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A Comparison of Online and Face-to-Face Achievement in Physical Science

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A COMPARISON OF ONLINE AND FACE-TO-FACE ACHIEVEMENT IN PHYSICAL SCIENCE

by

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ABSTRACT

This study provided a descriptive analysis of learning outcomes in both online and face-to-face grades 9-12 physical science courses. Archived data from a single school system were used for a comparative analysis of learning outcomes in high school physical science between students enrolled in online classes and students enrolled in face-to-face classes. The study compared two years of summative assessment scores of two student groups and, overall, found equality between the two learning environments. Online learning outcomes and face-to-face learning outcomes were similar for both school years, 2013-2014 and 2014-2015. The overall comparison between learning environments was further examined to include independent variables. The additional analyses showed some significant differences in the learning outcomes relevant to gender, grade level, and ethnicity. In 2013 and in 2014, white American students significantly outperformed four other ethnic groups, Asian American, African American, Hispanic American, and Multi-Racial Americans, in face-to-face classes. However, in online classes these significant differences in student achievement between white American and the other four ethnic groups were not found. When comparing each of the reported ethnic groups, between online and face-to-face learning outcomes, one ethnic group's assessment scores were significantly higher in online classes than in face-to-face classes. Hispanic American students in online classes had higher scores compared to Hispanic American students in face-to-face classes. Online learning outcomes also indicated gender equality in student achievement for both school years. The 2013 face-to-

face findings indicated that African American female students had lower scores compared to African American male students.

Key statistical findings from the comparative analyses were shared with teachers using an online survey. The teacher interpretations of the indicated differences in student achievement between ethnic groups pointed to possible limitations in the African American community of this study, such as support of education and value of education. Teacher response narratives also indicated that teachers viewed higher grade level students as more mature learners with technology skills needed for online learning. Teachers also indicated a learning environment preference for face-to-face student-to-teacher interaction, and teachers' learning environment preference for hands-on-tasks in physics was the traditional classroom. The online learning environment was preferred for chemistry content lessons that teachers believed to be more dependent on recall and memorization.

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CHAPTER 1: INTRODUCTION

This comparison study examined differences and similarities in the online and face-to-face learning outcomes of students enrolled in a high school physical science course. Although online learning can be equally effective as traditional learning, Barbour et al. (2011) noted that comparison research is authentic and valuable only when comparing similar elements. This study targeted a single high school physical science course and compared the course assessment scores of the entire course population for a 2-year period. The physical science course assessment scores were those of students enrolled in either online or face-to-face classes.

Chapter 1 focuses on the virtual learning landscape and the spectacular growth of the online model that became an accepted part of public education. The growth and current landscape of online learning in Georgia were fundamental in justifying this study. The national and international origins of online learning have been connected to government initiatives. The exploration offered here is largely a reflection of the delivery of education in the United States and Canada.

The rapid growth of e-learning has been tethered to a void in the literature on Kindergarten to Grade 12 (K-12) and specific content subjects. The conceptual framework of the study has two sections. The first section begins with the ways in which learning occurs in general, as explained by constructivism. The constructivist approach is associated with traditional science pedagogy (Taber, 2010) and e-learning design practices (Koohang, Riley, & Smith, 2009). Constructivism, as viewed by Piaget and Garcia (1989), is the way in which knowledge happens. It is the process of understanding through interacting with others and experiencing events of the world. It is important to understand how digital instructional media and learning theory come together (Harasim, 1990).

The second component of the conceptual frame is the result of the analytical comparison method used in the study. The learning conditions theory (Gagne, 1985) points to different levels of learning that require different types of instruction because of internal and external conditions. Learning outcomes are behavioral changes that can be assessed (Gagne, 1985). This study compared learning outcomes in science in two learning environments, namely, online and face-to-face learning.

Virtual Landscape

In the United States, online learning initially was widely adopted initially to resolve teacher shortages and course offerings in secondary education. Over the past decade, the number of online learning programs in the United States has grown from a few states with charter virtual programs to online programs in all 50 states (Barbour, 2014). Justification for the rapid growth of online learning has been linked to crowded schools, limited remedial and advanced courses, teacher shortages, and shrinking resources for students with learning challenges outside the classroom setting (C. Cavanaugh, Barbour, & Clark, 2009).

History of virtual schooling. First use of the term *virtual schooling* originated from information collected from two Canadian provinces, Alberta and Newfoundland and Labrador (Barbour & Reeves, 2009). In 1995, the first virtual schools in Alberta were in rural locations. From 1995 to 1999, the virtual landscape in Alberta grew to include 23 virtual school programs. The urban areas of Vancouver, British Columbia, and Toronto, Ontario, also experienced growth. The majority of the schools that participated in K-12 distance education and virtual schooling were in rural locations (Barbour & Reeves, 2009).

The first two virtual schools in the United States were established in 1997 (Barbour & Reeves, 2009). A federal grant worth $7.4 million funded creation of the Virtual High School (VHS). With $200,000 and Florida state legislation, the Florida Virtual School (FLVS) was established. Fulton (2002) cited the National Education Association's (NEA's) prediction that by 2006, the majority of American high school students would have completed at least one online course before graduation. Picciano and Seaman (2007) estimated that the U.S. online student population for the 2005-2006 school year was 700,000 participants. Picciano and Seaman also noted that the estimate was indicative of the need to better account for student participation in an increasing number of online schools. A later estimate proposed that 5 to 6 million public school students in the United States would be enrolled in online classes by 2016 (Liu & Cavanaugh, 2011).

In 2004, annual reports began targeting K-12 digital learning. Gemin, Pape, Vashaw, and Watson (2015) noted that the type of K-12 online learning that individuals in the United States are accustomed to originated in distance education. The Internet then facilitated the evolution of distance learning to online courses. The majority of early online classes provided advanced placement (AP) subject and college preparatory courses that were not available in rural or urban traditional school programs. Early online course development was a basic transfer of traditional classroom content to the digital learning environment. Online course development then grew into today's teacher-student and student-to-student interactive learning environment (Gemin et al., 2015).

Policies that guide online learning continue to depend on legislation passed by individual states. Michigan was the first state to pass online learning high school graduation requirements. Michigan, Alabama, and West Virginia adopted state legislation requiring students to take online classes to meet high school graduation requirements (Watson, Murin, Vashaw, Gemin, & Rapp, 2011). Georgia's first e-learning program began in 2001 when the Georgia Board of Education approved a virtual learning business plan. The program offered AP and core curriculum courses to students in Georgia high schools. The program expanded to target and increase the number of participants from low-income and other disadvantaged groups that needed AP courses and exams throughout the state of Georgia.

Public high schools with a 50% or higher free and reduced-price lunch rate qualified to participate in a federal 3-year U.S. Department of Education (USDoE) Advanced Placement Test Fee Program grant that was known as AP Nexus. AP Nexus was a collaborative effort of Georgia, South Carolina, and Tennessee to make AP courses available to economically disadvantaged students. In 2003, 13 Georgia school systems convened in Atlanta and expressed the desire for a statewide program, resulting in Governor Perdue signing Georgia Virtual School (GaVS) Bill 33 (Georgia General Assembly, 2005). As a result, schools not qualifying to participate in the AP Nexus grant made a major impact in e-learning through further development of Georgia's online program.

Current Virtual Programs and Online Student Populations

The increasing numbers of online programs and students participating in online learning in the United States have been substantial. According to Watson, Pape, Murin, Gemin, and Vashaw (2014), 30 states had fully online schools in operation in 2014. They also reported that online schools in the United States are anticipating continued growth in the number of online programs and student participation. As more states pass laws that encourage, and even require, online school classes, student participation in this learning environment is likely to increase.

National virtual outlook. During the 2013-2014 school year, an estimated 315,000 students attended fully online statewide school programs. By 2014, virtual schools were operating in 26 states, and virtual programs had expanded the number of courses that they offered online. These additional courses, which served as supplemental coursework, were available to students not participating entirely online. Eleven states have policies or programs that allow students to choose online courses from multiple providers (Watson et al., 2014).

For-profit education management organizations (EMOs) have largely driven the rapid growth of online programs (Miron, Urschel, Yat Aguilar, & Dailey, 2011; Molnar et al., 2015). Molnar et al. (2015) documented that 311 full-time K-12 virtual schools with nearly 200,000 students were operating in the United States during the 2011-2012 school year (see Table 1).

Table 1

Virtual School Populations, 2012-2013

Program type	No. of schools	No. of students	% of all enrollment	Average enrollment
For profit	95	133,128	66.7%	1,401
Nonprofit	9	2,156	1.1%	240
Independent	207	64,309	32.2%	311
Total	311	199,593	100.0%	642

Note. Adapted from A. Molnar et al. (2013), Virtual Schools in the U.S. 2013: Politics, Performances, Policy, and Research Evidence. Retrieved from http://nepc.colorado.edu/

In 2014, K12 Inc. operated 99 full-time virtual schools with an enrollment of almost 96,000 students. Connections Academy managed 29 schools with more than 52,000 students (Molnar et al., 2015; see Table 2).

Table 2

Virtual School Populations, 2013-2014

Program type	No. of schools	% of all schools	Enrollment
Nonprofit	19	4.75%	6,659
For-profit	160	40.00%	183,809
Independent	221	55.23%	70,769
K12 Inc.	99	24.75%	95,535
Connection Academy	29	7.25%	52,138

Note. Adapted from A. Molnar et al. (2015), Virtual schools in the U.S. 2015: Politics, Performance, Policy, and Research Evidence. Retrieved from http://nepc.colorado.edu/

Connections Academy is the second largest for-profit operator, with 21 schools and more than 27,000 students during the 2010-2011 school year. In 2015, the growth of the online student population was primarily the result of larger virtual schools operated by for-profit EMOs (Molnar et al., 2015). In 2010, more than 1.8 million K-12 students were enrolled in U.S. virtual schools. Other estimates have listed figures for the U.S. online student population near 4 million (Waters, Barbour, & Menchaca, 2014).

The International Association for K12 Online Learning (iNACOL, 2014) found that K-12 online U.S. enrollment continued to grow in the 2012-2013 school year and that the performance ratings of virtual schools, when compared to traditional school ratings, were not acceptable. Nearly one third of census-counted virtual schools in the 2012-2013 school year did not receive state accountability and performance ratings. Although not a state or national requirement, of the 231 schools with ratings, only 33.76% had academically acceptable ratings (iNaCOL, 2014). On average, virtual schools' adequate yearly progress (AYP) results were 22 percentage points lower than those of traditional brick-and-mortar schools (iNaCOL, 2014).

Molnar et al. (2014) noted that the AYP rating of 28.69% was substantially weaker for virtual schools managed by EMOs than the traditional brick-and-mortar schools rating of 51.1%. EMOs are for-profit companies that oversee and run schools. The on-time graduation rate for full-time virtual schools was 43.8%, close to half the national average of 78.6%. Recommendations have been made for policymakers to slow or stop the growth in the number of virtual schools and to scale back virtual school enrollment. Molnar et al. also stressed the need to identify the performance ratings of cyberschools, and they asserted that without such ratings, the entire industry of education innovation is at risk.

K-12 online learning programs in the United States that have largely been created by federal grants and state funding have been mirrored globally. Government funding is a consistent trend among international online programs (Barbour, 2014). In the United States, FLVS is the largest state virtual school program and is recognized nationally for its online model. State policy and government funding established and continue to maintain FLVS (Barbour, 2014).

Georgia's virtual outlook. A variety of virtual public and private school programs are available in Georgia. Examples of K-12 Georgia public virtual school programs include the following: Atkinson County Virtual Program, Dublin City Schools Virtual School, Georgia Connections Academy, Georgia Credit Recovery, Georgia Cyber Academy, GaVS, and Montgomery Academy. The Atkinson County Virtual Program is open to Georgia students in Bleckley, Dodge, Emmanuel, Johnson, Laurens, Montgomery, Telfair, Treutlen, Twiggs, Washington, Wheeler, and Wilkinson Counties. The Georgia Credit Recovery Program allows private high school students in the state to enroll for a fee. The program is tuition free for public high school students in the state and first-time enrollments. Georgia students in Grades 9 to 12 can enroll in the Graduation Achievement Charter High School (GACHS) and take advantage of flexible and individualized schedules. According to GACHS, part of the program mission is to provide a flexible schedule to underserved students. Students anywhere in Georgia can attend online courses at Georgia Connections Academy Charter School (GACA) and the GaVS. The Georgia Department of Education (GaDOE, 2015) manages the GaVS for students in Grades 6 to 12. District public schools' virtual programs include the following: Cobb Virtual Academy (CVA), DeKalb Online Academy (DOLA), Fulton Virtual, Gwinnett Online Campus (GOC), and Glenn County School System's Virtual High School. Virtual programs adhere to the Georgia Performance Standards and Common Core curriculum (GaDOE, 2015).

In 2015, the GaVS served public, private, and home school students. The GaVS lists more than 125 unique core courses, AP, and elective courses, including SAT preparation, with 281 course variations. These online courses meet the same Georgia professional standards (GPS) as traditional courses (GaDOE, 2015). The GaVS reported 33,041 course enrollments for the 2014 school year. For 2013-2014, the state listed three fully online Georgia schools. The Georgia Cyber Academy served 13,300 enrollments in Grades K to 12; the Georgia Connections Academy served 2,994 students in Grades K to 12; and the Provost Academy Georgia, now the Graduation Achievement Centers of Georgia (GAHS), served 1,741 students in Grades 9 to 12. Total enrollment in the three statewide fully online schools increased 34% in 2013-2014 over the 2012-2013 school year (GaDOE, 2015).

In addition, several districts in the Atlanta vicinity provide online programs, including GOC and CVA. GOC opened its virtual doors in 2011. The program offers full-time and supplemental courses for Gwinnett County students. In 2012-2013, GOC served 107 fully online enrollments. Another 5,000 enrollments were considered blended participants, meaning that enrollments were supplemental courses. CVA served 1,903 course enrollments and 1,023 unique students. Fulton, DeKalb, and Henry school Districts also provide online programs with courses listed in Georgia's Online Clearinghouse, though the student program population data have not been shared publically (GaDOE, 2015). Participant data also were reported as limited for Twiggs County public schools, a district that established a nine-district fully online school in the 2013-2014 school year. Forsyth County Schools' iAchieve Virtual Academy (iAVA) offers a fully online program for county residents, and the county accepts out-of-district students for tuition fees (Gemin et al., 2015).

Statement of the Problem

Online courses and programs are administered by state boards of education, nonprofit foundations, for-profit companies, and individual school districts. Developers of online learning content are a mix of vendors and educators, and the implementation of online programs depends largely on a school's management and administrators (Waters et al., 2014). Research on the growth of online learning in the United States has estimated that if current trends continue, 50% of all high school classes will be offered solely online by 2019 (Allen & Seaman, 2011).

In Georgia, July 2012, Senate Bill 289 passed (Georgia General Assembly, 2012). This legislation directed the Georgia State Board of Education to give public school students in Grade 3 and beyond access to online school courses. Georgia public students can enroll in online classes available via the GaVS and other vendor-purchased virtual programs.

K-12 online and blended courses and schools have provided more than a decade's worth of evidence to suggest that teaching and learning online can work over time (Watson & Murin, 2014). The primary question has changed from "Does online work?" to "Under what conditions does online learning work?" Watson and Murin (2014) concluded that many online and blended online programs are to inform and transform teaching education practices.

This study sought to determine whether online education, when compared to face-to-face learning, is beneficial to public high school science students. Georgia public high school students are assessed for science content knowledge gains upon required science course completion. Teachers facilitating science content instruction inside the virtual classroom need to understand the impact of technology on science instruction to ensure adequate learning progression. Research descriptive of online science content gains, compared to face-to-face science content gains, has been limited. The lack of research in this area consequently has restricted the advancement of virtual science pedagogy. This study provided a descriptive analysis of public school students' learning gains by comparing the outcomes of online versus face-to-face learning in high school physical science, as measured by a formal assessment.

Research Questions

In this study, the following research questions (RQs) were addressed:

1. Is there a significant difference in assessed achievement, based on students' end-of-course test (EOCT) scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning?
2. Are there significant differences in assessed achievement, based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning, and based on variables such as gender, grade level, and ethnicity?
3. Are there significant differences in assessed achievement, based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning based on physical science domain?
4. What explanations will teachers provide if differences in learning outcomes are indicated?

Following are the physical science course content domains that were measured in the study: (a) Chemistry: Atomic and Nuclear Theory, and Periodic Table; (b) Chemistry: Chemical Reactions, and Properties of Matter; (c) Physics: Energy, Force, and Motion; and (d) Physics: Waves, Electricity, and Magnetism.

Purpose and Significance of the Study

Science instruction can be abstract, objective, and information oriented, making science content difficult to comprehend as intended (Ciechanowski, 2009). Ciechanowski (2009) pointed out that the science curriculum was developed to appear neutral, with an informational tone that steers away from the inclusion of cultural components. Although the online and face-to-face learning environments have been structured to ensure that students learn the same subject content, the two environments have difference infrastructures. Identifying differences in the learning outcomes from the two learning environments was the purpose of this investigation. Few researchers have used statistical student data from standardized high school assessments to find differences or similarities in science learning outputs from the two environments.

In the current study, test scores of students enrolled in online and face-to-face physical science classes were sorted and analyzed statistically for group comparisons. The findings from the statistical analysis were then used to construct a teacher survey. The survey participants were teachers from the same school program; their input was based on their teaching experience in online and face-to-face learning environments. The survey responses provided the practitioners' perspectives, which the researcher analyzed and interpreted to obtain qualitative findings (Bernard, 2006). The analysis of the archival data and completion of the survey comprised the components for a quasi-experimental design, with the survey added for the discussion of the statistical findings.

Additional research seeking to identify differences in online learning and face-to-face learning in science content is needed to further develop the online learning model. The implications of this study are related to the ongoing debate regarding the influence of instructional media on learning outcomes. Debate on whether the technology medium merely delivers the content or has an influence on the learning outcomes continues. The implications of this debate have meaning for online learning, just as it did for the precursor model of distance education. On one side of the debate, R. Clark (1994) proposed that the medium does not influence learning. Conversely, Kozma (1994) viewed learning as occurring with and, to some extent, dependent on technology. Kozma supported pursuing a more in-depth understanding of the influence that instructional media have on learning and specific students, tasks, and situations. This investigation of virtual science learning compared students' learning gains and considered the independent variables (IVs) of gender, grade level, and ethnicity. The dependent variables (DVs) were the students' physical science EOCT scores for the 2012-2013 and 2013-2014 school years based on learning environment (i.e., online or face-to-face). Helping to bridge research from the traditional classroom to the virtual classroom, this study was an effort to identify similarities and differences in learning outcomes associated with online and the face-to-face learning environments.

Local Context

Until 2010, few researchers had investigated specific content-related learning outcomes in the high school virtual learning environment. This study applied a statistically based investigation and a qualitative follow-up examination to provide a descriptive comparison of learning outcome differences and similarities in high school physical science. Because of the concerns expressed by educational leadership to increase student achievement in math and science needed to maintain global competitiveness, public schools began to adopt online classes (Roblyer, 2004; Roblyer, Porter, Bielefeldt, & Donaldson, 2009). In Georgia, Senate Bill 289 directed the Georgia State Board of

Education to maximize the number of students using digital learning in some capacity to complete high school coursework. Georgia school districts by law must allow students to take online courses, even if face-to-face classes in the same courses are offered at students' local schools (Georgia General Assembly, 2012).

This study examined the science learning gains measured by a state-approved assessment, namely, the EOCT. The EOCT for physical science was aligned with the GPS for physical science. Physical science EOCT data from the 2012-2013 and 2013-2014 school years comprised the four curriculum domains of physical science (GaDOE, 2014):

1. Chemistry: atomic and nuclear theory and the Periodic Table - the description of the basic atomic structure, such as atomic mass particles, chemical activity, and element placement on the Periodic Table, and tasks, such as differentiation between radioactive particles, identification of phases of molecular motion, and data collection in a laboratory setting.
2. Chemistry: chemical reactions and properties of matter - writing, classification of chemical formulas and compounds, balance of equations, identification of chemical reactions, and the law of conservation of matter.
3. Physics: energy, force, and motion – work comprehension of simple machines, identification of energy transformations, such as conduction, convection, and radiation, and calculation of velocity and acceleration, and demonstration of comprehension of Newton's three laws of motion.
4. Physics: waves, electricity, and magnetism - recognition of wave energy, such as light and sound phenomena, the Doppler Effect, electricity, and magnetism.

The physical science EOCT was one of several core mandatory assessments given to Georgia students (GaDOE, 2014). The EOCT was aligned with Georgia's state content standards for specific content knowledge and skills. According to the GaDOE (2014), the assessments provided diagnostic information used to identify strengths and weaknesses in learning. EOCT data also were used to evaluate the effectiveness of classroom instruction at the school, district, and state levels. The Georgia State Board of Education adopted the EOCT in 2011 and continued to use it until 2015 (GaDOE, 2014).

Learning is an opportunity for students to gain life choices. Public education is mandated to provide equal opportunity for all students to learn. Fair practices in public education were required with passage of the federal Equal Educational Opportunities Act (EEOA) in 1974. The act, signed into law by the residing U.S. president, prohibited discrimination on the basis of ethnicity or gender. Any impact that instructional media have on learning gains and learning outcomes is relevant to national public education policy, and anything other than EEO infringes on the EEOA.

Conceptual Framework

The need to provide students with quality science instruction, along with the availability of online learning, has made the virtual classroom a practical course option for many traditional public schools (Roblyer et al., 2009). The instructional technology used in the learning environment facilitates delivery of the content. This study took into account that the online learning model adopted the face-to-face science curriculum and learning expectations.

According to Taber (2010), traditional science pedagogy is associated with constructivism, established by Dewey (1988), Piaget and Garcia (1989), and Vygotsky

(1978). The constructivist approach, according to Shulamit and Yossi (2011), is used by individuals to construct their own understanding of the world through experience and reflection on those experiences. Constructivism is a valuable guideline for science education, and according to Duit (1996), constructivists view learning as a particular way of conceptualizing knowledge that brings about knowledge acquisition. Constructivism is about the relationships and variables that impact student learning (Koohang et al., 2009).

Research has been inconclusive regarding the influence of instructional media on learning outcomes. Science content and science pedagogy in the virtual classroom are part of the new e-learning model, with participant interactions involving cybersemiotic elements. According to Brier (2013), virtual information becomes knowledge through the transfer of signs and signals that have to be interpreted by the learner. It is necessary to include the meaning aspect of reality with information, cognition, and communication research (Brier, 2013).

In general, learning outcomes are the result of a process of cognitive growth that quantifies changes in behavior. Proof of learning, according to the learning conditions theory (Gagne, 1985), can by quantified by measuring an outcome, such as by using an established summative assessment. This investigation examined the learning output assessed by the physical science EOCT. The physical science assessment scores served as the measured learning output for both the online and the face-to-face learning environments.

Review of Relevant Terms

In the United States, K-12 online learning evolved from a long history of distance education (Waters et al., 2014). Online learning is a form of distance education that defines learners as separated from teachers. The terms *online* and *virtual* refer to learning over the Internet (Waters et al., 2014). Most virtual schools are organized as charter schools (Molnar et al., 2013), generally defined as public schools managed by private organizations. Charter schools receive government funding and must adhere to government education regulations, generally under the direction of local school districts. Concerns regarding the manner in which online charter schools are managed are growing (Molnar et al., 2013).

Barbour and Reeves (2009) included a table in their research that had been developed earlier by T. Clark (2001) to define common terms used for online learning. Table 3 identifies seven categories and defines virtual schools by type. Only online learning programs in Canada and the United States have been classified as virtual schools.

Table 3

T. Clark's (2001) Definitions of Virtual Schools

Program type	Program description
State-sanctioned, state level	Virtual schools operating on a state-wide level, such as the Florida Virtual School
College and university-based	Independent university high school or university-sponsored delivery of courses to K12 students, such as the University of California College Prep Online (UCCP)
Consortium and regionally-based	Virtual schools operated by a group of schools of school districts, such as the Virtual High School (VHS)
Local education agency-based	Virtual schools operated by a single school or school district, such as the Gwinnett County Online Campus
Virtual charter schools	Virtual schools created under the charter school legislation in many states, such as Connections Academy, also commonly known as cyberschools
Private virtual schools	Virtual schools that are operated in the same manner as a brick and mortar private school, such as the Christa McAuliffe Academy
For-profit providers of curricula, content, tools and infrastructure	Companies that act as vendors for the delivery of courses or the use of course materials, such as APEX Learning

Note. Adapted from M. Barbour & T. Reeves (2009), "The Reality of Virtual Schools: A Review of the Literature," *Computers & Education, 52*(2), pp. 402-416. doi:10.1016/j.compedu.2008.09.009

Watson, Winograd, and Kalmon (2004) offered a different table (see Table 4) with five classifications that defined the types of virtual programs. Barbour and Reeves (2009) noted that Watson et al.'s definitions were more widely used.

Table 4

Watson et al.'s (2004) Definitions of Virtual Schools

Program type	Program description
Statewide supplemental programs	Students take individual courses but are enrolled in physical school or cyber school within the state. These programs are authorized by the state and overseen by state education governing ardencies.
District-level supplemental programs	Are typically operated by autonomous districts and are typically not tracked by state agencies.
Single-district cyberschools	Provide an alternative to the traditional face-to-face school environment and are offered by individual districts for students within that district.
Multidistrict cyber schools	Are operated within individual school districts but enroll students from other school districts within the state. This represents the largest growth sector in K-12 online learning.
Cybercharters	Are chartered within a single district but can draw students from across the state.

Note. Adapted from J. Watson et al. (2004), Keeping Pace With K12 Online Learning: A Snapshot of State-Level Policy and Practice. Learning Point Associates/North Central Regional Educational Laboratory.

Definitions of Terms

The terms *e-learning*, *online learning*, and *virtual learning* all had the same meaning throughout this study, and they were used interchangeably in the study.

E-learning – course content using the Internet, a network, or a standalone computer; electronic delivery methods include Internet-based learning delivery packages, CD-ROM, online video conferencing, websites or email/messaging (Nichols, 2003).

Face-to-face – instruction provided by teachers to learners who are together in the same physical space and moment in time (Davis et al., 2007).

Internet – a global network that connects millions of computers and exchanges digital data (Roblyer, 2004).

Online – an online connection to the Internet and/or a computer connected to a network (Roblyer, 2004).

Virtual classroom – A learning environment that exists solely in the form of digital content that is stored, accessed, and exchanged through networked computers and information systems (Watson et al., 2004).

Organization of the Study

This study was a quantitative quasi experimental investigation that compared the learning outcomes of two independent groups of students who completed a high school physical science class in either an online or a face-to-face learning environment. The archived data collected for this study targeted assessment scores from a single program from the 2012-2013 and 2013-2014 school years. The 2 school years of data also included demographics (i.e., gender, grade level, and ethnicity). The case scores came from a mandatory state assessment of high school physical science. This study included only case information formatted as deidentifiable data. Statistical examination of the archived EOCT assessments in physical science from the 2012-2013 and 2013-2014 school years yielded a comparison of differences and similarities in student learning outcomes in physical science.

The descriptive findings in Chapter 4 resulted from quantitative comparisons of measured learning outcomes. A qualitative component was added for discussion of the findings. Similarities and differences in the findings between the two learning environments were used to assemble the teacher survey, which comprised multiple-choice, open-ended questions and was placed online (see Appendix A). The online survey facilitated the collection of the perspectives of teachers of students in either learning environment. The teachers' survey responses were narratives that pertained to the statistical findings from the comparison analyses. The findings of both approach methods, quantitative and qualitative, are presented in Chapter 4. Discussion of these findings, along with the limitations, is presented in Chapter 5.

CHAPTER 2: LITERATURE REVIEW

The number of online learning programs has surpassed the level of research on K-12 online learning. The limited amount of available research regarding learning outcomes in specific subject areas has made it difficult to draw on previous results regarding the level of effectiveness of online learning for K-12 students. This review of the literature has three parts. The key focus targets differences in online K-12 learning outcomes versus face-to-face outcomes. The unique features of online participation are explored at the high school and college levels to reveal the challenges that researchers face when comparing academic outcomes in the two learning environments. The final part of the review discusses changes in regulations and policy governing online programs. The chapter opens with information regarding the theoretical base of this study. The learning theories presented here emphasize the possible influence of instructional media on learning outcomes.

Theoretical Framework

This study was supported by the learning theories of Ciechanowski (2009), Clark (1994), and Gagne (1985). The constructivist theory of learning holds that people learn by constructing their own understanding through experience and reflection upon that experience. According to Ciechanowski, science education builds on participant community resources and the community's knowledge and life examples of science, along with explicit real-world examples. Such examples are necessary for students to gain specific knowledge about scientific concepts and processes.

Science pedagogy has traditionally taken the approach of constructivism (Ciechanowski, 2009). Constructivism, as referenced by Taber (2010), has been recognized widely as the dominant theory of informing science curricula since the 1970s. Constructivism supports learning that develops students' abilities to learn collaboratively, construct knowledge independently, and discover new understandings (Ciechanowski, 2009; Taber, 2010). According to Taber, constructivist teachers provide tools such as problem-solving and inquiry-based learning activities that allow students to formulate and test their ideas, draw conclusions and inferences, and pool and convey their knowledge in a collaborative learning environment. The learning outcomes of science content taught in the online and face-to-face learning environments investigated by this study were aligned with and held to the same traditional science standards (GaDOE, 2014).

This investigation of learning outcomes also was related to the historical debate on the influence of instructional media on learning outcomes (T. Clark, 2001). According to T. Clark (2001), increases in learning have been credited to technological media, but they really have been the result of the reformation and new implementation of curriculum associated with a change in teaching media. In direct contrast to how R. Clark (1994) viewed media, Kozma (1994) claimed that variations in instructional media have distinct capabilities that can complement learners' learning styles and produce unique learning experiences. Kozma explained that learners are unique and process information in different ways. Variations in learning are dependent on the media, the learning tasks, and learners' preferences (Kozma, 1994). Shulamit, and Yossi (2011) viewed the e-learning environment as contributing to the teaching and learning processes, provided that the instructional technology is guided by an appropriate pedagogy framework. The current study explored physical science content learning output for variations in assessed student achievement from two different learning environments, namely, online and face-to-face.

Obtaining knowledge has been widely considered a multistep learning process (Gagne, 1985). Gagne (1985) developed the conditions of learning theory by positing that the learning process has two components, internal conditions and external conditions. The internal conditions include learners' attention, motivation, and memory recall. The external conditions include facilitator input, content materials, and interactions with other learners (Gagne, 1985). According to Gagne, the learning process involves nine steps: gain attention, describe objective, present the material, provide learner guidance, guide performance practice, offer feedback, assess performance, and enhance retention. His theory stipulates that these elements of learning require different types of instruction. Whether different learning environments mimic the same learning process and produce equity in learning outcomes was questioned in this study.

According to Gagne (1985), learning has four sequenced phases: Phase 1: receipt of the stimulus situation, Phase 2: Acquisition, Phase 3: Storage, and Phase 4: Retrieval. This sequence of events promotes successful learning, and the internal conditions of learning, coupled with the external conditions of learning, result in best learned outcomes (Gagne, 1985). Internal conditions, such as previous things learned, must be recalled before new intellectual skills can be learned. External conditions allow individuals to learn concepts because they have the opportunity to experience or practice what is to be learned.

Gagne (1985) described learning as a change in behavior, and he explained that learning outcomes could be measured using grades and posttests. Collected postdata, such as grades and assessments, are quantitative measurements of students' participation and students' learning of specific content (Gagne, 1985). Differences in the post assessment data from the two learning environments were key to this investigation regarding the question of equality in learning outcomes.

The learning theories of Ciechanowski (2009), Kozma (1994), and Gagne (1985) framed this comparison investigation of science learning outcomes in online and face-to-face learning environments. In the following sections is a review of research that has used these learning theories. This study investigated academic outcomes in science based on face-to-face and online learning environments. The study was unique because it compared learning outcomes of a single course subject, physical science.

Learning Outcomes

Evidence of learning is associated with learning outcomes, and it can be measured by assessments (Gagne, 1984). Direct measures provide more evidence of an increase in students' knowledge and abilities over time (Kilgus, Kazmerski, Taylor, Crystal, & von der Embse, 2016). Early meta-analysis research (C. Cavanaugh, Gillian, Kromrey, Hess, & Blomeyer, 2004) on the effectiveness of online programs was examined by using students' grades, attitudes toward learning experiences, and program retention. Barbour and Reeves (2009) pointed to a deficit of rigorous research on student performance in K-12 virtual schools. Literature related to academic outcome comparisons between online and face-to-face learning environments is reviewed here.

Tasks. Similar to Kozma's (1994) concerns about the impact of learning tasks on learning outcomes, Callister and Love (2016) questioned whether the learning outcomes of online skills-based college courses were similar to face-to-face skills-based outcomes. Callister and Love suggested that classes in applied qualitative coursework, such as management and marketing, might be bettered suited to the online environment, as opposed to quantitative coursework, such as classes in finance.

One of the few investigations of specific science learning tasks was conducted by Australian researchers Peat, Franklin, Lewis, and Sims (2002). Their research included skills-based learning objectives for an online science lab course. In the dissection component of a required university science class, the lesson on animal organ structure and animal organ functions emphasized dissection practices. Their quantitative findings showed few differences in achievement between the two types of science lab instruction. However, Peat et al. (2001) indicated that the participants favored the use of online learning for sensitive science topics. The live lessons and labs were known to have the highest disapproval rating because of the involvement and use of live and dead animals (Peat et al., 2001).

Assessments. C. Cavanaugh et al. (2004) and Means, Toyama, Murphy, and Baki (2013) examined reviews of comparison studies that targeted college-level learning outcomes for online and face-to-face environments using a meta-analysis. The earlier meta-analysis by C. Cavanaugh et al. that focused solely on K-12 programs provided evidence that online learning was equal to the academic achievement of traditional instruction. For the 14 studies completed between 1999 and 2004, student achievement between online and face-to-face learning environments showed no significant differences (C. Cavanaugh et al., 2004).

For their meta-analysis, Means et al. (2013) examined the literature on college and public school programs. After comparing the learning outcomes of experimental and quasi-experimental research, they interpreted the results of 176 studies from 1996 to 2008. On average, students in the online learning environment performed modestly better than those receiving face-to-face instruction (Means et al., 2013).

At the university level, an early report by Urtel (2008) gave some indication that first-year students performed less successfully online when comparing distance learning and face-to-face environments. Urtel's quantitative investigation of academic outcomes using course grades favored face-to-face learning. The face-to-face student group earned a grade point average (GPA) of 3.16; the distance student group earned a GPA of 2.28. Employing a statistical analysis, Urtel assessed the coursework of 269 university students enrolled in the distance education section and 116 enrolled in the face-to-face section. The most notable trend was the disproportionate rate of lower learning outcomes for students classified as being in the first-year cohort. Sixty-five percent of first-year students earned grades of D, F, and W when taking an online class.

Smith and Stephens (2010) compared learning outcomes of students in a marketing college course and found significant differences in learning outcomes that favored online learning. They followed a quantitative approach and used the mean scores calculated from students' final class exams. Results showed a lower mean score ($M = 61.43$) for the face-to-face student group than for the online student group

(*M* = 73.92). In addition to these statistical findings, Smith and Stephens suggested that student demographics might help to explain why the online students performed better and that further research is needed.

A more recent report by CREDO (2015) showed weaker academic growth in math and reading compared to traditional public school academic growth. A shortfall in performance was equal to a loss of 72 learning days in reading and a loss of 180 learning days in math for a 180-day school year. The lower student performance groups included ethnic and economically disadvantaged student groups. Reports of higher online performance growth were not typical. Research on content learning outcomes have produced mixed results (Callister & Love, 2016; Gulacar, Damkaci, & Bowman, 2013; Smith & Stephens, 2010). Mathieson, Beaumont, and Barnfield (2010) concluded that outcomes, student achievement, were generally similar between face-to-face and online learning environments. In their systemic review of comparison literature at the postsecondary level, they noted a prevalence of methodological limitations, such as lack of randomization, lack of generalizability, and a failure to account for learning variables.

Internal and External Conditions

This section focuses on the literature on external and internal learning conditions, as referenced by Gagne (1985) in his conditions of learning theory. Internal conditions include cognitive abilities and motivation, and external conditions include content and its context (Gagne, 1985). The section is descriptive of internal conditions, such as learning level and ability, and external conditions, such as task objectives and course context.

Internal conditions. Gagne's (1985) conditions of learning theory stipulates that there are levels of learning. The significance of the learning levels is linked to different types of instructions. These internal components reflect students' cognitive range.

Learning levels. The outcome comparison research by Gulacar et al. (2013) targeted student performances in a general college-level chemistry class. They based their observations on successful student performance associated with problem solving, such as work fluency, checking of work, and sequencing of work. From the performance observations and the learning outcomes, they assessed the learners' levels of thinking. They concluded that online student performance was higher. They considered higher level thinking analytical and lower level thinking recall. Callister and Love (2016) compared student performance in a skills-based college course for negotiation. In their comparison study, the online and the face-to-face classes were instructed by the same professor. Results indicated that the face-to-face learners achieved higher negotiation skills than the online learners did.

Learning abilities. Researchers have asserted that online learners have some key attributes that complement the online learning process (C. Cavanaugh et al., 2009; de la Varre, Irvin, Jordan, Hannum, & Farmer, 2014; Roblyer et al., 2009; Swan, 2003). According to Roblyer et al. (2009), the Internet and online practices have changed the role of students in the learning process. The online approach has made learning more student driven by tasking them with self-paced participation and self-motivation.

The integration of print, audio, video, and interactive elements with synchronous and asynchronous communication has made the online learning interactive experience possible (Roblyer, Davis, Mills, Marshall, & Pape, 2008; Swan, 2003). Swan (2003) suggested that students' use of this hypermedia has developed learning abilities that connect ideas and thinking in a more complex manner. Roblyer et al. (2009) claimed that teachers have become more of course facilitators and students have become active self-directed learners. According to de la Varre et al. (2014), online learning is complementary to student-centered learning and, therefore, favorable for advanced learners or high achievers. Students with good study habits and computer skills gain the most from online learning (de la Varre et al., 2014). According to C. Cavanaugh et al. (2009), data have shown that failure to complete online courses successfully continues to be associated with passive student participation. C. Cavanaugh et al. also asserted that the absence of teachers from the online learning environment has contributed to less student participation.

To identify differences in grade-based learning outcomes, J. Cavanaugh and Jacquemin (2015) reviewed more than 5,000 university courses facilitated by more than 100 faculty members over 10 academic terms. Seeking a macrolevel of confirmation for student performance, they used a multiple regression analysis to investigate students' demographics and the factors known to bias course grade-based outcomes. A key element in their findings was that students with higher GPAs performed better in online courses than students with lower GPAs.

Tanyel and Griffin (2012) claimed that differences in college student populations in online versus face-to-face courses might be a factor in outcome success. They suggested that this factor is linked to certain skill sets, attitudes, and levels of maturity that students need to be successful in online courses. Roblyer et al. (2008) developed the Education Success Prediction Instrument (ESPRI), a statistical tool, to identify the characteristics of students who are successful as online learners. Results showed that the ESPRI tended to identify the characteristics of privileged learners, that is, students with regular access to technology, computer experience, and high levels of self-efficacy. The ESPRI calculations helped Roblyer et al. to identify students likely to engage in and adjust to online learning. The instrument was not successful in identifying the characteristics of students who are not successful as online learners.

External conditions. Researchers have generally agreed that online learning appeals to students because of its schedule flexibility and broader access to course sections (Burns, 2013; C. Cavanaugh, 2001). External conditions such as content and context are environmental factors and stimuli that can impact student performance. Research discussed next focuses on the external conditions of facilitators, course design and instructional methods, and technology.

***Facilitators*.** Teachers in both learning environments tend have to similar characteristics (Archambault et al., 2010; Greer, Roland, & Smith, 2014). Archambault et al. (2010) conducted descriptive research of online educators via a national survey of 596 respondents from 25 U.S. states. The investigation targeted educators teaching in the K-12 online environment. Approximately 465 participants were European American women who ranged in age from 36 to 45 years. They had been teaching for an average of 12 years. Archambault et al. described the majority of online courses and pedagogy as evenly distributed among mathematics, science, language arts/reading, social studies, and humanities. The majority of the online teachers were teaching classes in their areas of expertise. Mathematics was the most common subject taught by teachers from outside fields. According to Greer et al. (2014), online educators are held to the same professional standards as face-to-face teachers, namely, holding a college degree, demonstrating knowledge of the subject, and having state licensure or certification requirements.

***Design methods and instructional strategies*.** To determine the effectiveness of online learning, K-12 and university researchers also have looked at program development and course design (Dell, Low, & Wilker, 2010; DiPietro, 2010; Laing, 2010; Means et al., 2013; Murray, Pérez, Geist, & Hedrick, 2013). Means et al. (2013) claimed that programs using a blend of face-to-face and online instruction, not only face-to-face instruction, are more effective. Their investigation supported efforts to design and implement more blended learning models.

Teachers play a key role in course design, according to the results reported by DiPietro (2010). The online teachers in the study preferred to structure online content with a scaffold-like learning journey. Survey participants identified teacher-to-student communication and accessibility as priorities. The teachers confirmed that interactions with students helped to clarify course learning goals, avoid misunderstandings in content instructions, and maintain positive connections with students. Monitoring students' learning gains was identified as a critical strategy in providing highly individualized learning. DiPietro concluded that positive student-teacher communication about content instructions and content objectives supported student performance. The more frequent the communication between students and teachers and students to others, along with the content expertise of the teacher, the greater were the students' learning outcomes (DiPietro, 2010).

C. Cavanaugh et al. (2009) concluded that students' online success is associated with student interactions online. They suggested linking in-school and online classmates and establishing K-12 learning communities. The relationship between student-teacher communication and learning outcomes also was viewed as a critical learning component by Dell, Low, and Wilker (2010), who claimed that the online or face-to face platform , was not as important as the frequency of teacher feedback. DiPietro (2010) categorized three general realms of online teaching practices: communication practices, pedagogic practices, and instructional design. DiPietro claimed that in addition to using corrective feedback, the online teachers in the study used a variety of strategies that they individualized according to the needs of the learners. These strategies, which called for the use of various digital media to engage in individual and group dialogues with online learners, were considered unique qualities of virtual school teachers (DiPietro, 2010).

Research regarding course design has indicated that students in well-designed online courses perform better than students in similar face-to-face courses (Murray, Pérez, Geist, & Hedrick, 2012). A well-designed course was defined as having multiple methods for interactions between student, teacher, and content (Murray et al., 2012). Swan (2003) reported that students value individualized instructor-to-student feedback on homework assignments, term papers, and discussion boards. Students also place less importance on auto-graded quizzes and discussion board submissions (Swan, 2003).

Instructional design specific to credit recovery might be available in the future, but evidence to support its use of online application remains unproven (Ronsisvalle & Watkins, 2005; Watson & Gemin, 2008). More than half of the respondents to a national survey of administrators from 2,500 school districts reported using online learning in their schools for credit recovery programs. Typically, regular online course models are used for credit recovery programs. According to Ronsisvalle and Watkins (2005), although online and blended learning programs are an increasingly important component of high school reform efforts, the design of online credit recovery programs lacks a research base.

Technology. In addition to the debated influence of digital media on learning outcomes (R. Clark, 1994: Kozma, 1994), there has been some question about the influence of technology on the participants. Brier (2013) advocated for a cybersemiotic framework as a way to bridge the semiotic cognition and the communication in the technology environment that allowed the learner to conceive knowledge. Brier explained his view of semiotics as linguistic communication through symbolic behavior and the use of technology. The common understanding of semiotics is that learning is processed through words, sounds, and even body language. Brier explained that the purpose of the technology environment is the retrieval of content, meaning, and experience for cognitive gain.

Some known differences in environmental learning experiences exist (Aydin, 201l; Roblyer et al., 2009). Aydin (2011) expressed concern that unfamiliarity with technology and the Internet can make students apprehensive and anxious, subsequently hindering their academic performance. He explained that English language learners (ELLs) with infrequent or inadequate access to online resources can experience added stress when participating in online learning. Inexperience and access limitations to the Internet are tied to limited monetary resources, which might explain some students' exclusion and lower academic performance (Aydin, 2011). Roblyer et al. (2008) pointed to the use of a computer at home and computer access during the school day as contributing factors to online learning success. Limitations to the availability of support for students with specific learning challenges and special learning needs also leaves some students out of the online learning environment (C. Cavanaugh et al., 2009). Science is a required high school credit course, and because all students can benefit from research-based content development, this comparison study helped to link learning output to practices in the online and face-to-face learning environments.

Population and Diversity

Education demographics for K-12 U.S. public schools might have skewed numbers regarding online learning. The overall online student population has not reflected that of face-to-face public school (Aydin, 2011; Molnar et al., 2015; Ronsisvalle & Watkins, 2005). According to Ronsisvalle and Watkins (2005), early online learning programs categorized students as traditionally underserved. Online learning mostly served home-schooled students, students with health conditions, students at risk of dropping out of high school, students with professional commitments, or student athletes (Ronsisvalle & Watkins, 2005). Molnar et al. (2015) noted that in 2013, online student populations did not reflect the ethnic diversity of the U.S. population. Three quarters of the virtual student population were European American, 10.3% were African American, and 11% were Hispanic American (Molnar et al., 2015). Figure 1 shows student demographics during the 2010-2011 school year.

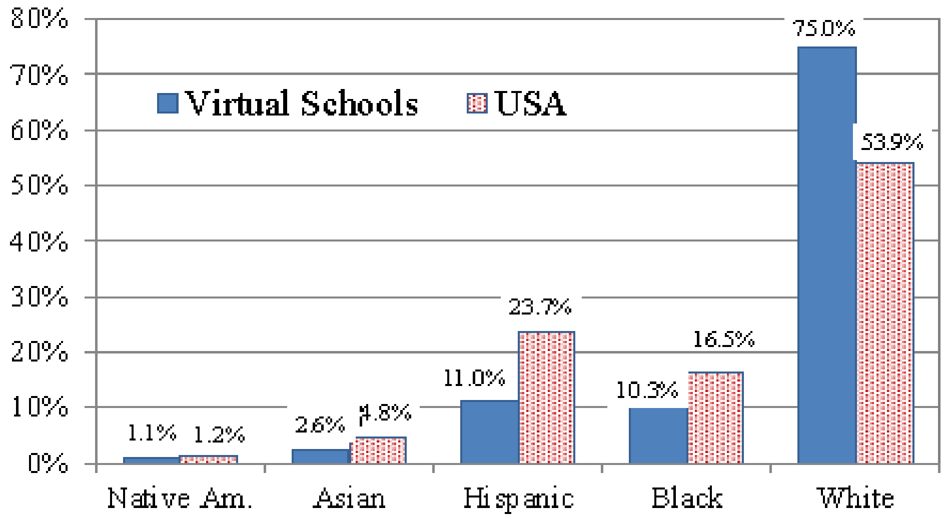

Figure 1. Student demographics 2010-2011.
Note. Adapted from A. Molnar et al. (2013), Virtual Schools in the U.S. 2013: Politics, Performances, & Policy, and Research Evidence. Retrieved from http://nepc.colorado.edu/

Molnar et al. (2015) contended that virtual school programs are mostly available in states such as Arizona, California, and Florida, all of which have large Hispanic American populations in the traditional school classroom setting. Large Hispanic American student populations are not represented in online courses. Furthermore, the researchers stated that only 0.1% of full-time virtual school students were classified as ELLs. According to Aydin (2011) virtual schools serve a lower percentage of economically disadvantaged students, such as students who are eligible for the free or reduced-price lunch program (FRL). Figure 2 shows the percentage of students served by three subgroup populations: FRL, special education, and ELLs.

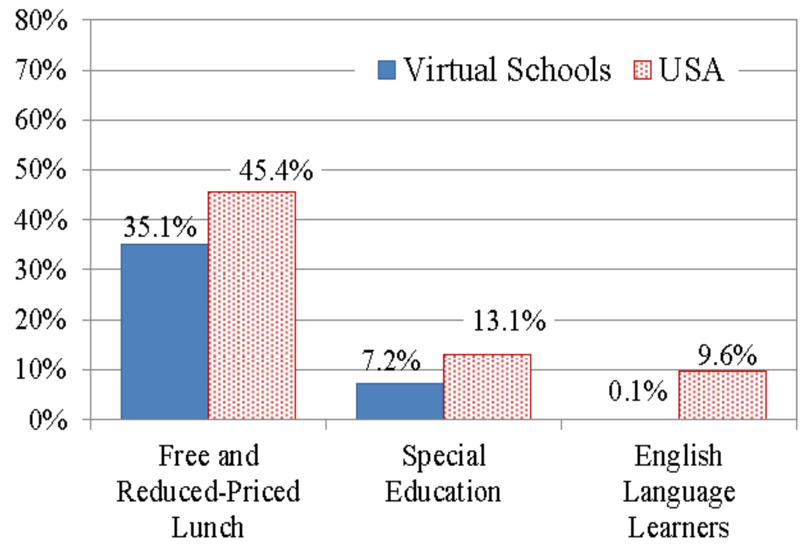

Figure 2. Subgroup populations.
Note. Adapted from A. Molnar et al. (2013), Virtual Schools in the U.S. 2013: Politics, Performances, Policy, and Research Evidence. Retrieved from http://nepc.colorado.edu/

Laing (2010) claimed that virtual learning is an option solution to the high dropout rate among African American male students. Lang pointed to the resource disparities in public schools attended by African American male students and claimed that online programs that do not rely on being government run or receiving taxpayer funding could be provided. The researcher also postulated that virtual learning would eliminate problematic racial bias between students and teachers. Laing concluded that engaging in online learning is contingent upon access to Internet technology. Lang also asserted that little has been written about African American students and their use of the virtual learning model.

According Wang and Decker (2014), although lower student performance in the online learning environment has not been limited to marginalized student populations, Ohio's K-12 virtual schools were viewed as alternative options to traditional schools for marginalized students. Ohio law mandated that virtual schools plan and provide related services for students with disabilities, so the new policy called for program development and teaching methods for specific online content pedagogy (Wang & Decker, 2014).

According to Wang et al. (2014), 27 of the chartered virtual schools in the Ohio public school system experienced an increase in student population. In a 5-year period, virtual school enrollment increased by almost 11%; during that same period, traditional student enrollment decreased by 2%. This increase in the online student population was experienced even though traditional Ohio public schools had consistently outperformed virtual schools and had reported higher student achievement (Wang & Decker, 2014).

Governance

This final section of the reviewed literature reflects on standards and policies that define the governance of online programs. A call for accountability, quality, and change in pedagogy went out regarding missing national policies for online education (Barbour & Reeves, 2009). Barbour and Reeves (2009) concluded that despite the efforts by organizations for more online standards, such as those developed by the Southern Regional Education Board and the NEA, it cannot be assumed that the online learning environment has attained a high level of quality. The standards focus on the quality of virtual school courses, online course development, and online pedagogy.

Expensive start-up costs and a wider digital divide in technology because of financial disparities have been expressed as concerns regarding the online model. State funding for charter schools continues to be diverted from traditional public school programs. Public schools with more diverse student populations will likely continue to lose funding as offerings of online programs expand. Molnar et al. (2015) recommended that funding formulas be based on the actual costs of operating virtual schools, and they advocated for the establishment of policies ensuring that virtual schools do not prioritize profit over student performance.

Quality Matters (QM) is an organization that promotes quality assurance of online education in general. A K-12 rubric was developed by QM in collaboration with the University Professional and Continuing Education Association. According to QM, the rubric, which is a guide for online quality assurance, has eight components: learning objectives, assessment and measurement, instructional materials, course activities and learner interaction, course technology, learner support, accessibility, and usability. The rubric is available for users via an online subscription. The nonprofit organization iNACOL (2014) also has published standards for online programs that address quality course design and quality online teaching.

The GPS do not differentiate between online and face-to-face learning environments. The GPS serve as the foundation of curricula for online and face-to-face programs, and they steer instructional strategies in Georgia (GaDOE, 2014). The characteristics and concepts of science emphasize hands-on, student-centered, and inquiry-based approaches, as well as student use of technology.

Conclusion

This review of the literature disclosed some of the challenges facing educators and administrators. After reviewing literature spanning 20 years, it became evident that virtual learning is a desired and growing education model and that the need for a distant learning option has remained unchanged. Online learning continues to be favored for its convenient access and course selection (Barbour & Reeves, 2009; C. Cavanaugh, 2001).

Early research comparing online and face-to-face learning environments mostly targeted university programs and tended to focus on participant satisfaction. Although some research has suggested that successful online students have specific learning traits that are reflected in their higher online academic performance (de la Varre et al., 2014; Roblyer et al., 2009), public education programs must be beneficial for all students.

Recent research has pointed to differences in scores (CREDO, 2015); the lack of diversity in online student populations (Aydin, 2011; Molnar et al., 2015); and program funding (Molnar et al., 2015). Research has suggested that limitations in services, such as access to technology and course design, can negatively impact learning outcomes (Laing, 2010). The literature also has identified the exclusion of students with special learning needs (C. Cavanaugh et al., 2009) and ELLs (Aydin, 2011).

Both learning environments offer the benefit of learning. However, differences in school populations and student demographics made student performance comparisons between the two environments a challenging endeavor. This study compared learning outcomes from a single subject and a predominately African American student population. Results here also pointed to learning inequities.

CHAPTER 3: METHODOLOGY

The methodology used to conduct this study is described in this chapter. Using quantitative methods, statistical comparisons of the physical science EOCT assessment scores also are described. All Georgia high school students are required to enroll in credited science courses, and students are assessed for content knowledge gains. The EOCT was a mandatory part of course completion for high school course credits for 2012 and 2013 school years. Quasi-quantitative methods were used to compare physical science learning outcomes between the two independent groups (i.e., online vs. face-to-face learners). All data were deidentified, as per Kennesaw State University's Institutional Review Board (IRB) requirements.

In addition to the statistical findings from the quantitative approach, a survey also was implemented. The interpretation of the quantitative findings dictated how the survey questions were derived. Volunteer participants for the teacher survey were from the same education program as the case data. The participating teachers had experience in teaching physical science in online and face-to-face learning environments. The responding teachers completed the open-ended survey.

Research Questions

Science content gains by students in the face-to-face science sample and the online sample were compared using EOCT scores for physical science. The following RQs were addressed:

1. Is there a significant difference in assessed achievement, based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning?
2. Are there significant differences in assessed achievement, based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning, and based on variables such as gender, grade level, and ethnicity?
3. Are there significant differences in assessed achievement, based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning based on physical science domain?
4. What explanations will teachers provide if differences in learning outcomes are indicated?

Research Design

This study used a quasi-experimental approach to answer three RQs using quantitative methods. A forth RQ was implemented to add a reflective approach to the discussion of the quantitative findings. The study, descriptive in design for comparison learning outcomes, was possible by using student cases from a single school district. The district-wide online program consisted of mostly core classes, such as English, math and science. Students' online enrollment was part of students' regular in-school schedule. Physical science was available for online and face-to-face enrollment. The two student enrollment groups were the source of the archived student data obtained for this study. The archived student data was requested at the district level for county-wide sample inclusion. From the archived data, participant grouping was determined by pooling groups based on the two instructional models, that is, face-to-face and online learning. Participant groups were formed by the inclusion of all students who completed the physical science course and then took the EOCT. Data samples were from the 2012-2013 and 2013-2014 two school years.

An online survey targeted teacher participants. Teachers with experience teaching face-to-face and online science classes were solicited to complete a 10-item survey. The volunteer teachers were solicited from the same school program that had provided the student cases. The first survey item required the participants to provide informed consent, and the second survey item asked for background information. Items 3 and 4 were open-ended questions that asked for participants' specific input on science content. Items 6 to 10 on the open-ended survey were derived from the analysis of the archival data.

Participants

The context for this study was a metropolitan area in Georgia. Pooled groups from the selected Georgia district accounted for countywide participants. Approximately 3,000 high school students completed physical science and scored on the physical science EOCT during the 2012-2013 and 2013-2014 school years. Nearly 6,000 students formed two key groups for this study, namely, an online group of approximately 600 student scores and a face-to-face group of approximately 6,400 student scores. Physical science is a high school credit course and is one of three online or face-to-face science courses that students select to meet the academic requirements for high school graduation.

The survey participants were teachers pooled from the same schools that were the source of the student data. Survey participants, all of whom were volunteers, were solicited for input using school directories and school websites. School principals were contacted initially via e-mail with a request for science teachers to participate anonymously. The e-mail message included the online survey link that the principals could forward to the science teachers. Their collective input provided a deeper understanding of the quantitative comparison findings.

Pilot Study

The pilot study for this investigation used 2011-2012 data. The pilot study was instrumental in determining the overall feasibility of conducting a larger scale study. This exploratory investigation compared the content gains of county-wide participant groups. The statistical comparison of the physical science EOCT scores indicated no significant differences in learning outcomes. Findings from *t* tests indicated some pattern differences in passing benchmarks scores for grade levels (see Table 5). Comparisons of the pilot Grade 10 and Grade 11 levels for two content domain stains indicated two significant differences in student scores.

Table 5

Descriptive Statistics: Means of Physical Science EOCT

Grade level	Face-to face	Online
9	385 (below passing benchmark)	393
10	418	375
11	408	400 (meets passing benchmark)
12	427	408 (above passing benchmark)
All grade levels	413	396

Note. Adapted from L. Mozer & T. Chan (2012), A Comparison: Face-to-Face and Online Learning. Paper presented at 36th annual meeting of the Georgia Educational Research Association, Savannah, GA.

The mean scores for the face-to-face levels for Grades 10, 11, and 12 were above a score of 400, the minimum score for “Meets Expectations.” This pattern prompted additional testing of learning gains of each content strain. The additional *t* tests compared grade levels and learning gains in each science domain strain. Results indicated significant differences at two levels, Grade 10 and Grade 11. These scores favored student achievement for the face-to-face group.

The Grade 10 online group had a mean score of 6.37; the Grade 10 face-to-face group had a mean score of 8.99. This significant difference of $p = .036$ between the two groups indicated higher achievement by the face-to-face group in chemistry (atomic). A significant difference in student achievement also was indicated in physics (waves). The Grade 11 face-to-face group had a mean score at 7.76; the Grade 11 online group had a mean score at 7.50, a significant difference of $p = .046$. At the Grade 9 level, only a small sample of data was available for the online group, so the statistical analysis of the four domains was not considered reliable for the purpose of the pilot study (see Tables 6 & 7).

Table 6

Descriptive Statistics: Online, Means of Physical Science EOCT Domains

Domain strain	Raw max	Grade level			
		9	10	11	12
Chemistry (1)	15	7.67	6.36	9.17	8.53
Chemistry (2)	12	6.67	6.51	6.17	6.80
Physics (1)	13	7.00	6.55	6.75	8.67
Physics (2)	13	6.33	6.00	7.50	8.67

Note. Adapted from L. Mozer & T. Chan (2012), A Comparison: Face-to-Face and Online Learning. Paper presented at 36th annual meeting of the Georgia Educational Research Association, Savannah, GA.

Table 7

Descriptive Statistics: Face-to-Face, Means of Physical Science EOCT Domains

Domain strain	Raw max	Grade level			
		9	10	11	12
Chemistry (1)	15	6.96	8.99	8.54	9.64
Chemistry (2)	12	6.30	8.14	7.70	8.75
Physics (1)	13	6.65	8.30	7.64	8.62
Physics (2)	13	6.53	8.38	7.67	8.42

Note. Adapted from L. Mozer & T. Chan (2012), A Comparison: Face-to-Face and Online Learning. Paper presented at 36th annual meeting of the Georgia Educational Research Association, Savannah, GA.

Instrumentation

According to the GaDOE (2015), the EOCT was aligned with Georgia curriculum standards and was a reliable assessment of physical science content knowledge. As a content assessment, the EOCT served as a diagnostic tool used to identify student performance strengths and weaknesses in learning (GaDOE, 2015). The EOCT was administered from 2012 to 2014, the period of this investigation. The physical science EOCT test score was averaged into the course grade at a weight of 15% of a final course grade. According to the GaDOE, the EOCT assessment was a valued reflection of student achievement for the period of this study. EOCT tests provided scores that reflected student achievement levels and were based on internal consistency measures using Kuder-Richardson 20 (KR-20). Based on the assumption that use of the KR-20 by the state of Georgia provided reliable results, this investigation assumed that the assessment results reflected students' content achievement. The study used the EOCT data to measure learning outcomes for all four content domains of physical science.

Each of the four EOCT strains had a maximum raw score value: Chemistry: Atomic and Nuclear Theory and Periodic Table, a raw score of 15; Chemistry: Chemical Reactions and Properties of Matter, a raw score of 12; Physics: Energy, Force, and Motion, a raw score of 13; and Physics: Waves, Electricity, and Magnetism, a raw score of 10. In addition to seeking a general overview of learning outcomes in physical science, learning outcomes in the four domains of physical science were examined The EOCT had scaled scores (see Table 8): below 400-Does Not Meet Expectations, 400 to 449-Meets Expectations, and scores at/or above 450-Exceeds Expectations.

Table 8

Physical Science Pilot Study EOCT Score Scale

Descriptors	Scores
Does not meet expectations	Below 400
Meets expectation	400-449
Exceeds expectations	450 and Higher

Although the full study resembled part of the pilot study, the follow-up online teacher survey was not part of the pilot study. The online survey, formatted as a web-based instrument, was used to collect data from the teachers anonymously. No identifiable data or information was collected (e.g., name, date of birth, identification number, mailing address, e-mail address, etc.). Online and face-to-face physical science teachers from the same school program were solicited via e-mail to be volunteer participants. The e-mail message contained a link to the online survey. Participants were experienced in teaching in both online and face-to-face learning environments. The teacher narratives from the survey provided inside classroom perspectives of the quantitative findings. All participants responded to the same online survey items.

Data Collection

Two IRB applications were obtained to collect the data. The student assessment data were obtained by an IRB application required by the school program. The submitted application required an approved version of Chapters 1, 2, and 3 of this study. Data requested for this study included student demographics (i.e., gender, grade level, and ethnicity) and EOCT scores for physical science. Data from 2012, 2013, and 2014 were requested. The data cases were students enrolled in online or face-to-face physical science courses. The EOCT was implemented from 2011 to 2014, but not in 2015. Georgia adopted a different assessment in 2015.

The researcher's university school program IRB application from the 2012 pilot investigation was renewed for this study. The university IRB required a copy of the online survey and a participant consent form. The online survey consent page required permission (i.e., an online yes or no response) from each participating teacher for their data to be collected anonymously. The yes response allowed the participant to take the online survey. Once the IRB requirements were completed, teachers were solicited to participate in the teacher survey.

Teachers were solicited with the use of school program contact directories. High school principals were initially contacted via e-mail, as required by school protocols. The nature of the survey was explained in the e-mail message sent to principals, requesting each principal to forward the enclosed survey link to individual teachers.

The 10-item survey was derived from the assessment comparison findings. The survey used a contextualized data collection method with Likert-type scales and open-ended items. The teachers' responses to the online survey provided the narratives that were coded and analyzed. These narratives provided more descriptive interpretations of the statistical comparison findings.

Data Analysis

The EOCT scores were pooled into groups that were independent of each other. The two groups, namely, online and face-to-face learning environments, were defined by all cases available in the archived data. Multiple grouping was defined using the IVs of gender, grade level, and ethnicity.

A quantitative comparison of learning outcomes and EOCT scores between the online and face-to-face groups was possible using SPSS. An independent-samples *t* test was used to compare assessment scores and resulted in mean scores for each group. As defined by the DVs of learning environment, and the IVs, the *t* test and ANOVA comparison methods can indicate similarities and differences in mean scores that might be significant with a *p* value < .05 (American Psychological Association [APA], 2010). Statistical analyses using *t* tests can provide descriptive values that facilitate comparisons of learning outcomes using the scores of two independent groups (Field, 2007).

For comparisons of multiple variables, ANOVA testing was applied. Multiple testing, using *t* tests and ANOVA techniques, was used to compare scaled and raw EOCT scores. The IVs used for the comparisons were gender, grade level, and ethnicity. According to Glenn (2009), resulting layers of evidence can add credibility to the research by identifying statistical outcome differences and similarities between group variables. ANOVA analysis uncovered some similarities and some differences in the learning outcomes.

The follow-up qualitative method was implemented to include the teachers' interpretations of the comparison findings. The volunteer participants, all of whom had experience teaching in online and face-to-face learning environments, completed the online survey. Demographic data were limited to the number of years of teaching, and all other data collected from the survey targeted comparison findings. Participants provided survey responses that reflected their perceptions of the quantitative evidence. Likert-type items allowed the teachers to rate content strain difficulty, and open-ended items required the teachers to respond in reflective narratives regarding specific findings. The survey and the comparison comprised the investigation approach taken to conduct the current study. According to Field (2007) and Glenn (2009), mixed methods research can yield new data not found in a quantitative-only research approach.

Content analysis is the process of organizing information into categories (Filed, 2007; Glenn, 2009). Similar to qualitative manual coding techniques used to sort and evaluate textual data, for this study, the survey data, a collection of unstructured responses to open-ended questions, along with the demographic descriptors, were coded using Dedoose. The researcher used Dedoose, web-based software application, to aggregate the scoring of the survey content narratives. The Dedoose analysis process generated systemic theme descriptors that are summarized in Chapter 4.

Summary

Together, the components presented in Chapter 3 comprised the methodology used to address the RQs. The data presented in Chapter 4 apply to each of the research questions, and the teachers' narratives. The principles of this investigation approach were implemented to bring new insight not anticipated or uncovered by prior research. The evidence found from the implemented approach methods and analyses of the teacher narratives and grouped comparisons are provided in Chapter 4 and further discussed in Chapter 5.

CHAPTER 4: FINDINGS

This chapter details the results of the data analysis. The statically compared archived assessment scores were obtained from a single high school education program. The data originated from the total population of high school students enrolled in physical science in a single school district who had completed physical science either online or in a traditional face-to-face class. The goal of the study was accomplished by addressing three RQs. The overall objective was to determine whether online learning and face-to-face learning environments had similar learning outcomes. The RQs also targeted learning outcomes; similarities and differences between the two learning environments for the four content strains of physical science; and sample demographics, including gender, grade level, and ethnicity.

Learning outcomes from students enrolled in physical science were measured by the physical science EOCT. Adoption of the physical science EOCT assessment provided an acceptable measurement of student learning gains. The EOCT scale scores and EOCT strain raw scores were considered representative of learning outcomes in physical science (see Table 9). According to the GPS, the EOCT assessments were aligned with Georgia's state-mandated content standards. SPSS independent-samples *t* tests were used to compare assessment scores and resulted in mean scores for the online and face-to-face groups. Comparison methods using *t* tests and ANOVA were used to compare the mean scores of multiple groups. Of the 54 comparison results, 31 of the findings identified significant differences ($p \leq .05$) between and among the compared groups. The significant difference value of $p \leq .05$ was used for this investigation of data, as recommended by the APA (2010).

Table 9

EOCT Benchmarks

Descriptors of learning gains	Scores
Does not meet expectations	Below 400
Meets expectation	400-449
Exceeds expectations	450 and Approve

Note. The EOCT scale scores range from 200 to 600.

Demographics for the Study

Physical science is a high school credit course that counts toward graduation. More than 6,000 high school students, approximately 3,140 in the 2012-2013 school year and 3,100 in the 2013-2014 school year, completed physical science in the targeted education system. The student data for these students accounted for the approximately 6,000 assessment scores. The data sets reflected students who had enrolled and completed physical science and had taken the physical science EOCT.

Online and Face-to-Face Population

The data samples were pooled into two learning environments: online and face to face. These two groups served as the basis for the comparative analysis of learning outcomes. The online group totaled 236 student cases for the 2012-2013 school year and 818 student cases for the 2013-2014 school year. The face-to-face group totaled 2,907 student cases for the 2012-2013 school year and 2,286 for the 2013-2014 school year (see Table 10).

Table 10

Two Key Learning Environment Groups

Cases	2012-2013 school year	2013-2014 school year
Online cases	236	818
Face-to-face cases	2,907	2,286
Total cases	3,143	3,104

Gender

The reported gender in the data sample for 2013 totaled 1,485 female cases and 1,657 male cases. These gender groups were grouped further by learning environment. For 2013, the online male cases totaled 131, and the female online cases totaled 105. The online groups included reported female and male genders that accounted for 3,142 cases. The 2013 face-to-face data consisted of 1,526 male cases and 1,380 female cases, a total of 2,906 cases (see Table 11).

Table 11

Participant Data by School Year, Gender, and Learning Environment

Student cases (2013)	Online	Face-to-face	Total no. of cases
Both genders	236	2,906	3,142
Female	105	1,380	1,485
Male	131	1,526	1,657

Of the 2014 reported gender data, the female group totaled to 1,438 cases, and the male group totaled 1,666 cases. The 2014 online male cases totaled 425, and the online female cases totaled 393. The face-to-face male cases totaled 1,241 cases, and the female cases totaled 1,045 in 2014 (see Table 12).

Table 12

Participants by School Year, Gender, and Learning Environment

Student cases (2014)	Online	Face-to-face	Total no. of cases
Both genders	818	2,286	3,104
Female	393	1,045	1,438
Male	425	1,241	1,666

Ethnicities of Student Population

The ethnicity of the students initially fell into six categories: African American, Asian American, European American, Latino American, Native American, and Multiracial. The limited number of ethnic student cases (< 10 Native American and Multiracial cases) was not included in the comparison data analysis. The largest ethnic group, African American, totaled 2,513 (80%) of all 3,143 cases. The Asian American group totaled 162 (5%), the Hispanic American group totaled 312 (10%), and the European American group totaled 100 (3%) of all cases for 2013 (see Table 13).

Table 13

2013 Ethnicity and Learning Environment

Ethnic category	Online	Face-to-face	Total no. of cases	% of cases
Asian American	9	153	162	5%
African American	135	2,378	2,513	80%
Hispanic American	78	234	312	10%
Native American	1	1	2	.06%
European American	10	90	100	3%
Multiracial	3	51	54	2%
Total	236	2,907	3,143	100%

The 2014 data were obtained from 2,483 African American cases, which comprised 79% of the total number of 3,103 cases. The Asian American group totaled 145 (5%), the Hispanic American group totaled 330 (11%), the European American group totaled 99 (3%), and the Multiracial group made up 30 (1.3%) of total cases for

2014 (see Table 14). The reported cases of Native Americans were not included for the comparison analyses.

Table 14

2014 Ethnicity and Learning Environment

Ethnic category	Online	Face-to-face	Total no. of cases	% of cases
Asian American	50	95	145	5%
African American	731	1,752	2,483	79%
Hispanic American	23	307	330	11%
Native American	1	6	7	.2%
European American	6	93	99	3%
Multiracial	7	32	39	1.3%
Total	818	2,285	3,103*	100%

Note. *One case did not identify an identity and was not included in the analysis.

High School Levels

The pooled samples showed that most students completed physical science in Grade 10. The online and face-to-face cases totaled 669 for the Grade 10 group in 2013 (see Table 15). Fewer cases were counted for the other grade levels: 266 for Grade 9, 110 for Grade 11, and 75 for Grade 12. Reported grade-level data were missing for five cases, so the total number of cases for 2013 was 3,103.

Table 15

2013 Participants by Year, Grade, and Group Environment

Group	High school grade level				Group totals
	Grade 9	Grade 10	Grade 11	Grade 12	
Online	73	90	42	26	231
Face-to-face	193	596	88	57	2,907
Total per level	266	669	110	75	3,143*

Note. *Five cases in the online group did not included grade level data, and four cases in the face-to-face group were not included in analysis because of missing indicators of grade levels.

The case samples also showed that in 2014, most students completed physical science in Grade 10. The online and face-to-face cases totaled 1,983 for the Grade 10 group in 2014. Grade 9 had 593 cases, Grade 11 had 346 cases, and Grade 12 had 178 cases. Data for two online cases and two face-to-face cases could not be identified by grade level, so the total number of cases for 2014 was 3,100 (see Table 16).

Table 16

2014 Participants by Year, Grade, and Group Environment

Group	High school grade level				Group totals
	Grade 9	Grade 10	Grade 11	Grade 12	
Online	134	481	103	98	818*
Face-to-face	459	1,502	243	80	2,286*
Total per level	593	1,983	346	178	3,104

Note. *Two cases in the face-to-face groups did not include grade level data. Two cases in the online groups were also missing grade level data. Cases with missing items were not included in the analysis.

Research Question 1

Is there a significant difference in assessed achievement, based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning? The EOCT scale scores of the online students and the face-to-face students were compared using an independent-samples *t* test. The EOCT scale scores were calculated to determine the group mean scores for the online and the face-to-face cases for 2013 and 2014. The *t* tests comparing learning outcomes for the online and face-to-face groups for all 2013 and 2014 cases did not show a significant difference. The 2013 analysis showed that the EOCT mean scale scores between the online and face-to-face learning groups were not significantly different. The online group had a mean score of 421.30, and the face-to-face group had a mean score of 417.57. The 2014 comparison between the same two groups did not show a significant difference in learning outcomes. The online group's mean score was 414.61, and the face-to-face group's mean score was 419.28, indicating no significant difference (see Table 17).

Table 17

Mean Scale EOCT Scores of Key Groups, Online and Face-to-Face

	Learning environment				
School year	Online	Face-to-face	Sig	*t*	*df*
2013	421.30	417.57	.441	-1.176	3141
2014	414.61	419.28	.648	2.468	3102

Note. No significant difference equals $p \leq .05$.

Research Question 2

Are there significant differences in assessed achievement based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning, and based on variables such as gender, grade level, and ethnicity? To answer RQ2, *t*-tests and ANOVA analyses were used to compare groups' EOCT scale scores. Of the eight statistical comparisons of female and male cases, the analysis indicated one significant difference in learning outcomes.

Gender. The gender analysis of the 2013 data comparing online male cases and female cases indicated no significant difference in learning outcomes, as indicated by the EOCT scale scores (see Table 18). The 2013 online female group had a mean score of 419.03, and the male group had a mean score of 423.14, indicating no significant difference. significant difference.

Table 18

2013 Genders, Online

Gender	EOCT (*M*)	Sig	*t*	*df*
		.151	.720	234
Female	419.03			
Male	423.14			

The comparison analysis of online 2014 data between male and female cases resulted in no significant difference. The online female group had a mean score of 411.34, and the online male group had a mean score of 417.163 (see Table 19).

Table 19

2014 Genders, Online

Gender	EOCT (*M*)	Sig	*t*	*df*
		.515	1,926	816
Female	411.34			
Male	417.63			

The 2013 face-to-face learning outcomes comparison between female and male cases resulted in a highly significant difference ($p \leq .001$). The face-to-face female group had a mean score of 416.81, which was lower than the face-to-face male group's mean score of 418.28 (see Table 20).

Table 20

2013 Genders, Face-to-Face

Gender	EOCT (*M*)	Sig	*t*	*df*
		.001*	.838	2904
Female	416.81			
Male	418.28			

**Note*. Highly significant difference $p = .001$

The 2014 comparison between the face-to-face female and male groups resulted in no significant difference. The face-to-face female group had a mean score of 419.13, and the face-to-face male group had a mean score of 419.45 (see Table 21).

Table 21

2014 Genders, Face-to-Face

Gender	EOCT (*M*)	Sig	*t*	*df*
		.065	-.166	2284
Female	419.13			
Male	419.45			

The 2013 and 2014 data were analyzed to compare the EOCT scale scores of the online female group and the face-to-face female group. Results of the analysis did not indicate a significant difference in learning outcomes between the two female groups (see Table 22).

Table 22

Female Gender, Online and Face-to-Face

Year	EOCT (*M*)				
	Online	Face-to-face	Sig	*t*	*df*
2013	419.03	416.78	.363	-.502	1484
2014	411.34	419.45	.998	3.053	1436

The 2013 and 2014 comparisons of EOCT scale scores between the online male group and the face-to-face male group did not indicate significant differences in learning outcomes (see Table 23).

Table 23

Male Gender, Online and Face-to-Face

Year	EOCT (*M*)				
	Online	Face-to-face	Sig	*t*	*df*
2013	423.14	418.28	.606	-1.081	1655
2014	417.63	419.13	.608	.556	1664

Grade Level. To further address RQ2 for the IV of grade level, an ANOVA analysis was conducted to compare 2013 and 2014 learning outcomes and learning environments. The findings indicated significant differences ($p \leq .05$) among the high school grade-level groups for 2013 and 2014 cases. In 2013, the highest mean score, 444.04, belonged to the online Grade 12 group (see Table 24), and the lowest mean score belonged to the online Grade 10 group. Results of the ANOVA analysis also showed that the highest EOCT maximum scale score, 573, belonged to the online Grade 12 group and the lowest minimum scale score, 322, belonged to the online Grade 10 group. These scores among all 2013 online grade levels indicated a significant difference of $p = .013$ (see Table 25).).

Table 24

2013 Online Grade Levels – Descriptive Statistics: EOCT Scores

Grade	*n*	*M*	*SD*	Min	Max
9	73	423.34	39.27	333	503
10	90	416.83	43.45	322	536
11	42	417.95	42.53	350	527
12	26	444.04	49.45	350	573

Table 25

2013 Online Grade Levels: ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	23657.82	4	5914.45	3.25	.013*

**Note.* Significant difference (p = .013).

The significant difference, p = .013, in the online groups based on grade level was followed by a second analysis of the learning outcome using the ANOVA post hoc test. The 2013 post hoc test results indicated significant differences in learning outcomes between the online Grade 10 and Grade 12 groups. The significant difference of p = .021 was between these two online grade level groups only. The post hoc analysis results were organized in groups. Group 1 was Asian American, Group 2 was African American, Group 3 was Hispanic American, Group 5 was European American, and Group 6 was Multiracial. Group 4, Native American, was excluded because few or no data cases were available for statistical comparison (see Table 26).

Table 26

2013 Post Hoc Test, Online Grade-Level Groups

(I) GradeLEVEL	(J) GradeLEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
9.00	10.00	6.97168	6.74731	.730	-10.4920	24.4354
	11.00	5.39008	8.27546	.915	-16.0289	26.8090
	12.00	-20.69600	9.75886	.150	-45.9543	4.5623
10.00	9.00	-6.97168	6.74731	.730	-24.4354	10.4920
	11.00	-1.58159	7.99918	.997	-22.2854	19.1223
	12.00	-27.66768*	9.52569	.021	-52.3225	-3.0128
11.00	9.00	-5.39008	8.27546	.915	-26.8090	16.0289
	10.00	1.58159	7.99918	.997	-19.1223	22.2854
	12.00	-26.08608	10.66283	.071	-53.6841	1.5120
12.00	9.00	20.69600	9.75886	.150	-4.5623	45.9543
	10.00	27.66768*	9.52569	.021	3.0128	52.3225
	11.00	26.08608	10.66283	.071	-1.5120	53.6841

The face-to-face Grade 9 group had the lowest mean score, 397.05. The face-to-face Grade 12 group had the highest mean score, 430.56. The lowest minimum EOCT scale score, 200, belonged to the face-to-face Grade 9 group. The highest maximum scale score, 648, belonged to the face-to-face Grade 10 group. The face-to-face Grade 10 group had a mean score of 419.25. This score was significantly different, $p = .030$, from the higher mean score, 426.22, of the face-to-face Grade 12 group (see Table 27). The ANOVA analysis of the 2013 face-to-face grade-level data showed a highly significant difference of $p = .000$ (see Table 28).

Table 27

2013 Face-to-Face Grade Levels – Descriptive Statistics: EOCT Scores

Grade	*n*	*M*	*SD*	Min	Max
9	384	397.05	47.31	200	602
10	2072	419.25	45.60	242	648
11	314	426.22	52.11	294	602
12	133	430.56	43.12	326	535

Table 28

2013 Face-to-Face Grade Levels – ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	214024.13	4	53506.03	3.25	.000*

**Note.* A highly significant difference (p = .000).

These 2013 findings for the face-to-face comparisons were followed with a post hoc test. The additional analysis indicated a highly significant difference, p = .000, between the face-to-face Grade 9 group's learning outcomes and the learning outcomes of the other three face-to-face grade-level groups. The Grade 9 group had a mean score of 397.05, which was a significant difference, p = .000, from the higher mean scores of the Grade 10, 11, and 12 groups. Results also indicated a significant difference between the face-to-face Grade 10 group's learning outcomes and the face-to-face Grade 12 group's learning outcomes (see Table 29).

Table 29

2013 Post Hoc Test, Face-to-Face Grade Level Groups

(I) GradeLEVEL	(J) GradeLEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
9.00	10.00	-22.55954*	2.58097	.000	-29.1940	-15.9251
	11.00	-29.53102*	3.53267	.000	-38.6118	-20.4502
	12.00	-33.87200*	4.67036	.000	-45.8773	-21.8667
10.00	9.00	22.55954*	2.58097	.000	15.9251	29.1940
	11.00	-6.97148	2.81013	.063	-14.1950	.2520
	12.00	-11.31246*	4.15083	.033	-21.9823	-.6427
11.00	9.00	29.53102*	3.53267	.000	20.4502	38.6118
	10.00	6.97148	2.81013	.063	-.2520	14.1950
	12.00	-4.34098	4.80080	.803	-16.6816	7.9996
12.00	9.00	33.87200*	4.67036	.000	21.8667	45.8773
	10.00	11.31246*	4.15083	.033	.6427	21.9823
	11.00	4.34098	4.80080	.803	-7.9996	16.6816

Analysis of the online 2014 grade-level cases using the ANOVA results indicated a highly significant difference, p = .000, in learning output. The online Grade 9 group had the lowest mean score, 386.13. The online Grade 12 group had the highest mean score, 422.65. The lowest minimum EOCT scale score, 266, belonged to the online Grade 10 group, and the highest maximum scale score, 622, belonged to the online Grade 10 group (see Tables 30 & 31).

Table 30

2014 Online Grade Levels – Descriptive Statistics: EOCT Scores

Grade	*n*	*M*	*SD*	Min	Max
9	134	386.13	36.78	300	496
10	481	419.63	46.54	266	622
11	103	420.25	44.24	332	561
12	98	422.65	49.31	321	543

Table 31

2014 Online Grade Levels – ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	130969.91	4	32742.48	16.08	.000*

Note. A highly significant difference (p = .000)

The 2014 ANOVA online comparison findings were followed by a post hoc test. Results of the additional layered analysis of the 2014 grade-level cases indicated a highly significant difference, p = .000, between the online Grade 9 group and the online Grade 10, Grade 11, and Grade 12 groups (see Table 32).

Table 32

2014 Post Hoc Test, Online Grade Level Groups

(I) GradeLEVEL	(J) GradeLEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
9.00	10.00	-33.49891*	4.40901	.000	-45.5528	-21.4450
	11.00	-34.38294*	5.93106	.000	-50.5980	-18.1679
	12.00	-36.52620*	5.99939	.000	-52.9280	-20.1244
	99.00	-44.87313	32.15369	.631	-132.7786	43.0324
10.00	9.00	33.49891*	4.40901	.000	21.4450	45.5528
	11.00	-.88402	4.92029	1.000	-14.3357	12.5676
	12.00	-3.02728	5.00245	.974	-16.7036	10.6490
	99.00	-11.37422	31.98267	.997	-98.8122	76.0637
11.00	9.00	34.38294*	5.93106	.000	18.1679	50.5980
	10.00	.88402	4.92029	1.000	-12.5676	14.3357
	12.00	-2.14326	6.38455	.997	-19.5981	15.3116
	99.00	-10.49020	32.22778	.998	-98.5982	77.6179
12.00	9.00	36.52620*	5.99939	.000	20.1244	52.9280
	10.00	3.02728	5.00245	.974	-10.6490	16.7036
	11.00	2.14326	6.38455	.997	-15.3116	19.5981
	99.00	-8.34694	32.24042	.999	-96.4896	79.7957

Comparison findings for the 2014 face-to-face ANOVA analysis also showed a highly significant difference, $p = .000$, in mean scores among grade levels. The face-to-face Grade 9 group had the lowest mean score, 396.03. The highest mean score, 437.00, belonged to the face-to-face Grade 12 group. The lowest EOCT scale score, 285, belonged to the face-to-face Grade 9 group. The highest maximum score, 692, belonged to the face-to-face Grade 10 group (see Tables 33 & 34).

Table 33

2014 Face-to-Face Grade Levels – Descriptive Statistics: EOCT Scores

Grade	*n*	*M*	*SD*	Min	Max
9	459	396.03	41.37	285	535
10	1,502	423.43	45.57	294	692
11	243	431.90	47.55	320	620
12	80	437.00	38.88	358	543

Table 34

2014 Face-to-Face Grade Levels – ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	345161.72	4	86290.43	16.08	.000*

* *Note.* A highly significant difference (p = .000).

The 2014 face-to-face comparisons were followed by a post hoc test. Findings indicated significant differences, p = .000 and p = .030, in learning outcomes. Between the face-to-face Grade 9 group and the face-to-face Grade 10, 11, and 12 groups, the significant difference was p = .000. Between the face-to-face Grade 10 and Grade 11 groups, the significant difference was p = .030 (see Table 35).

Table 35

2014 Post Hoc Test, Face-to-Face Grade Level Groups

(I) GradeLEVEL	(J) GradeLEVEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
9.00	10.00	-27.54890*	2.39144	.000	-33.6971	-21.4007
	11.00	-36.02623*	3.55132	.000	-45.1564	-26.8960
	12.00	-41.76250*	5.41990	.000	-55.6967	-27.8283
10.00	9.00	27.54890*	2.39144	.000	21.4007	33.6971
	11.00	-8.47734*	3.09226	.031	-16.4273	-.5273
	12.00	-14.21360*	5.13085	.029	-27.4047	-1.0225
11.00	9.00	36.02623*	3.55132	.000	26.8960	45.1564
	10.00	8.47734*	3.09226	.031	.5273	16.4273
	12.00	-5.73627	5.76354	.752	-20.5539	9.0814
12.00	9.00	41.76250*	5.41990	.000	27.8283	55.6967
	10.00	14.21360*	5.13085	.029	1.0225	27.4047
	11.00	5.73627	5.76354	.752	-9.0814	20.5539

To further examine the grade-level learning outcomes, post hoc testing was followed up by *t*-test analysis to compare 2013 online and face-to-face EOCT scale scores of each grade-level group. Each of these groups was analyzed using a *t* test to compare online and face-to-face assessed learning outcomes. The 2013 analysis of each grade level using *t* tests did not indicate any significant differences in learning outcomes between online and face-to-face groups (see Table 36). The online Grade 12 group had the highest mean score, 450.50. The face-to-face Grade 12 group had the highest face-to-face mean score, 449.76. No additional testing of the 2013 grade-level data followed these findings (see Table 36).

Table 36

2013 Online and Face-to-Face Comparison by Grade

Grade	EOCT scores (*M*)		Sig	*t*	*df*
	Online	*Face-to-face*			
9	423.34	401.33	.501	-3.52	264
10	421.04	419.63	.925	-.253	667
11	425.04	434.90	.122	.726	108
12	450.50	449.76	.172	-.598	73

Note. The *t* tests comparing each grades level groups between online and face-to-face showed no significant difference ($p \leq .05$).

For the 2014 analysis of the grade-level data, *t* tests were implemented to compare the EOCT scale scores of all online and face-to-face groups (i.e., Grades 9, 10, 11, and 12). The 2014 grade-level learning outcome comparisons between online and face-to-face groups indicated one significant difference. The online Grade 12 group had a mean score of 422.65, and the face-to-face Grade 12 group had a mean score of 437.64. The two mean scores were significantly different, $p = .022$ (see Table 37).

Table 37

2014 Online and Face-to-Face Comparison by Grade

Grade	EOCT scores (*M*)		Sig	*t*	*df*
	Online	*Face-to-face*			
9	386.13	396.03	.096	2.498	591
10	419.63	423.43	.641	1.587	1981
11	420.25	431.90	.392	2.126	344
12	422.65	437.64	.022*	2.213	176

**Note.* The Grade 12 *t*-test comparisons between online and face-to-face EOCT scale mean scores showed a significant difference $p = .022$

Ethnicity To address RQ2, the 2013 and 2014 data were further analyzed. EOCT scale scores, learning outcomes, between ethnic groups and learning environments were compared using ANOVA regression tools. The 2013 comparisons of online ethnic groups revealed a significant difference ($p \leq .05$) in mean scores for learning outcomes. The highest online mean score, 438.00, belonged to the Multiracial group. Among all the cases in the online groups, the highest maximum scale score, 573, belonged to the European American group, and the lowest minimum scale score, 322, belonged to the African American group. These results indicated a significant difference, $p = .010$, in the learning outcomes of the various ethnic groups (see Tables 38 & 39) (see Tables 38 & 39)

Table 38

2013 Ethnicity Groups, Online – Descriptive Statistics: EOCT Scores

Ethnicity	*n*	*M*	*SD*	Min	Max
Asian American	9	411.44	52.00	350	480
African American	135	413.14	20.33	322	527
Hispanic American	78	433.77	39.32	333	536
European American	10	434.60	64.16	364	573
Multiracial	3	438.00	62.01	374	562

Table 39

2013 Ethnicity Groups, Online – ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	589.691.63	4	6147.423	3.376	.010

Note. Significant difference ($p = .010$).

These findings prompted the use of a post hoc test. The post hoc analysis indicated which mean scores were significantly different by ethnic group. This follow-up post hoc test indicated the learning outcomes between Group 2, African American, and Group 3, Hispanic American, had a significant difference ($p = .007$). The ANOVA results (see Table 38) listed the mean score of 413.14 for Group 2 and the mean score of 433.77

for Group 3. The post hoc test did not indicate any other differences in learning outcomes between online ethnic groups (see Table 40).

Table 40

2013 Post Hoc Test, Online Ethnic Groups

(I) RACE	(J) RACE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.69630	14.68982	1.000	-42.0865	38.6939
	3.00	-22.32479	15.02153	.573	-63.6271	18.9775
	5.00	-23.15556	19.60554	.762	-77.0618	30.7507
	6.00	-26.55556	28.44671	.884	-104.7709	51.6598
2.00	1.00	1.69630	14.68982	1.000	-38.6939	42.0865
	3.00	-20.62849*	6.06874	.007	-37.3147	-3.9422
	5.00	-21.45926	13.98429	.541	-59.9096	16.9911
	6.00	-24.85926	24.90779	.856	-93.3442	43.6257
3.00	1.00	22.32479	15.02153	.573	-18.9775	63.6271
	2.00	20.62849*	6.06874	.007	3.9422	37.3147
	5.00	-.83077	14.33235	1.000	-40.2381	38.5766
	6.00	-4.23077	25.10486	1.000	-73.2576	64.7961
5.00	1.00	23.15556	19.60554	.762	-30.7507	77.0618
	2.00	21.45926	13.98429	.541	-16.9911	59.9096
	3.00	.83077	14.33235	1.000	-38.5766	40.2381
	6.00	-3.40000	28.08887	1.000	-80.6315	73.8315
6.00	1.00	26.55556	28.44671	.884	-51.6598	104.7709
	2.00	24.85926	24.90779	.856	-43.6257	93.3442
	3.00	4.23077	25.10486	1.000	-64.7961	73.2576
	5.00	3.40000	28.08887	1.000	-73.8315	80.6315

The ANOVA analysis of the 2013 face-to-face mean scores revealed a highly significant difference of p = .000 in learning outcomes between ethnic groups. Among the 2013 face-to-face ethnic cases, the highest mean score, 445.26, belonged to Group 5, European American, and the lowest mean score, 415.95, belonged to Group 2, African American. The 2013 face-to-face highest maximum scale score, 648, belonged to Group 2, African American, and the lowest minimum scale score, 200, also belonged to Group 2, African American. The ANOVA analysis of the 2013 face-to-face ethnic cases indicated a highly significant difference in learning outcomes among the five ethnic groups (see Tables 41 & 42).

Table 41

2013 Ethnicity Groups, Face-to-Face – Descriptive Statistics: EOCT Scores

Ethnicity	*n*	*M*	*SD*	Min	Max
Asian American	153	418.36	56.48	320	621
African American	2378	415.95	45.20	200	648
Hispanic American	234	418.76	49.44	300	552
European American	90	445.26	59.18	322	552
Multiracial	51	434.08	55.58	339	586

Table 42

2013 Ethnicity Groups, Face-to- Face – ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	103558.39	5	20711.68	9.42	.000*

**Note.* Highly significant difference (p = .000).

The follow-up post hoc test showed highly significant differences between Group 5, European American, and Group 1, Asian American, and between Group 5, European American, and Group 2, African American, and between Group 5, European American, and Group 3, Hispanic American, with $p = .000$. A significant difference, $p = .050$, was also found between Group 6, Multiracial, and Group 2, African American (see Table 43).

Table 43

2013 Post Hoc Test, Face-to-Face Ethnic Groups

(I) RACE	(J) RACE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	2.40742	3.91015	.973	-8.2653	13.0801
	3.00	-.39693	4.87417	1.000	-13.7010	12.9071
	5.00	-26.89608*	6.22781	.000	-43.8948	-9.8973
	6.00	-15.71895	7.58025	.232	-36.4092	4.9713
2.00	1.00	-2.40742	3.91015	.973	-13.0801	8.2653
	3.00	-2.80435	3.21197	.907	-11.5714	5.9627
	5.00	-29.30350*	5.03436	.000	-43.0448	-15.5622
	6.00	-18.12637*	6.63471	.050	-36.2358	-.0170
3.00	1.00	.39693	4.87417	1.000	-12.9071	13.7010
	2.00	2.80435	3.21197	.907	-5.9627	11.5714
	5.00	-26.49915*	5.81490	.000	-42.3709	-10.6274
	6.00	-15.32202	7.24484	.214	-35.0967	4.4527
5.00	1.00	26.89608*	6.22781	.000	9.8973	43.8948
	2.00	29.30350*	5.03436	.000	15.5622	43.0448
	3.00	26.49915*	5.81490	.000	10.6274	42.3709
	6.00	11.17712	8.21680	.653	-11.2506	33.6048
6.00	1.00	15.71895	7.58025	.232	-4.9713	36.4092
	2.00	18.12637*	6.63471	.050	.0170	36.2358
	3.00	15.32202	7.24484	.214	-4.4527	35.0967
	5.00	-11.17712	8.21680	.653	-33.6048	11.2506

Although the 2013 descriptive statistics for the online and face-to-face ethnic groups had significant differences, the results for the 2014 data were split. The ANOVA analysis for the online ethnic groups indicated no significant differences in learning outcomes (see Tables 44 & 45). In the 2014 results of the ANOVA test, significant differences were not found among the five ethnic groups, and no post hoc test was performed for the 2014 online ethnic group data.

Table 44

2014 Ethnicity Groups, Online – Descriptive Statistics: EOCT Scores

Ethnicity	*n*	*M*	*SD*	Min	Max
Asian American	50	407.54	59.48	326	622
African American	731	414.07	45.52	266	586
Hispanic American	23	430.74	52.15	321	543
European American	5	450.50	49.33	353	485
Multiracial	7	440.00	62.01	376	471

Table 45

2014 Ethnicity Groups, Online – ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	25041.63	5	4313.68	1.99	.079

Note. No significant difference.

The findings from the face-to-face 2014 ANOVA analysis of EOCT scale scores indicated a highly significant difference of p = .000 in learning outcomes among the ethnic groups. Group 5, European American, had the highest mean score, 449.76. The lowest mean score, 416.28, belonged to Group 1, Asian American. The highest maximum scale score, 692, belong to Group 3, Hispanic American, and the lowest minimum scale score, 285, also belonged to Group 3, Hispanic American (see Tables 46 & 47).

Table 46

2014 Ethnicity Groups, Face-to-Face – Descriptive Statistics: EOCT Scores

Ethnicity	*n*	*M*	*SD*	Min	Max
Asian American	95	416.29	52.93	308	543
African American	1752	417.53	45.49	293	620
Hispanic American	307	420.10	46.21	285	692
European American	93	449.76	46.37	343	562
Multiracial	32	429.84	35.84	338	508

Table 47

2014 Ethnicity Groups, Face-to- Face – ANOVA

	SS	*df*	*MS*	*F*	Sig
Between groups	97062.184	5	19412.448	9.22	.000*

**Note*. Highly significant difference of p = .000.

The follow-up post hoc test indicated highly significant differences in learning outcomes between Group 5, European American, and Groups 1, Asian American; 2, African American; and 3, Hispanic American (see Table 48).

Table 48

2014 Post Hoc Test, Face-to-Face Ethnic Groups

(I) Race	(J) Race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.24433	4.82786	.999	-14.4242	11.9356
	3.00	-3.81351	5.38062	.955	-18.5024	10.8754
	5.00	-34.12883*	6.70371	.000	-52.4297	-15.8279
	6.00	-13.55954	9.36732	.597	-39.1320	12.0129
2.00	1.00	1.24433	4.82786	.999	-11.9356	14.4242
	3.00	-2.56918	2.83558	.895	-10.3102	5.1719
	5.00	-32.88450*	4.90196	.000	-46.2667	-19.5023
	6.00	-12.31521	8.17534	.558	-34.6336	10.0032
3.00	1.00	3.81351	5.38062	.955	-10.8754	18.5024
	2.00	2.56918	2.83558	.895	-5.1719	10.3102
	5.00	-30.31532*	5.44720	.000	-45.1860	-15.4446
	6.00	-9.74603	8.51346	.783	-32.9875	13.4954
5.00	1.00	34.12883*	6.70371	.000	15.8279	52.4297
	2.00	32.88450*	4.90196	.000	19.5023	46.2667
	3.00	30.31532*	5.44720	.000	15.4446	45.1860
	6.00	20.56929	9.40572	.185	-5.1080	46.2466
6.00	1.00	13.55954	9.36732	.597	-12.0129	39.1320
	2.00	12.31521	8.17534	.558	-10.0032	34.6336
	3.00	9.74603	8.51346	.783	-13.4954	32.9875
	5.00	-20.56929	9.40572	.185	-46.2466	5.1080

To further address RQ2 and ethnicity, more *t* tests were used to compare learning outcomes represented by EOCT scores. Online and face-to-face scores for each ethnic group were compared using *t* tests. Results indicated a significant difference in learning outcomes between the two learning environments. The findings for Group 3, Hispanic American, resulted in a significant difference of $p = .007$ between the online group and the face-to-face group. The online Hispanic American group mean score of 433.7, when compared to the Hispanic American face-to-face mean score of 418.7, indicated a significant difference of *p* = .007 in learning outcomes (see Table 49).

Table 49

2013 t-*Test Comparison Results for Ethnic Groups, Online and Face-to-Face*

Ethnicity	EOCT scores (*M*)		Sig	*t*	*df*
	Online	Face-to-face			
Asian American	426.57	417.43	.835	.451	102
African American	413.37	415.86	.580	.530	706
Hispanic American	433.77	418.76	.007*	-2.36	310
European American	434.60	445.26	.995	.536	98
Multiracial	438.00	434.08	.056	1.113	52

**Note.* The Hispanic ethnic groups', online and face-to-face, comparison indicated a significant difference in learning outcomes between learning environments, online and face-to-face.

The 2014 comparison analysis using *t* tests for all online and face-to-face ethnic groups did not reveal any significant differences (see Table 50).

Table 50

2014 t-*Test Comparison Results for Ethnic Groups, Online and Face-to-Face*

Ethnicity	EOCT scores (*M*)		Sig	*t*	*df*
	Online	Face-to-face			
Asian American	414.18	416.71	.258	.095	23
African American	414.07	417.53	.375	1.727	2481
Hispanic American	430.73	420.10	.292	-1.056	328
European American	450.50	449.76	.577	-.038	97
Multiracial	440.57	429.84	.656	-.728	37

Note. No significant differences resulted from the 2014 single ethnic group comparisons between online and face-to-face groups.

Research Question 3

Are there significant differences in assessed achievement based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning based on physical science domain? To address RQ3, EOCT raw strain scores were analyzed. Comparisons of online and face-to-face data for each of the four content domains are presented here. The maximum EOCT raw score for Chemistry-One (Atomic and Nuclear Theory, and Periodic Table) was 15. The raw score for Chemistry-Two (Chemical Reactions, and Properties of Matter) was 12. The raw score for Physics-One (Energy, Force, and Motion) was 13, and the raw score for Physics-Two (Waves, Electricity, and Magnetism) was 10.

Content Strains The 2013 content strain domains were compared using *t* tests (see Table 51). The 2013 comparison analysis of content strains and learning environment, online or face to face, did not indicate any significant differences in learning outcomes. outcomes.

Table 51

2013 Online and Face-to-Face, and Domain Strains

Domain	Raw EOCT scores (*M*)		Sig	*t*	*df*
	Online	Face-to-face			
Chemistry One	8.84	8.77	.746	-.343	3141
Chemistry Two	8.73	8.53	.742	-.926	3141
Physics One	8.83	8.59	.134	-1.155	3141
Physics Two	8.96	8.62	.232	-1.670	3141

Note. Of the four *t* tests to compare 2013 domains, no significant differences were found between online and face-to-face learning environments

The 2014 content domains were compared using *t* tests (see Table 52), and these analyses between content strain and learning environment, online or face to face, did not indicate any significant differences in learning outcomes.

Table 52

2014 Online and Face-to-Face, and Domains Strains

Domain	Raw EOCT scores (*M*)		Sig	*t*	*df*
	Online	*Face-to-face*			
Chemistry One	8.67	8.93	.689	2.770	3102
Chemistry Two	8.22	8.45	.287	1.726	3102
Physics One	8.43	8.68	.193	1.944	3102
Physics Two	8.54	8.89	.556	-1.670	3141

Note. No significant differences.

Research Question 4

What explanations will teachers provide if differences in learning outcomes are indicated? This section is descriptive of the reflections expressed by the volunteer participants of the online teacher survey and the findings are summative of the teachers' interpretations of quantitative findings. The survey items were derived from the statistical descriptions in the quantitative comparison findings. Teachers with experience in online and face-to-face instruction consented to respond anonymously to the open-ended survey items. The survey data and the archival student data were from the same district program. The teacher input provided insight from inside the learning environments regarding learning outcomes.

During the process of developing the teacher survey, several significant wing values were mistaken for actual significant values, and the survey had to be amended and resent to each participant. Four survey items were corrected to reflect the archival data findings, and one item was dropped from the survey. The corrected questions formed the amended survey, and the summative results are presented next.

Item 1. This question solicited their signed consent to participate in the survey (see Appendix B)

Item 2. The survey item solicited the number of years of online and face-to-face teaching experience. Most of the participants had 3 years or less of experience teaching physical science either online or in a face-to-face learning environment (see Figure 3).

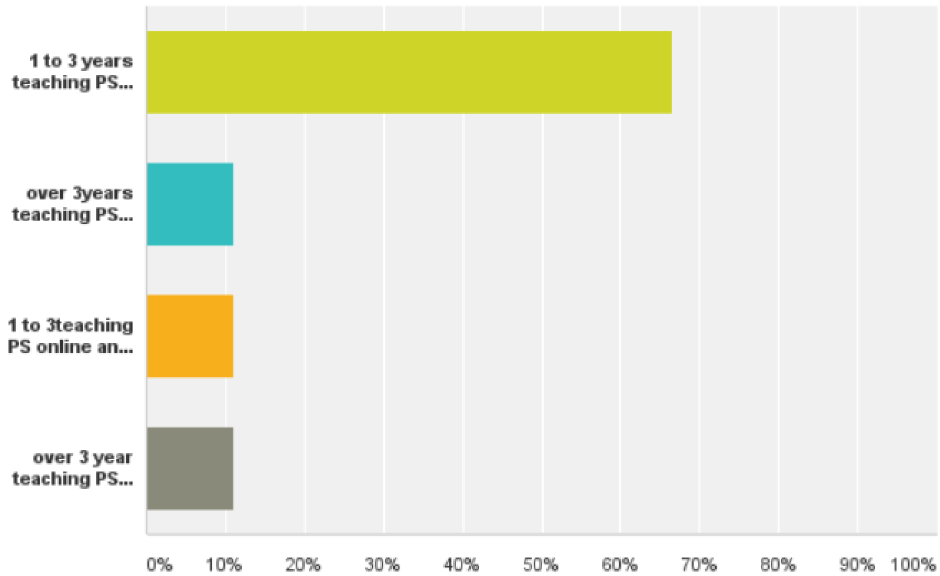

Figure 3. Years of teaching experience.

Item 3. When considering student learning in general: On a scale of 1 to 5, with 1 indicating *least difficult* and 5 indicating *most difficult*, please rate the overall difficulty students experience in learning physical science content in a traditional classroom (face-to-face). According to the responses (see Figure 4), physical science was considered moderately difficult to learn in the face-to-face learning environment.

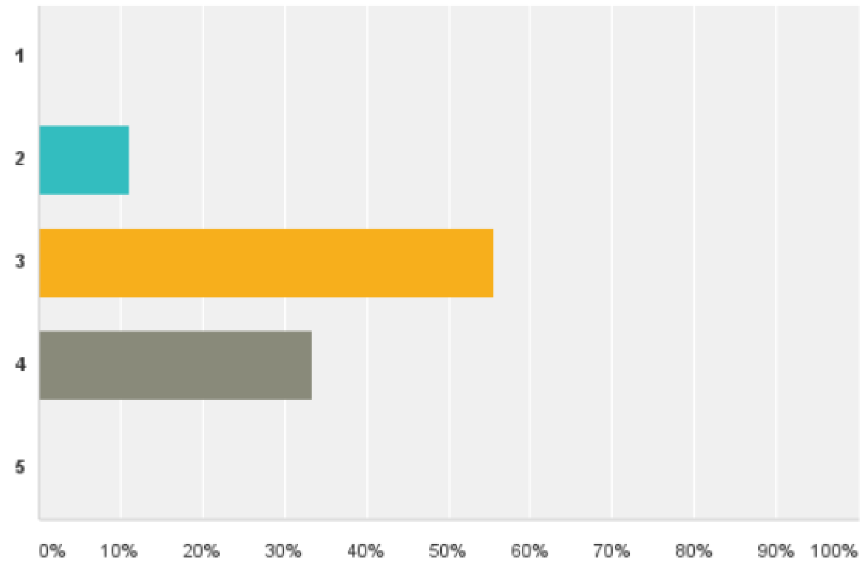

Figure 4. Physical science learning difficulty, face-to-face.

Item 4. When considering student learning in general: On a scale of 1 to 5, with 1 indicating *least difficult* and 5 indicating *most difficult*, please rate the overall difficulty students experience in learning physical science content in a virtual classroom (online). Physical science was rated as more difficult to learn in the online learning environment (see Figure 5).

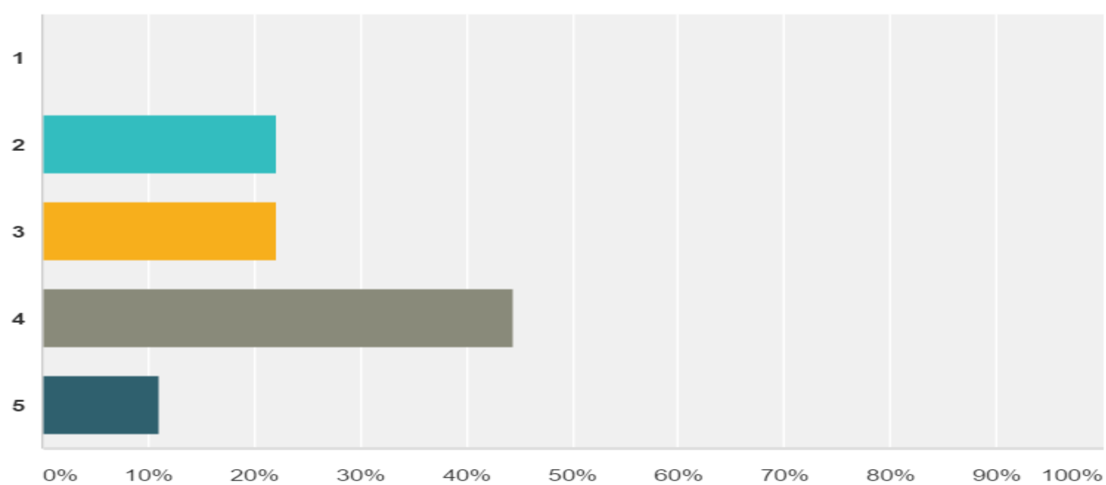

Figure 5. Physical science learning difficulty, online.

Item 5. If the four strains of physical science were placed in a blended model, which of the strains, or strain, would you recommend for online, which for face-to-face, and why?

The four physical science strains:

Chemistry: Atomic and Nuclear Theory, and Periodic Table

Chemistry: Chemical Reactions, and Properties of Matter

Physics: Energy, Force, and Motion

Physics: Waves, Electricity, and Magnetism

With the exception of Physics II, Waves, Electricity and Magnetism, the availability of visuals and ongoing access to content as key benefits of learning the science content domains online. Contrary to the perception of the Physics II domain, Chemistry I - Atomic and Nuclear Theory, was viewed as abstract and seen as the content that mostly required memorization. Physics II was recommended for face-to-face learning because the content was viewed as mostly hand-on labs and content learning tasks.

Item 6. This item was not an accurate reflection of the comparison data and was removed from the findings.

Item 7. This item was amended to accurately reflect the archival data. In 2013, the physical science EOCT mean scores of face-to-face male and female groups were significantly different. The male face-to-face group's mean score was 418.28. The female face-to-face group had a mean score of 416.81. This was a highly significant difference of $p = .001$. How would you explain this difference? The surveyed teachers indicated that female students experienced a less favorable face-to-face learning experience and that a positive online learning experience resulted from a background in technology use.

Item 8. This item was amended to accurately reflect the archival data. With the exception of Grade 12, 2014 data, there were no significant differences in the physical science EOCT mean scores between online and face-to-face groups for any of the grade-level comparisons. How would you account for these findings? The participants indicated that earlier high school years provided students with a background in the use of technology by the time student reach their 12th grade year in high school.

Item 9. This item was amended to accurately reflect the archival data. In 2014, the online Grade 12 group had a mean score of 422.65, and the face-to-face Grade 12 group had a mean score of 437.64. This was a significant difference of p = .002. How would you explain this? Participants indicated a perceived teacher bias for face-to-face content learning because of content familiarity and learning practices, such as student-to-teacher direct questions and students' hands-on learning activities.

Item 10. This item was amended to accurately reflect the archival data.

European American students scored significantly higher than other ethnic groups

How would you account for differences in ethnic learning outcomes? Participants indicated perceived low value of education, along with limitations in external support of education among the African American population.

Summary

The overall comparison between online and face-to-face students' EOCT physical science scores did not indicate a significant difference in student achievement, for 2013 or 2014. Further analyses of learning outcomes indicated that significant differences existed between several student groups. For 2013 face-to-face groups, males outperformed females (see Table 20). In 2013, online and face-to-face, 12th graders outperformed 10th graders (see Table 26). In 2013, face-to-face, 9th graders were outperformed by all higher grade levels. Online, in 2014, all higher grade levels significantly also outperformed 9th graders (see Table 32). Although African American students were the dominant student population, online and face-to-face, the 2013 online learning outcomes showed Hispanic American ahead in performance. In 2013 and 2014 all face-to-face ethnic groups performed lower than European American group (see Table 43 & 48). The only significant difference between online and face-to-face learning environments was between the online Hispanic American group and the face-to-face Hispanic American, which indicated a higher performance in the online learning environment (see Table 49).

Summary of the Significant Findings

Findings presented in this chapter are the result of 38 *t* tests, eight ANOVA tests, and seven post hoc tests. Of the 38 *t* tests, three findings were significant, and of these three differences one significant finding was between learning environments. Of the eight ANOVA tests, the results indicated seven significant differences in learning outcomes among grade level and ethnic group comparisons. The post hoc tests further examined these analyses and indicated 21 significant differences (see Tables 26, 29, 32, 35, 40, 43, & 48). A total of 31 significant differences were revealed.

Significant difference in gender:

1 – 2013 *t* test face-to-face (see Table 20).

Significant differences in grade level indicated by:

2 - ANOVA findings for 2013 (online and face-to-face, see Tables 24, 25, 27, & 28)

2 - ANOVA findings for 2014 (online and face-to-face, see Tables 30, 31, 33, & 34)

1 - 2013 post hoc, online (see Table 26)

4 - 2013 post hoc, face-to-face (see Table 29)

3 – 2014 post hoc, online groups (see Table 32)

5 – 2014 post hoc, face-to-face (see Table 35)

1- 2014 *t* test, online versus face-to-face (only Grade 12 groups, see Table 37)

Significant differences among ethnic groups:

2 - ANOVA findings for 2013 (online and face-to-face, see Tables 38, 39, 41, & 42)

1 - 2013 post hoc, online (see Table 40)

4 - 2013 post hoc, face-to-face (see Table 43)

1 - ANOVA findings for 2014 (face-to-face, see Table 46)

3 – 2014 post hoc, face-to-face (see Table 48)

1 – *t* test 2013 online versus face-to-face (see Table 49)

These comparison tests were possible with the use of 6,247 cases from two school years, 2012-2013 and 2013-2014, of student data. The key comparison groups were the 1,054 online cases and the 5,193 face-to-face cases, as well as the reported female and male gender groups, 2923 females and 3323 males, respectively. Comparisons between these large student groups were complemented with comparisons between the four high school grade level groups and five ethnic groups. The predominant ethnic group, 80% of the total cases, was African American; the European American group made up less than 4% of the total cases.

The final statistical analysis between online and face-to-face groups examined the learning output for each of the four physical science content domains; however, these comparisons did not reveal any significant differences in learning output between learning environments. Findings from the contextual analyses of the online teacher survey responses were synthesized to provide an inside-the-classroom perspective of student achievement in both learning environments. The combined findings from the statistical comparisons and the teacher survey served as evidence for the interpretation of the analyses presented in Chapter 5.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

This chapter provides a discussion of the evidence described in Chapter Four. The focus of this discussion targets the significant findings that resulted from addressing the four research questions and the purpose of the study. These interpretations reflect some claims by available prior comparison investigations. Evidence of similarities and differences in learning outcomes between two learning environments presented here provided insight to science pedagogy not available prior to this study. In addition to the discussion of quantitative descriptive statistical findings, discussion of a qualitative approach to further reflect on the comparison analyses is presented here. Teacher interpretations provided contextual narratives in Chapter Four, and are further synthesized in this chapter.

Online and Face-to-Face Overall

Overall finding indicated that student performance in the two learning environments was similar. This study showed that between the two key comparisons, the online student group and the face-to-face student group, for both years of data, 2013 and 2014, findings did not indicate significant differences in the EOCT mean scores (see Table 10). Previous comparison research has also indicated that learning outcomes of online and traditional face-to-face K-12 student achievement was similar (C. Cavanaugh et al., 2004; R. Clark, 1994: Nguyen, 2015). Prior research targeting K-12 online learning environments has also indicated differences. According to Molnar et al., (2015), K-12 students enrolled in full-time K-12 online learning environments had lower performance when compared to their face-to-face counterparts, Prior research has also brought into question the learning factors that influence learning outcomes not identified in overall comparisons of student achievement. According to research looking at supplemental K-12 online learning courses, student enrollment tended to be a selective group of students, as in motivated to learn, self-directed and independent learners, with interest in technology and good computer skills. (Molnar et al., 2015).

The overall equality in learning outcomes indicated by this investication is important. The results of the overall study comparison indicated that online learning was not harmful to student achievement for the overall student program population.

Content and Demographics

The student population for this comparison study consisted of students enrolled in a traditional school, and enrolled in an online physical science course. Data was not provided as to whether students enrolled in other classes also available online, and data was not collected on the student population enrolled in more advanced science classes, such as physics and or AP chemistry. The student cases used in this study belong to a diverse district population, with 37% of the K12 student population being African American, 42% white American, 13% being Hispanic and the remainder being multi-racial or other ethnicities. Sixty-two percent of the K-12 district student population was eligible for free or reduced lunch. The student population of this study was largely African American, nearly 79% for both years of data. These numbers imply that African American students were likely to enroll in physical science. Beyond the overall comparisons implemented for this study, the analyses inclusive of demographic variables, gender, grade level, and ethnicity, uncovered multiple significant differences in learning outcomes.

Gender. Research at the university level has indicated learning influences can include demographic factors such as gender, age, and ethnicity (USDoE, 2013). The learning of outcomes between female and male students from the face-to-face groups indicated a highly significant difference in student achievement for a single year, 2013 (see Table 20). This lower 2013 face-to-face student performance by female students was only identified in one of the two years of data, and only the face-to-face learning environment indicated a significant difference in learning outcomes between female and males genders. Although Clark (1994) proposed that the medium does not influence learning, it may be that the online environment is a better learning environment for girls. Conversely the imbalance of genders in STEM professions, makes this outcome for even a single year in secondary physical science is cause for concern.

In the debate over the influence of the online media (Clark, 2001, Kozma 1994), these learning outcomes lend support to Kozma (1994) and the idea that specific student learning characteristics could favor one learning environment over another. The teacher survey narratives accounted for the gender imbalance, as summarized in Chapter Four, as related to a less favorable traditional face-to-face classroom experience for female students (see Item 7). An explanation of what a less favorable learning experience may entail, was not provided in the teacher narratives for discussion. The evidence, for 2013, stands that female students in their face-to-face science classrooms did not have the same overall learning experience as the male students.

Grade Level. Research comparison studies indicated that older college students, with respect to course completion, had higher achievement than the younger college students did (Wladis et al., 2015). Such claims aligned with the perceptions of the participating teachers for this study. The teachers' perception was that high school seniors had more technology background knowledge and were more mature learners. Their school experience and maturity enabled them to be higher academic performers in the online and face-to-face learning environments (Item 8). The assumption was that first-year students have less technology skills and less academic experience.

In contrast to the achievement credited to students in higher grade level groups, GaDOE (2014) refers to the Georgia student growth model to describe students' learning performance and performance growth. K-12 student growth percentiles (SGPs) defined academic peers as students enrolled in the same grade level and taking the same course content with similar prior academic histories. The SGP analysis indicated that students with low outcome growth will generally maintain their level of low achievement in higher grades (GaDOE, 2014).

The teacher narrative generally credited students in upper grade levels as having more academic experience and technology skills that enabled their higher learning achievement (see Item 8 and 9). The majority of the student population in this study were enrolled in physical science in the 10th grade. The number, if any, of 10th grade students in 2013 and 2014 that were required to repeat the science course again due to incomplete or unsatisfactory achievement is unknown. Credit recovery classes make up the summer program and was not included in the regular school year data for this study. It is possible that some of the upper level students had previously enrolled in Physical Science and repeated the same physical science course while in a higher-grade level. It may be that student performance in higher grade levels observed by teachers in some students in higher grade level gain maturity from having repeated physical science in a higher grade.

Ethnicity. The student performance gap between white and black students was not evident in the online learning environment, in physical science learning outcome, as such was the case for the face-to-face learning environment. Research (CREDO, 2015) targeting K12 learning outcomes pointed to student characteristics of online student populations that differed from the learning outcomes by the student population of this study. Comparisons of the five ethnic groups, Asian American, African American, Hispanic American, white American, and Multiracial, showed obvious differences in learning outcomes between white American students compared to all other ethnic groups. Highly significant differences were found between the face-to-face white American group and the Asian American, African American, and Hispanic American groups. However, these findings, detailed in Chapter Four, that indicated significant differences in learning outcomes between African American and white Americans for the face-to-face learning environment were not duplicated in the online environment. The similarities in online learning outcomes between the African American and white American groups were evident for 2013 and 2014. The similarities in the online learning outcomes between these two ethnic groups aligned with Wladis et al.'s (2015) findings that indicated an achievement gap between African American and white American students in the face-to-face learning environment did not materialize in the online environment. These findings differed with the research by CREDO (2015), these findings showed lower online student performance included ethnic and economically disadvantaged student groups.

Looking at findings at the college and K-12 levels, research investigations concluded that multiple independent variables such as age (Urtel, 2008); grade level (Cavanaugh & Jacquemin, 2015); and ethnicity (Wladis et al., 2015) can result in significant differences in learning outcomes based on the learning environment. At the college level, research targeting science content and successful course completion has provided evidence that the learning outcome gap between ethnic groups, African Americans and Hispanic Americans, compared to Asian Americans and white Americans, did not increase for online classes in science, technology, engineering and mathematics (STEM) courses (Wladis et al., 2015).

Long before concerns of a digital divide between African American students and white American students, an achievement gap between them existed in the tradition of education. Coleman (1966) reported on the depth of the learning achievement gap and asserted that students' backgrounds and socioeconomic status (SES) were key factors influencing their academic outcomes. Although the demographics for the school community indicated 62 percent of the district's K12 student population was eligible for free or reduced lunch. Economic data was not included in the data collected for this study.

Research comparing student learning outcomes in 8th grade math from traditional classroom learning, and the findings indicated a persistent achievement gap, between African American and white American students (Bohrnstedt, Kitmitto, Ogut, Sherman, and Chan, 2015). In this comparison study, it was not known whether the online African American and white American shared similar SES backgrounds. However the significantly lower student achievement by the predominant ethnic group for the two year data set raises a number of questions for researchers to address. Few researchers have targeted the online achievement of African American students (Lang, 2010), and equity in technology access remains a concern for many socioeconomically disadvantaged school programs (NEA, 2016). The findings from this predominantly African American online and face-to-face high school science course gave some indication that learning equity is more of a concern in the face-to-face learning environment. The teacher narratives pointed to a lack of value in education and a perceived cultural indifference towards education that resulted in the learning outcome gap between the African American and white American ethnic groups (Item 10).

The learning outcomes between the Hispanic American online and Hispanic American face-to-face groups had a highly significant difference of $p = .007$ (see Table 49). This finding was the only significant difference between a single ethnic group and the two learning environments. At the college level, research by Johnson and Galy (2012) suggested that course design could improve learning outcomes for Hispanic American students and that because of language and cultural barriers, some Hispanic American students would benefit from online learning tools. Although this comparison study did not include first language as an IV, the finding is relevant for Hispanic American students learning English as a second language. This information points to online learning being beneficial for student achievement and possibly supporting online language acquisition programs.

Content Strains. There were no significant differences in assessed achievement, based on students' EOCT scores, between those who were enrolled in online learning and those who were enrolled in face-to-face learning based on physical science domain. These results indicated that skills-based objectives associated with the physics of physical science were being achieved in both learning environments without differences in learning outcomes (see Tables 51 & 52). Research targeting skills-based learning tasks (Callister & Love, 2016; Wladis et al., 2015) pointed to differences in STEM learning output relating to course objectives, such as memorization and applied project tasks. High school science education is a foundation for college courses and STEM career programs (Wladis et al., 2015).

(CREDO, 2015) targeting K12 learning outcomes pointed to poor performance of online students compared to face-to-face learning outcomes. From a quantitative comparison of student gains in reading, only two percent of the online charter schools outperform their comparison face-to-face schools, 32 percent of the online schools perform no differently, and 67 percent had weaker growth than their comparison face-to-face schools. In math, math 88 percent of online charter schools had significantly weaker growth than their comparison. In contrast to CREDO (2015). the content learning outcomes being similar for this study indicated similar learning impact between online and face-to-face, but speculatively speaking this may be due facilitation differences in online charter schools.

Limitations

The student data collected for this quasi-quantitative study were all archived student cases. All student information came from a district wide course enrollment population. The large number of cases, around 6000, was challenging to manage using a university student access computer server and software program. Due to the challenges of analyzing a large base of data, and the near capacity of program capability, the two-year volume of high school cases were divided into two samples by year.

Intrinsic and extrinsic factors were not collected as part of the data sample, and the assessment of students' cognitive abilities and academic achievements were limited to the scores of the one assessment of the one course subject, physical science. The assessment data were the key performance barometer of student performance in a single district school program. Extrinsic learning factors, such as parental support and economic status, English proficiency or ethnic biases were not addressed by this investigation. The study's sample population was derived from the quasi-experimental method that allowed the cases of students enrolled in physical science to be sorted into groups. The enrollment sample was largely African American, Due to the low number of Native American cases, Native American cases were not included in the comparison analyses. The district K-12 population as a whole was 37% African American, 42% white American and 14% Hispanic, however no ethnic data was collected for physical science course teachers, and any biases associated with student-to-teacher interactions were not addressed in this study, Ethnic data of the participating teachers for the online survey was not collected and any ethnic bias were not identifiable from the teacher survey content (see Item 10).

This investigation was unique in that it compared two learning environments for a single program population, of a single course subject, along with three independent variables (IV). No other comparison studies consisted of these same components, and although the overall findings indicated no significant differences in learning outcomes between environments, or environments and content domain strains. Some significant differences were uncovered between the independent variables of grade level and ethnicity. Where research indicated that low social economic and minority groups have lower performance online compared to white American students, this comparison study found similarities in online student achievement between ethnic groups. The findings from this study support efforts to define appropriate online learner characteristics that enable online success and growth of the eLearning model. The limitations of this investigation are challenging for future research, but not insurmountable.

Recommendations

Some student-to-student and student-to-teacher interactions and personal biases found in the traditional classrooms may be limited to the face-to-face environment, and female students may have more reason to favor an online learning experience. Research investigating equity in high school science have several inquiries to make, such as asking if female students can achieve higher learning outcomes in science by enrolling in online classes, and second, why female students in face-to-face science classes are not having a more favorable learning experience or higher achievement. As far as the ethnic achievement gap, research that addresses teacher-student biases, or lack thereof in the online learning environment, is a huge research question, along with whether English Learners (ELs) are more likely to have success participating in online classes. For English Learners and students with learning disabilities, the question of learning science online maybe a question of available resources and access to online programs. As stated by Barbour and Reeves (2009), for clarity of equity in student performance between online and face-to-face learning environments, additional research inclusive of homogeneous comparison groups is recommended. Not included in this investigation, but recommended, research that considers the role of language skills, along with prior knowledge of content, and compares student performance over several years would be more descriptive of vertical learning outcomes trends and possible environmental influences in specific content areas for specific student populations.

Also recommended for future content research, the known intrinsic and extrinsic learning factors, such as self-efficacy and motivation, might favor one of the two learning environments. Parental influence also has significant influence on learning outcomes (Gonzalez-DeHass, Willems, & Holbein, 2005) and has a place in the online leaning paradigm. Including community support, along with additional measures of student learning ability, such as GPA and reading skills, is also suggested for future comparison investigations. With these identified variables, the question of influence will be better addressed, and the online learning theoretical framework will take more shape. This is necessary to implement precise research and, in Barbour and Reeves' (2009) terms, compare student achievement of homogeneous student populations.

Conclusion

The online performance similarities between groups, such as the higher performance of online female students, and the performance of students in higher grade levels, pointed to Kozma's (1994) side of the media debate, and the need to consider how the online environment may influence the learner. Evidence here supports the adoption of physical science in the online learning model for specific students and not all students.

Efforts to further science pedagogy may have to address the female students' learning experience in the face-to-face environment to increase student performance and overall leaning equity. Freshmen students had significantly lower student performance in physical science, in both learning environments, and class enrollment prerequisites, middle school science instruction, and student performance in physical science in early grade level years may require some science program amendments. Considering the lower face-to-face performance of Hispanic American students when compared to online

Hispanic American performance, online learning may aid English Learners. The learning gap between white American students and other ethnic groups in the face-to-face learning environment remains evident, however similar online learning outcomes between African American students and white American students points to steps in the learning process that may be influenced by the online learning environment due to students' learning characteristics. The conditions of learning theory (Gagne, 1985) along with constructivism practices are familiar elements reflected in the online learning model, however the full development of the eLearning theory likely consist of elements forthcoming.

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Appendix A: Teacher Reflection Survey

Page 1

Teacher Survey

Title of Research Study: A Comparison: Achievement in Physical Science, Online and Face-to-Face

Researcher's Contact Information: Lisa F. Mozer, 678-429-5656, Email
lisa_mozer@att.net

Introduction
As a Science educator, for physical science, you are being invited to take part in a research study conducted by Lisa f. Mozer of Kennesaw State University. Before you decide to participate in this study, you should read this form and ask questions about anything that you do not understand.

Description of Project (The purpose of the study is}:
This study explored assessment scores, learning outcomes measured by EOCT, in physical science for 2013 and 2014, between online and face-to-face scores. Multiple comparisons resulted in no significant differences. The survey questions here target the few differences indicating by the quantitative comparisons of mean scores.
The purpose of this survey is to gain some perception of the findings by educators. Instructors with experience in both learning environments are asked to comment on content difficulty and the quantitative findings.
Explanation of Procedures
This 10-question survey consist of Likert-type questions pertaining to science content, and questions 7 to 10 are open-ended questions that will require teachers to respond in reflective narratives regarding the findings.
Time Required:
The survey is fairly short, and the suggested time to complete the ten questions is 10 to 15 minutes.
Risks or Discomforts:
There are no known risks or anticipated discomforts in this study.

Benefits:
Although there are no direct benefits for volunteering to participate (in taking this survey), this project partially fulfills a dissertation study requirement for the researcher. Also, the study may benefit future research in science pedagogy.
Compensation: None
Confidentiality
The results of this participation will be anonymous. This project does not collect identifying information of participants (e.g., name, address, Email address, etc.).
Inclusion Criteria for Participation
You must be 18 years of age or older to participate in this study.

Use of Online Survey
IP addresses will not be collected.

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to the Institutional Review Board, Kennesaw State University,

585 Cobb Avenue, KH3403, Kennesaw, GA 30144-5591, (470) 578-2268.

PLEASE PRINT A COPY OF THIS CONSENT DOCUMENT FOR YOUR RECORDS,
OR IF YOU DO NOT HAVE PRINT CAPABILITIES, YOU MAY CONTACT THE RESEARCHER TO OBTAIN A COPY

1. Consent:

I agree and give my consent to participate in this research project. I understand that participation is voluntary and that I may withdraw my consent at any time without penalty.
I do not agree to participate and will be excluded from the remainder of the questions.

Page 2

Teacher Survey - Thank you for participating!

2. Experience in teaching Physical Science (PS):
Please select the most appropriate response between the two

1 to 3 years teaching PS online and 1 to 3 years teaching PS face-

to-face over 3 years teaching PS online and over 3 years teaching

PS face-to-face 1 to 3 teaching PS online and over 3 years teaching face-to-face over 3 year teaching PS online and 1 to 3 years teaching PS face-to-face

3. **When considering student learning in general... On a scale of 1 to 5, with 1 indicating *least difficult* and 5 indicating *most difficult, please* rate the overall difficulty students experience in learning Physical Science content in a traditional classroom (face-to-face).**

    1

    2

    3

    4

    5

4. **When considering student learning in general... on a scale of 1 to 5, with 1 indicating least difficult and 5 indicating most difficult, please rate the overall difficulty students experience in learning Physical Science content in a virtual classroom (online).**

    1

    2

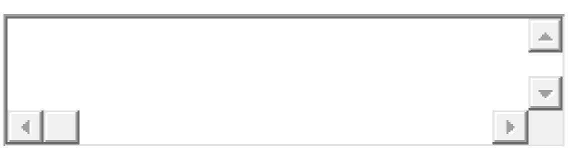
    3

    4

    5

5. **If the four strains of PS were placed in a blended model, which of the strains (or strain) would you recommend for online, which for face-to-face, and why?**

<u>The 4 PS Strains/Domains</u>
Chemistry: Atomic and Nuclear Theory, and Periodic Table
Chemistry: Chemical Reactions, and Properties of Matter
Physics: Energy, Force, and Motion
Physics: Waves, Electricity, and Magnetism



6. **The overall comparison between online and face-to-face EOCT Physical Science scores for 2013 did not indicate a significant difference in learning outcomes (assessed by the EOCT for PS). However a significant difference was indicated**

between outcomes in 2014. The mean score for online was 414.6, and the face-to-face mean score was 419.2. How would you account for the outcome? Please use the following space to explain your response.

7. **A significant difference was indicated between online and face-to-face when comparing mean EOCT scores of the female groups (online and face-to-face). There was not a significant difference indicated for the male groups. How would you account for this finding? Please use the following space to explain your response.**

8. **A significant difference between ethnic groups was indicated by the findings in 2013. The online mean score was lower for the African American group compared to the white American group, How would you account for this finding (a lower EOCT mean score of 418, the higher mean score was 433)? Please use the following space to explain your response.**

9. **The grade level comparisons between online and face-to-face indicated a significant difference in outcome for the 9th grade. The 9th grade mean score (423) for online was higher than the face--to-face mean score (401). How would you account for this finding? Please use the following space to explain your response.**

10. **The comparison between grade levels of all online groups indicated the highest online mean score for was for the 10th grade, and the lowest online mean score was for the 9th grade. How would you account for this finding? Please use the following space to explain your response.**

Appendix B: Teacher Reflection Survey (Amended)

Page 1

Teacher Survey (amended)

Title of Research Study: A Comparison: Achievement in Physical Science, Online and Face-to-Face

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585 Cobb Avenue, KH3403, Kennesaw, GA 30144-5591, (470) 578-2268.

PLEASE PRINT A COPY OF THIS CONSENT DOCUMENT FOR YOUR RECORDS,
OR IF YOU DO NOT HAVE PRINT CAPABILITIES, YOU MAY CONTACT THE RESEARCHER TO OBTAIN A COPY

11. Consent:

I agree and give my consent to participate in this research project. I understand that participation is voluntary and that I may withdraw my consent at any time without penalty.
I do not agree to participate and will be excluded from the remainder of the questions.

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2. In 2013 the EOCT Physical Science mean scores of Face-to-Face groups, between male and female students, were significantly different. The male Face-to-Face

group's mean score was 418.28. The female Face-to-Face group had a mean score of 416.81. This is a highly significant difference of p = .001. How would you explain this difference?

3. With the exception of the 12th grade 2014 data, there were *no significant differences* in the EOCT Physical Science mean scores (for any of the grade level comparisons), between online and face-to-face groups. How would you account for these findings?

4. In 2014, the online 12th grade group had a mean score of 422.65, and the Face-to-Face 12th grade group had a mean score of 437.64. This is a significant difference of p = .002. How would you explain this?

5.
The 2013 Face-to-Face Data:
Asian students scored significantly lower than White American students.
African American students scored significantly lower than White American students.
Spanish students scored significantly lower than White American students.
African American students scored significantly lower than Multi-Racial students

The 2013 Online Data:
African American students scored significantly lower than Spanish students.

How would you account for differences in the African American learning outcomes?