, resulting in a recorded test score of zero (J. Baggley, personal communication, July 8, 2014). To ensure internal consistency within the data, scores were compared only on students who had taken the test, thus eliminating the zero score subpopulation, and students who had the same possible total and individual standard test scores, thus eliminating the pilot test subpopulations. Elimination of these small subpopulations of consistency outliers still enabled near the 37.2% sample size of the comparable gender-stratified random Utah high school students from both testing groups to produce the 99% confidence interval set for this study (Neuman, 2006).

Validity of Assumptions

The assumption of this study was that the necessary data would be adequately conveyed to the Utah State Office of Education staff and they would deliver the data necessary to complete this study's quantitative statistical approach using a descriptive comparative within-participants posttest-only design (Christensen et al., 2011) with an analysis of variance (Neuman, 2006; Steinberg, 2008). Research access to the data as pulled by the Utah State Office of Education staff from the IBM Corporation Cognos® database and reporting software application (Utah Education Network, 2012) based on researcher stipulated parameters, inclusions, and exclusions was granted (see Appendix A). The data provided met the assumptions of its completeness and adequacy, enabling successful completion of this study's quantitative statistical approach using a descriptive comparative within-participants posttest-only design (Christensen et al., 2011) with an analysis of variance (Neuman, 2006; Steinberg, 2008). Date analysis was able to determine if the 1996 decision allowing a modified agriculture curriculum with an enhanced focus on biology rather than requiring agriculture students to take a separate general biology course in addition to their agriculture curriculum was well-founded (Utah State Office of Education, 2012).

Consistency within the Research

Christensen et al. (2011) noted that internal consistency reliability defines the consistency of the results of the test, ensuring that the various items measuring the different constructs deliver consistent scores. Findings within this study of the descriptive within-participant posttest only design provided a powerful technique of control by allowing the test results of the Utah CRT-Biology test to serve as its own control. Since both sets of data from each group perfectly matched the treatment condition, this significantly increased the sensitivity to the experiment (Christensen et al., 2011).

Discussion of the Results

Research Question 1 (Overall Test Score Analysis)

The first research question, to what extent is there a difference in Utah CRT-Biology results from students in traditional biology programs compared to students in B/AS programs, addressed the significance of the difference for the overall CRT-Biology score between General Biology students and those taking the B/AS curriculum. In reviewing the results shown in Table 3, the mean difference for the General Biology group was nearly 3.44 percentage points higher than for the B/AS group, with there being a significantly ($p \leq .05$) higher result in 2009 and 2010. While the difference was not statistically significant ($p > .05$) in 2008, 2011, and 2012, General Biology students still tended to score higher on the CRT-Biology test than did BA/S students. The statistical significance in CRT-Biology test scores was greatest in 2011 (66.2% score for General Biology vs. 61.9% score for BA/S, p =

0.0176) and least in 2012 (66.1% score for General Biology vs. 63.5% score for BA/S, $p = 0.1136$) (see Table 3).

Research Question 2 (Individual Standards)

The second research question, to what extent is there a difference in the Utah CRT-Biology results in any of the Utah CRT-Biology individual standards for students enrolled in traditional biology courses compared to students enrolled in B/AS courses, addressed the significance of difference between General Biology and B/AS students for the 10 individual standards that comprise the CRT-Biology test (see Table 1) for each of the five years of the longitudinal study (see Tables 4-8). Even in 2008, 2011, and 2012 where there were not significant ($p > .05$) differences in overall CRT-Biology scores (see Table 3), the B/AS students scored significantly ($p \leq .05$) lower in at least one of the standards (see Tables 4, 7-8) than the General Biology students. In 2009 and 2010, when the overall CRT-Biology score was significantly ($p \leq .05$) lower for the B/AS students, this was further noted by B/AS students scoring significantly ($p \leq .05$) below the General Biology students in 80% of the individual standards (see Tables 5-6). Table 12 highlighted these individual standard significant differences.

Research Question 3 (Analysis of Variance)

The next item of interest was to see if the gap between General Biology students' scores and B/AS students' scores narrowed, increased, or neither during the span from 2008 to 2012. *T-tests* were run measuring the difference in scores between consecutive years (i.e., 2008 versus 2009, 2009 versus 2010, etc.) to see if the change in these differences was statistically significant ($p < .05$). Also, one final analysis was performed to see if there was a difference between the 2008 results and the 2012 results (see Tables 9-10).

In reviewing the results seen in Table 10, the positive mean difference for 2008 vs. 2009 and 2010 vs. 2011 indicates that the General Biology students' average scores increased in comparison to the B/AS students. Negative values in 2009 vs. 2010, 2011 vs. 2012, and 2008 vs. 2012 mean that the B/AS students' average scores increased versus their General Biology counterparts. However, in each of these comparisons the data showed no evidence that the gap between General Biology and B/AS student scores narrowed, nor expanded, rather, the gap remained consistent ($p > .05$).

Implications from Study Findings

Upon reviewing the literature (Connors & Elliot, 1995; Degenhart et al., 2007; Morgan et al., 2011; Nolin & Parr, 2013; Parr & Edwards, 2004; Roegge & Russell, 1990; Thompson & Warnick, 2007) and understanding that agriculture education is heavily laden with plant, animal, and environmental sciences (Nolin & Parr, 2013), one would think that students who were enrolled in a curriculum so saturated in biology principles (i.e. Agriculture biology) would perform well on a biology test such as the Utah CRT-Biology test. Convinced of the value of the agricultural curriculum, Nolin and Parr (2013) suggested that students in agriculture classes be compared to students in non-agriculture classes, presumably to demonstrate the equal if not better success of the agriculture students. As seen in this study, however, not only did B/AS students tend to score lower than their General Biology counterparts, in multiple cases this difference was significant ($p \leq .05$). This contrary finding challenges the theoretical foundation of this study.

To address this puzzling discovery, Nolin and Parr (2013) provide some possible indications for the findings: (a) the Utah CRT-Biology test may not be a reliable gauge of academic achievement in agriculture biology, (b) agriculture students in the sample population have not been taught with rigorous biology standards, and (c) biology standards taught in agricultural biology classes may not have been aligned with content tested by the biology portion of the Utah CRT-Biology test standards. Any of these or combinations may help explain the unexpected study findings.

Reliability of Standardized Test

The NCLB Act (2001) has mandated accountability for academic progress, with states utilizing standardized test scores to monitor student progress toward the goal of 100% proficiency for all students by 2014. Clemens and McElroy (2011) noted that because of this mandate, statewide districts, schools, and teachers use some form of standardized testing procedure to document student achievement. The results of the standardized testing are critical as 21st century education has seen student performance on standardized tests become the basis for funding and policy making in all levels of education (Clemens & McElroy, 2011).

While many may argue the degree to which standardized testing yields reliability and validity, standardized tests have undergone much scrutiny and rigorous statistical procedures to ensure reliable and valid results (Clemens & McElroy, 2011). Thus, it is crucial to not discount the lower than expected performance on the CRT-Biology test by B/AS students that this study elucidated. Rather, it is intended for the data results of this study to raise the interest and focus on the natural abilities and interest of students and to take appropriate actions to ensure the success of the students on the Utah CRT-Biology test.

Granted, the B/AS students tended to demonstrate lower percentage scores, and in some cases statistically lower ($p \leq .05$) performance on the CRT-Biology test compared to their General Biology counterparts. However, a factor that needs to be addressed is the overall low score of all students. With overall (see Table 3) and individual component (see Tables 4-8) scores on the CRT-Biology test showing in only the 60% range, there should be concern that both B/AS and General Biology are failing to prepare students. The low percentile may be an indicator to stakeholders that there is a gap occurring within all of biology education, potentially indicating immediate action is needed to reevaluate the entire biology curriculum delivery.

Rigorous Biology Standards

Parr and Edwards (2004) noted that historically, agriculture education has presented learning in a “hands on” and “minds on” (p. 107) approach in both design and delivery. Agriculture education is well grounded and teaches scientific laws, methods, and procedures to provide a means for students to learn science and provide the hands and minds on experiences to complement scientific theory (Parr & Edwards, 2004). Degenhart et al. (2007) and Thompson and Warnick (2007) also stated that students were more likely to experience learning from their accomplishments while engaging in hands-on learning experiences rather than passively listening to lectures. This was where Parr and Edwards (2004) claimed the agriscience curriculum excels because of its intrinsic hands-on learning approach (Parr & Edwards, 2004).

In this study, however, the investigation of the longitudinal comparative CRT-Biology test score found contrary results to the Parr and Edwards (2004), Degenhart et al. (2007), and Thompson and Warnick (2007) foundation. Not only did the investigation find statistically lower ($p \leq .05$) overall CRT-Biology test scores for B/AS students in 2009 and 2010 (see Table 3), B/AS students also statistically ($p \leq .05$) scored lower on 2-8 of the individual standard sections of the test (see Tables 4-8, 12), depending upon the year.

Prior evidence has shown that agriculture education influences what students learn because of how they were taught and that agriscience students can achieve higher-order thinking skills and problem solving behaviors that encourage them to be interactive and life-long learners (Nolin & Parr, 2013). Thus, these findings do not conclude that agriculture students are not capable. Rather, the data from this study, in seemingly contradicting the literature, suggests that the hands-on and minds-on approach may need to be reevaluated to include a more rigorous approach to agriculture and biological learning. Included in this reevaluation is the need to consider if the agriculture curriculum is teaching what students were expected to learn, i.e., what is assessed on the CRT-Biology test.

Agriculture Curriculum Realignment

While the findings do suggest that B/AS students were not as well-prepared for the standardized assessment as were General Biology students, it also brings into question that there may be other factors involved beyond the content of the two academic curriculums. Nolin and Parr (2013) suggested that the entire CTE realm, which includes agricultural education as well as other technical/vocational fields, has a place in preparing students for standardized testing. However, Nolin and Parr (2013) noted the importance of agriculture teachers being willing to break the mold of older versions of vocational classes and learn how to not only enhance the curriculum, but to also bring out the concepts found on standardized tests.

A viable curriculum is based on standards that require teachers and schools to provide sufficient time and opportunities for all students to learn (Clark, 2012). While agriculture education has prided itself in providing these learning experiences and opportunities to its students (Thompson & Warnick, 2007), this study's findings suggest that a more directed focus in these efforts are needed in agriculture courses. NCLB (2001) assessments mandate a focus on measurable outcomes, not on providing experiences and opportunities. Moore (1993) and Connors and Elliot (1995) suggested that there has been an increased call for improved science education for our Nation's students. Edwards (2004) added that there has been a call from stakeholders for a restructuring of fundamental components and for identifying opportunities for systematic improvements within education. Maguire et al. (2012) provided insight that the situation facing science education was the need to provide education in more appropriate ways. This situation is especially true of CTE classes as they become more directly linked to the Common Core Curriculum (Maguire et al., 2012).

Conducting the comparative analysis study was critical in providing better understanding and insight to the B/AS curriculum and Biology-CRT results. Warnick (1998) had suggested this analysis be done shortly after the 1996 decision allowing a B/AS curriculum to be substituted for a General Biology curriculum in Utah. However, this 2014 study, nearly two decades after that 1996 decision, was the first attempt to retrieve and analyze the necessary comparative data (Utah State Office of Education, 2012). Data collected from this study should encourage stakeholders and state directors to evaluate the current state of the agriculture curriculum. Efforts to ensure that the B/AS curriculum is aligned with the intended goal of performing well on the CRT-Biology test are crucial to not only ensure the viability of Agriculture Education within Utah, be more importantly, to ensure that Utah high school students enrolled in an agricultural curriculum are being well-prepared for success. The results of this study necessitate and warrant further discussion on the impact of student achievement within agriculture education.

Recommendations for Further Study

Beyond addressing concerns expressed about the lower than expected performance of B/AS students on the CRT-Biology competency exam, the findings from this study suggest the need for continued research so that an 18-year gap does not occur again between the implementation of a program or changes and its assessment.

- The data gathered from CRT-Biology test results only compared General Biology and B/AS student results. Future research should include student and school demographics to more explicitly identify areas of both success and those facing the greatest challenge.
- Agricultural teacher education has been called upon to support the learning of core academic subjects (Nolin & Parr, 2013). Therefore, future research should examine the efficacy of biology and science teaching, including agriculture teacher preparation, certification, and areas of endorsement to ensure that academic rigor exists in both agriculture and non-agriculture biology classrooms.
- This study should be replicated in other agriculture student populations in other states to similarly determine the success of agriculture courses in preparing students for the competency outcomes needed in core-related classes to provide necessary preparation for more advanced study.

Replicated Studies

The purpose of this study was to assess Utah high school agriculture student performance on the Utah CRT-Biology to determine if agriculture students were scoring as well as their general biology student counterparts. Unfortunately, this first-time assessment in 2014 occurred 18 years after the 1996 Utah policy change (Utah State Office of Education, 2012). Continued assessment needs to be ongoing to help evaluate the effect of improvement efforts in the B/AT curriculum and B/AT teacher preparation, not wait an additional nearly 20 years to revisit the issue.

As the research indicated, agriculture students are scoring slightly below their counterpart students enrolled in general biology. However, before the 1996 decision of allowing biology into the agriculture classroom (Utah State Office of Education, 2012) is reconsidered, future studies are needed to determine the outcome of CTE classes hosting core-related subjects, particularly biology in the agriculture curriculum. The call for a replication id not just a challenge for Utah, but for all states, as only Georgia (Ricketts et al., 2006), Arizona (Elliot, 2008), and Alabama (Nolin & Parr, 2013) have conducted similar comparative research.

Greater Research Detail

One flaw Christensen et al. (2011) noted of the of the descriptive within-participant posttest only design is the *differential carryover effect*, which can cause a sequencing threat to its internal validity. Consequently, unmeasured attributes may have affected the outcome and should be considered in future studies. For example, students may differ in their agriculture background and schools may differ in their geographical location, such as rural or urban locales. These factors could potentially confound the test results unless they are studied separately, thus necessitating a means of eliminating a differential carryover effect (Christensen et al., 2011). For example, it would seem conceivable that students from agriculture backgrounds may score higher on the CRT-Biology test because of a life-long experience of integrating science with agriculture (Warnick, 1998) compared to a student who was taking the B/AS course merely as a matter of preference.

Academic Rigor

The results of this study suggest both immediate and future ramifications, with the necessity of closing the agriculture achievement gap being imperative to agriculture education in the State of Utah as agriculture becomes more in-line with the common core taught classes (Warnick, 1998). Effective classroom teaching has been the strongest school-based factor impacting student achievement (Mowen et al., 2007). Every student deserves to have an excellent teacher. While certification gives a teacher the authority to teach content areas and curriculum related to specific subjects (Mowen et al., 2007), proper certification and training is crucial in demonstrating teacher's expertise in providing quality and stimulating learning experiences. The Utah State Director of Agriculture Education has been striving to have all agriculture education teachers earn a biology teaching endorsement (Utah State Office of Education, 2012) so that they are truly prepared to ensure that their students are receiving the quality of biology and agriculture education needed to excel on the CRT-Biology and beyond.

MacQuarrie et al. (2008) and Nolan and Parr (2013) reported that teachers and schools across the country have been mandated to improve student skill levels to prepare students for the next stage. Rojewski et al. (2008) suggested CTE and agriculture education are excellent avenues as they integrate STEM into the curricula, providing students with the technical skills, knowledge, and the training necessary to succeed in specific occupations and careers. As Utah agriculture educators follow national trends in science education (Warnick, 1998), they have access to an arsenal of materials and approaches (Warnick & Straquadine, 2005). With agriculture providing practical application to give meaning to theory (Warnick & Straquadine, 2005), these efforts can encourage agriculture students to become interested in STEM education, strengthen student competencies, and ensure students are learning academic content in core content-related classrooms.

State and local educational leaders must acknowledge the importance of non-core curriculum and its ability to fulfill the education process by incorporating students' interest, talents, and abilities into the learning experience. For this acknowledgement to happen, teacher certification, qualification, endorsement, and academic rigor must be at its best to ensure that the states and Nation maintain the initiative of becoming the leaders in STEM education (Herschback, 2011). STEM leadership would also benefit from the studying of the student demographics of CRT-Biology-type results as agriculture has seen a dramatic rise in female student enrollment (Herschback, 2011). Studies have indicated that agriculture may serve as an excellent gateway to encourage greater female pursuit of STEM-careers (Thoron et al., 2011). This further supports the importance Jackson (2007) and Legewie and PiPrete (2011) placed on the need to tap the new majority of young women and ethnic minority groups, both of whom are underrepresented in STEM professions.

According to Heerkens, Norde, and Van der Heijden (2011), Core Requirement Tests (CRTs) are important because they pertain to an individual's or group's level of knowledge, skills, and experiences. Heerkens et al. (2011) suggested that when ascertaining testing importance, attribute importance should be taken into serious consideration when determining the factors that play key parts and roles in the assessment process. Heerkens et al. (2011) advised "generals always fight the present battle instead of the next" (p. 750), stressing that those who administer CRTs should be aware of the dangers of neglecting the need for flexibility in making necessary adjustments.

Furthermore, CRTs were intended as a reliable tool in determining the effectiveness and administration of instruction to gain a better understanding of individual and group learning (Butler & McMunn, 2006). If CRT results continually suggest that achievement and performance are not improving, it is an immediate reflection of the administration and their inability to adapt and measure the learning abilities of their learners (Butler & McMunn, 2006). Butler and McMunn (2006) suggested focusing specifically on learner needs as a means to close the achievement gap. In concert, however, administrators must be held accountable and urged to gather the most dependable information about individual and group learning on a daily, weekly, and monthly basis to know what and how information can change and be utilized to benefit learners (Butler & McMunn, 2006).

Thiem (2009) investigated the widespread and profound restructuring taking place in education, approaching educational restructuring with a "thinking through" and a "joining up" (p. 154) research on formal education. Changes surrounding the education system are accompanied by the repositioning of broader formations in social, political, and economic boundaries (Thiem, 2009). For example, inclusive education is a unified system that respects and supports challenges and experiences of students with fairness and equity, providing students better opportunities to learn and receive appropriate instruction (Thiem, 2009). Thiem (2009) argued that these inclusive assessment models must not only provide access to the regular curriculum and assessment procedures, but also must yield comparable student achievement gains.

Conclusion

Dufour (2002) stated that educational leaders promote "the success of all students by advocating, nurturing, and sustaining a school culture and instructional program conducive to student learning and staff professional growth" (p. 15). Within education, assessments help protect students by ensuring levels of competence for teachers (Dufour, 2002). As an educator, I believe assessments will remain a valuable tool to be utilized by educational leaders. The United States has taken the initiative to regain its leadership in science and education (Dufour, 2002), pushing for stronger test scores in STEM areas, with a fierce focus on standardized core testing as a means of determining student achievement (Asunda, 2011). Until other methods are developed that show clear and definitive ways to assess achievement, standardized testing will continue to be the "coin of the realm" (Edwards, Leising, & Parr 2002, p. 5, as cited in Nolin & Parr, 2013, p. 50).

Agriculture classes host a myriad of potential to increase student interest in science and science-related careers (Warnick, 1998). As this study has shown, the potential of agriculture in meeting its potential has not yet been met. However, this study was just a launching point in this effort, providing foundational fodder for future studies that can continue to take advantage of standardized testing's comparative abilities (Warnick & Straquadine, 2005) and further investigate the ability of agriculture to play a valuable role in providing students an applied alternative to traditional core subjects (Warnick, 2008) while potentially increasing STEM-motivated graduates (Asunda, 2011) to pursue more advanced study and enter much needed STEM-related career fields (Asunda, 2011). Stakeholders, administrators, and agriculture teachers will continually need to utilize comparative testing results on an ongoing basis to assure that agriculture students not only gain the hands-on experience and application benefits of agriculture education, but also demonstrate competency in knowledge attainment.

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APPENDIX A: PERMISSIONS

University of Phoenix Form

UNIVERSITY OF PHOENIX

PERMISSION TO USE PREMISES, NAME, AND/OR SUBJECTS
(Facility, Organization, University, Institution, or Association)

Utah State Office of Education

Name of Facility, Organization, University, Institution, or Association

Check any that apply:

☐ I hereby authorize _____, student of University of Phoenix, to use the premises (facility identified below) to conduct a study entitled (insert title of research study or a brief description of research study)

☐ I hereby authorize _____, student of University of Phoenix, to recruit subjects for participation in a conduct a study entitled (insert title of research study or a brief description of research study).

☒ I hereby authorize Deric W. Despain, student of University of Phoenix, to use the name of the facility, organization, university, institution, or association identified above when publishing results from the study entitled BIOLOGY IN THE AGRICULTURE CLASSROOM: A DESCRIPTIVE COMPARATIVE STUDY FROM THE STATE OF UTAH.

11/20/2013

Signature Date

William Deimler
Name

Specialist: Agriculture Education
Title

Address:
250 East 500 South/PO Box 144200
Salt Lake City, Utah 84114-4200

Utah State Office of Education Form

NOV-13-2013 WED 09:26 AM UT ST OFFICE OF ED FAX NO. 8015387882 [redacted]

[redacted]

Utah State Office of Education

EDUCATIONAL RESEARCH PROPOSAL

EDUCATIONAL RESEARCH OPPORTUNITY ANNOUNCEMENT

PURPOSE: This research initiative is intended to establish an ongoing state-sponsored program of statistical analysis utilizing Utah's statewide longitudinal data system (SLDS) to support the identification, development and evaluation of feasible interventions — policies, practices, processes, products, and programs — to improve academic outcomes for K-12 students.

REQUEST FOR PROPOSALS: The Utah State Office of Education (USOE) is interested in receiving proposals to conduct research using its SLDS data on topics related to its policy, administrative, and technical responsibilities as a state education agency, especially as these concern the development or validation of predictive measurements, evaluation of programs of assistance to students, or the improvement of instruction.

PROPOSAL RECEIPT DEADLINE: Proposals may be submitted at anytime and are reviewed as they are received.

ELIGIBLE APPLICANTS: In general, proposals will only be accepted from research organizations that maintain a local Institutional Review Board (IRB) registered with the Office for Human Research Protections at the U.S. Department of Health and Human Services. Exceptions to the IRB requirement may be made in cases where unaffiliated but otherwise qualified researchers are engaged to conduct evaluation studies.

MECHANISM OF SUPPORT: Grant in kind of temporary access to SLDS data sets. Depending on the proposed project, the data set may be de-identified and/or the research team may be obligated to implement specific security arrangements to ensure confidentiality.

FUNDING AVAILABLE: Neither this announcement nor approval of an application commits the USOE to pay any costs related to a study, including preparation of a proposal or negotiation of an agreement. Depending on the proposed project, the applicant may be required to pay a negotiated fee for preparation and delivery of the data.

PROPOSAL CONTENT REQUIREMENTS: Proposals will not be formally reviewed until the USOE receives a complete proposal, consisting of four documents: (1) A research plan that addresses each of the elements listed on the "Application to USOE for Extensive Research Data" form; (2) The curriculum vitae of the principal investigator (PI) designated on the *Application*; (3) A "Research Confidentiality and Use Agreement" signed by both the PI and, as applicable, an authorized organizational representative (AOR) of the applicant organization; and (4) the IRB letter of approval, also where applicable.

PROPOSAL PROCESSING: Proposals are reviewed in monthly meetings of the USOE Data Governance and Policy Board and will be approved as is, preliminarily approved pending requested changes, held for further information, or denied by consensus of the Board.

DELIVERABLES: The PI must agree to provide the USOE with a copy of each substantive presentation or article based on the data set, preferably prior to its public release. In some cases, the USOE may also request a more extensive technical report to be provided within six months of the conclusion of the project. In such cases, the *Standards for Reporting on Empirical Social Science Research* published by the American Educational Research Association should be consulted as guidance in preparing the technical report (http://www.aera.net/uploadedFiles/Publications/Journals/Educational_Researcher/3506/12ERv35n6_Standard4Report%20.pdf).

SUBMISSIONS AND INQUIRIES:

Aaron Brough
Data Quality Manager
Utah State Office of Education
250 East 500 South
P.O. Box 144200
Salt Lake City UT 84114-4200
E-mail: aaron.brough@schools.utah.gov
Phone: (801) 538-7922
Fax :

Application to the USOE
FOR EXTENSIVE RESEARCH DATA
(For student- or teacher-level data, extensive lists of variables, or multiple years of data)

Name of primary researcher(s), title, organization, address, phone, e-mail, website:
Deric Walter Despain, Agriculture Educator
[redacted]

Brief description of organization and any additional partnering organization(s):
Request of data from USOE for completion of doctoral dessertation.
University of Phoenix
1625 W. Fountainhead Parkway
Tempe, Arizona 85282-2371
866-766-0766 www.phoenix.edu

Project title and description: Biology in the agriculture classroom: A descriptive comparative study from the state of Utah.
Purpose of proposed research project(s): Examining the decision of having agriculture instructors teach the biology/agriculture science course is effective in preparing students for the Utah CRT-Biology by researching past five years of data collected from CRT-Biology scores from general biology students compared to agriculture biology students.
Research questions: To what extent is there a difference in Utah CRT-Biology results from students in general biology compared to students in B/AS programs? To what extent is there a difference in the Utah CRT-Biology results, in any of the Utah CRT-Biology sub-categories (genetics, botany, reproduction, origin of species, and ecology)?
Potential benefits to Utah Education: The significance of this study is to determine how effectively biology is being taught in the agriculture classroom by deploying a quantitative descriptive comparative study that will examine the Utah CRT-Biology results. This study may be the first to attempt in retrieving historical data to compare the Utah CRT-Biology results of the two different teaching approaches.
Other benefits: Will demonstrate to USOE leaders that considerable effort and resources that are being applied to revising and updating science programs to meet the skills and demands of post-secondary education.

Person at the USOE to whom you will provide a report (hardcopy, or electronic .pdf file, etc.) **of your research results:** William Deimler, Specialist Agriculture Ed.
[redacted]

Is there someone at the USOE who is already sponsoring your data request?
If so, please attach evidence such as a signed agreement or signed MOU (memorandum of understanding). Please see MOU

Research Plan and Desired Data Description Descriptive Comparative quantitative study w/a regression model.

List the variables of interest or data elements you are requesting:

Five consecutive years of general biology CRT results/2008-2012

Five consecutive years of agriculture biology CRT results/ 2008-2012.

Including the sub-category sores for each group of students.

Your selection criteria and/or filtered by what variables: The descriptive comparative with-in participant posttest-only design will be conducted utilizing an independent t test for correlated means to determine whether there is a statistically observed difference between the two populations studied.

Desired electronic file type (Excel 2003, Excel 2007, text, .csv, Access, etc.):

Excell 2007

Please describe or attach a sample of the desired layout with sample column headings and a description of what each row should represent (a student, a school, a month, a teacher, etc.):

Spread sheet with overall scores and scores of sub-sections CRT

Other data you plan to join/merge and from what source:

Resorces from STEM Research.

Proposed analysis methodology:

Random Sampling from two populations; general biology students and B/AS students representing those under investigation or the representative sample.

Your approximate timeline for this study: 12 months.

Other professionals or support staff at your organization who will conduct the research and analysis (provide VITAs, resumes, or website links demonstrating their qualifications):
University of Phoenix Review Board and academic committee.

How will you ensure that they agree not to disclose students' identification?
Data will be fully scrubbed, free from any personal identification

How the research data will be kept secure, including physical handling and storage of data, and how will you control access to it: The data will be in the researchers office which remains locked at all times, Furthermore the data will remain in a locked cabinet inside of the locked office

Federally recognized Institutional Research Board (IRB) that approves project methodology for your research organization: UOPX, IRB = University of Phoenix.

List supporting documentation, if any, that you will attach:

Researcher Confidentiality and Use Agreement

This Agreement is made between the Utah State Office of Education (USOE) and Deric Walter Despain, recipient of private or protected data provided by the USOE, hereafter known as "Researcher."

1. Researcher agrees to preserve the confidentiality of private and protected data about students, educators, or individuals, hereafter referred to as "Subject Data." Researcher agrees to not report or publish Subject Data in any manner that discloses students' identities in accordance with the Family Educational Rights and Privacy Act (FERPA), 34 CFR 99-31 (a) (6), such as publishing performance data for subgroups of students with a count, also known as n-size, less than 10. Researcher agrees not to make any effort to discover the identity of a subject.
2. Researcher agrees that any research projects requiring personally identifiable information need to have been commissioned by the Board of Education. In some cases, as approved by the Board, personally identifiable data may be provided to the researcher, but only in a secure manner. Those not commissioned but desiring data shall use the publically available data on the USOE websites or request the research data set provided by the USOE Computer Services Section. This standard, de-identified data set shall be developed each year and be made available upon request.
3. Researcher agrees to obtain formal Institutional Review Board (IRB) approval.
4. Researcher agrees not to use USOE data for any purpose other than research for the project identified in the "Application to the USOE for Extensive Data."
5. Researcher agrees to provide an electronic copy of each report or publication researcher produces using USOE data to William Deimler (contact) at the USOE at least 10 business days prior to the public release. Researcher understands that the USOE may publish annotated bibliographic information about the researcher's work but will not reproduce the report for distribution outside of the USOE without express written permission from the copyright holder. Researcher agree that persons or organizations who wish to conduct surveys or research through the USOE must obtain permission from the State Superintendent of Public Instruction and should adhere to the following guidelines as they seek approval:
   - 5.1. Study does not require questions that lead to intrusion in private family life, business, or interest, except as allowed with positive parental permission.
   - 5.2. Study does not take time away from instruction in schools.
   - 5.3. Study requires no significant additional work from USOE employees or public school employees.
   - 5.4. Study will benefit the USOE in its mission and work, or at least has a direct connection to its mission and work.
6. Researcher agrees that all data files, including derivative files and all data files resulting from merges, matches, or other uses of the subject data provided by USOE with data from other sources, are subject to this Agreement.

7. Researcher agrees to limit and restrict access to the subject data to the following persons:
   7.1. Leaders in charge of the day-to-day operations of the research and who communicate with the contact person within the USOE.
   7.2. Professional/technical staff in charge of the research.
   7.3. Support staff, including analysts, computer technicians, assistants, and secretaries, on a need-to-know basis.
8. Researcher agrees to notify and train each employee who will have access to subject data of the strict confidentially of such data, and shall require each of those employees to sign a non-disclosure agreement.
   8.1. Researcher shall maintain each non-disclosure agreement signed by its employees at its facility and shall allow inspection of the same by the USOE upon request.
   8.2. Researcher shall promptly notify the USOE in writing within one work day when a leader or professional/technical staff person has terminated, or access by specific staff members to subject data has been terminated, and give the date thereof.
   8.3. Researcher agrees to notify the USOE immediately in writing within one work day upon receipt of any request or demand by others for disclosure of the subject data.
   8.4. Researcher agrees to notify the USOE in writing immediately upon discovering any breach, or suspected breach, of security or any disclosure of subject data to an unauthorized party or agency.
9. Researcher agrees to retain the original version of the subject data at a single location and shall not make a copy or extract of the subject data available to anyone except individuals specified in paragraph 5.
   9.1. Researcher agrees to ensure access to the subject data is maintained in computer files or databases in a secure physical location. The data are controlled by password protection and procedures so that subject data cannot be accessed by unauthorized individuals.
   9.2. Researcher agrees to shred or destroy subject data, and all media used to transfer it from the USOE to the researcher, including all copies and derivative or merged files, when the research is completed or this Agreement terminates.
10. This Agreement shall terminate 12 (months) from the date it is signed. However, it may be extended by written agreement of the parties.
11. Any violation of the terms and conditions of this Agreement may result in the immediate revocation of this Agreement by the USOE.
   11.1. The USOE may initiate revocation of this Agreement by written notice to researcher indicating the factual basis and grounds of revocation.
   11.2. Upon receipt of the written notice of revocation, the Researcher shall immediately cease all research activity related to the Agreement until the issue is resolved. The Researcher will have 3 business days to submit a written response to the USOE indicating why this Agreement should not be revoked.
12. The USOE Data Governance Policy Board shall decide whether to revoke the Agreement based on all the information available to it. The USOE shall provide written notice of its

decision to the Researcher within 10 business days after receipt of the response. These timeframes may be adjusted for good cause.

13. Researcher understands that a violation of the above agreements will result in a material breach of contract and may subject the researcher and the organization for which he/she works to prosecution under applicable laws.
14. (OPTIONAL) Researcher agrees to pay fees in the amount of $ 60.00/hr for the preparation or delivery of the Research Data (this payment may be required in advance). Payment shall be made to:
USOE Data & Statistics

SIGNATURE PAGE

By signing below, the official of the Research Organization certifies that he or she has the authority to bind the Research Organization to the terms of this Agreement and that the Research Organization has the capability to undertake the commitments in this Agreement.

Location at which the subject data will be maintained and analyzed: [redacted]	
Signature of the Official of the Research Organization: Deric W. Despain	Date: 11/7/2013
Type/Print Name of Official: Deric W. Despain	E-mail: [redacted]
Title: Agriculture Educator	Telephone: [redacted]
Mailing Address: [redacted]	
Signature of the Principal Research Analyst: See above.	Date:
Type/Print Name of Principal Research Analyst:	E-mail:
Title:	Telephone:
Mailing Address:	
Signature of Utah State Board of Education/USOE Contact: William L Deimler	Date: Nov 12, 2013
Type/Print Name of USOE Contact: William L Deimler	E-mail: [redacted]
Title: Education Specialist	Telephone: [redacted]