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The Effect of Interactive Notebooks on the Science Proficiency of Biology 1 Students

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This is to certify that the doctoral study by

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Abstract

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EdS, Arkansas State University, 2013

MEd, University of Mississippi, 2006

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Project Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Local High School, a pseudonym, located in Northwest Mississippi has in place two differing Biology 1 curricula; in one curriculum, the students use interactive notebooks daily and in the other curriculum, they are not used. The purpose of this ex post facto quasi-experimental study was to investigate the impact that an instructional tool, such as the interactive notebook, could have on student achievement. Instructional design theory and the materials, methods, environment, collaboration, content, and assessment (MMECCA) framework served as the theoretical framework for this study. The standard measure of science proficiency was provided by the test results from the Biology 1 Subject Area Testing Program assessment (SATP). Using data from 2016-2017 Biology 1 students who took the pretest, CASE 21 assessment, and the posttest, Biology 1 SATP assessment (N = 184), three independent samples t tests were used to analyze the data. The first independent samples t test performed on data from the pretest established that the two groups began the study with similar science proficiencies. The second and third independent samples t tests, conducted using overall mean scores and the mean scores for each of the individual six categories from the SATP Biology 1 assessment, determined that there was a statistically significant difference in the overall science proficiency of the two groups. A position paper was developed recommending the use of the interactive notebook to improve science proficiency. Positive social change is expected to occur as this information can be used to inform educational policy makers and close the achievement gap.

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Dedication

This doctoral study is dedicated to my husband and best friend, Jonathan Newson, who pushes me to be better and dream bigger. I couldn’t have done this without your support, encouragement, and love. My children, Jamil and Jamiya Newson, who have endured many of mommy’s sleepless nights and quiet-time writing hours. You are my motivations for everything I do. My parents, J.C. and Bertha Owens, who have always told me I’m smart enough to be a doctor and instilled in me the drive to achieve anything I put my mind to and my effort towards. My brother, J.C. Owens Jr., and my sister, Jennifer Owens, for your continuous encouragement and prayers.

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Section 1: The Problem

Introduction

Ever since John Dewey (1916) recognized the concept of democratic education, American schools have been exploring different ways of transferring information to students to improve their academic achievement. In this vein, the passing of the No Child Left Behind (NCLB) Act in 2001 sought to level the playing field for all students through accountability systems and high-quality educational services. The NCLB accountability system mandated assessments for all 5th, 8th, 9th, 10th, and 11th-grade students' proficiency in science, social studies, mathematics, and language arts/reading by the end of the 2013-2014 school year (Furrer, Pitzer, & Skinner, 2014; Howard, 2015; Hoy, 2012). These high-quality educational services frequently involved various instructional practices of teachers across the United States (Furrer, Pitzer, & Skinner, 2014; Howard, 2015; Hoy, 2012). NCLB increased the requirements of educators to identify and employ data-driven instructional practices and tools that reduced achievement gaps and improved student performance in the four core subject areas, one of which was science (Goodman, 2012, Lee & Reeves 2012).

A successor to the No Child Left Behind Act, the 2009 Common Core State Standards (CCSS), provided vigorous, relevant, standards in mathematics and literacy/English language arts that reflected the knowledge and skills students need for success in college and careers (Agamba & Jenkins, 2013; National Governors Association Center, 2012; Valencia & Wixson, 2013; Webb & Williams, 2016).

Although the CCSS concentrated on standards for English language arts/literacy and mathematics, many CCSS-adopting states also developed new standards for their science and social studies curricula or improved upon their existing standards for those disciplines to better align with those of other rival countries. According to Calfee, Flannery, Kapinus, and Wilson (2014), CCSS called for educators to use more formative and rigorous curricular, instructional, and assessment practices to accomplish the vision of preparing students to become ready for college and career.

The Local Problem

Under the NCLB policy, high schools in the state of Mississippi implemented an accountability model that relied on the use of the Subject Area Testing Program (SATP) assessments. These assessments, known as graduation exams, were used to measure student academic growth and proficiency and to facilitate school improvement in Mississippi high schools (MDE, 2017). The SATP testing program encompassed standardized tests in Biology 1, English II, Algebra 1, and U.S. History. Students had to pass them receive their high school diplomas. The Biology 1 and Algebra 1 tests are typically administered during the student’s 9th grade year. The English II assessment is administered during the students' 10th grade year and the U.S. History exam during their 11th grade year. Passing scores on the exams varied depending on the subject area assessed (MDE, 2017). The passing scores for the various graduation assessments are given in Table 1.

Table 1

Passing scores for Mississippi graduation assessments

Subject area Mississippi state issued graduation assessments	*Passing scores*
Biology 1	645
Algebra 1	1050
English 2	1050
U.S. History	641

Note. Data are for public high schools in Mississippi. Adapted from "Mississippi Passing Scores on Graduation Exams" Mississippi Department of Education, retrieved from http://mdereports.mdek12.org/pdf/a/2016/MS%20A_F%20System%20explainer.pdf

Students are retested until a passing score is obtained (retesting is offered four times a year, twice during the Fall and Spring semesters). If a passing score is not attained on all four content areas at least 1 month before graduation, the student will not receive their high school diploma or be able to participate in graduation activities (MDE, 2017).

As a result of Mississippi adopting the CCSS in 2009, the American College Testing program (ACT) became a mandated, standardized test for all 11th-grade students in the state of Mississippi (DCS, 2017; MDE, 2017). The ACT consists of four subtests in reading, mathematics, science, and language arts. Under the Mississippi Accountability Model of 2013, science proficiency accounts for 50 points (as measured by students' performance on the Biology 1 SATP assessment) on a possible 1,000-point growth scale (DCS, 2017; MDE, 2017). All of the components of the 2013 Mississippi Accountability Model and the Mississippi School and District Grading Scale for high schools are in Tables 2 and 3.

Table 2

Components of the 2013 accountability model for high schools

Reading	Math	Other subjects	Graduation (4 years)	Acceleration (including AP, IB, and dual credit)	College readiness
Proficiency (100 points)	Proficiency (100 points)	Science proficiency (50 points)	All students rate (200 points)	Participation/ Proficiency (50 pts.)	Rate (50 points)
Growth all students (100 points)	Growth all students (100 points)	U.S. history proficiency (50 points)		70% participation/ 30 % performance in Year 1 60/40 Year 2 50/50 Year 3	ACT math 22 and reading 22 or English 18
Growth lowest 25% (100 points)	Growth lowest 25% (100 points)			↑ Phase in: Y1: 15-16 Y2: 16-17 Y3: 17-18	↑ Math: 50% R/E: 50%

Note. Data are for public high schools in Mississippi. Adapted from "Mississippi Components of Accountability for High Schools Report" Mississippi Department of Education, retrieved from http://www.mde.k12.ms.us/docs/communications-library/accountability-system-charts_oct2016.pdf?sfvrsn=2

Table 3

The Mississippi school and district grading scale for high schools

Ratings	Points
A	1000-738
B	737-626
C	625-552
D	551-470
F	Less than 470

Note. Data are for public high schools in Mississippi. Adapted from "Mississippi School and District Grading System Report" Mississippi Department of Education, retrieved from http://mdereports.mdek12.org/pdf/a/2016/MS%20A_F%20System%20explainer.pdf

Stagnant science SAT scores and marginal performance on the science subtest of the ACT have triggered Local High School administration to consider enhanced instructional practices for differentiated instruction, thus helping students better process information presented in the classroom (DCS, 2017; MDE, 2017). With high stakes accountability models similar to those in Mississippi, it is increasingly critical that all learners have access to apposite programs of study, including instructional modifications (Dulfer, Polesel, & Rice, 2014; Furrer, Pitzer, & Skinner, 2014; Lee & Reeves, 2012). One such instructional practice is the use of instructional tools, such as interactive notebooks.

Both the passage of NCLB and the adoption of the CCSS have qtriggered the need for increased research-based information on which instructional tools better differentiated instruction and helped students to better process the information presented in the classroom (Ates & Yildirim, 2012; Demski, 2012; Hussain, Rifat, Safdar, & Shah, 2012). This study will examine the specific interactional tool of interactive notebooks and their use in the Biology 1 classroom to assist teachers in improving students' knowledge, skills, and abilities in this subject area or course (Chingos & Whitehurst, 2012). The instructional tool of interest for this study, interactive notebooks, was used by the experimental group daily to record and model course information, process ideas and make connections, and demonstrate content learned through reflective writing and discussion (Meyer, 2014; Shen, 2014; Shepard, 2016). The teacher of the experimental group used interactive notebooks to administer ongoing formative assessments that helped navigate their lesson planning and pedagogical practices (Heilbronner & Mallozzi, 2013). The use of interactive notebooks was thought to help students in expressing science-learning processes, assimilating science skills, and increase science reasoning (Heilbronner & Mallozzi, 2013).

Problem Statement

A high school in Northwest Mississippi had in place two differing Biology 1 curricula; in one curriculum, the students regularly used interactive notebooks; in the other curriculum, they did not. The local problem that prompted this study was that it was unknown which curriculum had the more positive effect on the Biology 1 high school students' science proficiency (DCS, 2017; Shepard, 2016). This study helped address this gap by comparing science proficiency data from two parallel Biology 1 curricula, one with embedded interactive notebooks and one without.

Rationale

Evidence of the Problem at the Local Level

The number of Biology 1 students achieving proficient levels on the SATP Biology 1 assessment remained stagnant for Local High School in Local County School District in Northwest Mississippi (DCS, 2017; Kuykendall, 2017; MDE, 2017). The Mississippi statewide accountability model mandated that all public school students be college or career ready before graduating from high school. Consequently, many schools, including Local High School, sought to understand the instructional tools and practices, supportive resources, and appropriate curriculum practices that helped increase science proficiency (Dulfer, Polesel, & Rice, 2014; Furrer, Pitzer, & Skinner, 2014; Lee & Reeves, 2012). The percentages for science proficiency for Local High School, Local School County District, and the state of Mississippi as measured by students' performance on the Biology 1 SATP assessment for the 2014-2015 and 2015-2016 school years, are given in Table 4.

Table 4

Students Achieving Science Proficiency

School Year	School	District	State
2014-2015	75	72	59
2015-2016	75	70	62

Note. School, district, and state data represent percentages. Adapted from “Summary Performance Report: SATP2 Biology Mississippi Subject Area testing Program Report,” Mississippi Department of Education, retrieved from www.mde.com.k12.ms.us

The purpose of this quasi-experimental study was to determine (a) if there was a statistically significant difference in students' mean scores on the Biology 1 SATP assessment and (b) if there was a statistically significant difference among the six categories or competencies of the Biology 1 SATP Assessment between students in a curriculum where interactive notebooks were and were not embedded. The categorical independent variable for this study was curriculum embedded interactive notebooks as an instructional tool, and the dependent variable was students' science proficiency as measured by the Biology 1 SATP assessment. To protect the internal validity of this comparison, teachers from both groups have taught for over five years, have had the same established course objectives, used the same texts and course readings, and administered parallel tests throughout the period when the data was collected (Cook, 2015; Creswell, 2012; Dong & Maynard, 2013; Krishnan & Sitaraman, 2013; Lodico, Spaulding, & Voegtle, 2010).

Evidence of the Problem from the Professional Literature

The literature showed that teachers must employ enhanced and engaging instructional tools for differentiated instruction and increased processing of information presented in the classroom (Dee, Jacob, & Schwartz, 2012; Furrer, Pitzer, & Skinner, 2014; Lee & Reeves, 2012; Webb & Williams, 2016). Because of the No Child Left Behind Act, science is now a vital, high-stakes tested subject (Grave et al., 2012; Lavery, 2016). However, there is a gap in the literature on the effect of curriculum-embedded interactive notebooks as a specific instructional strategy on high school biology students' science proficiency (Chingos & Whitehurst, 2012; Fraser, 2015; Howard, 2015; Linn, 2013; Wilson, 2013). Heilbronner and Mallozzi (2013) recommended future studies to identify the effect of interactive notebooks as an instructional tool on students' achievement. They advocated for examining the use of interactive notebooks to increase student achievement or to investigate professional development endeavors that can train teachers to use interactive notebooks in their classrooms to improve student achievement in science-processing skills.

Definition of Terms

American college test (ACT): A standards-based assessment that measures students' academic readiness for college (MDE, 2017).

Biology curriculum: A course of studies designed to investigate life processes at all levels (Donovan, 2016; MDE, 2017).

Common core state standards (CCSS): A set of academic standards in language arts/literacy and mathematics to ensure that all students graduate from high school with the skills and knowledge necessary to succeed in the 21st-century workforce (National Governors Association Center, 2012)

Instructional tools: Any resources used to assist teachers in improving students' knowledge, skills, and abilities in a subject area or course (Chingos & Whitehurst, 2012).

Interactive notebooks: An instructional tool that provides students with personal, organized, and documented learning records usually encompassed in a composition notebook (Crippen & Waldman, 2009)

No child left behind (NCLB): Legislation, initiated in 2001, dedicated to closing the achievement gap in students nationally in the space of a decade through accountability, standardized testing, and high-quality standards (Boden, Gregory Harman, Karpenski & Muchowicz, 2016).

Subject area testing program (SATP): Assessments given to students in Biology 1 and U.S. History with the results being used to improve student achievement (MDE, 2017).

Science proficiency: A position in which students can identify scientific issues in a range of contexts; select facts and knowledge to explain phenomena and apply simple models or inquiry strategies; interpret and use scientific concepts from different disciplines and apply them directly; and develop short statements using facts and make decisions based on scientific knowledge (Liu & Whitford, 2011). In Mississippi, the proficient level for students on the Biology 1 SATP assessment is achieved at 650 points (MDE, 2017).

Significance of the Study

Arop, Umanah, and Effiong (2015) conducted a quasi-experiment to examine the role of instructional tools in the science classroom and how instructional tools have influenced the teaching and understanding of basic science. For the study, 240 students were chosen randomly by simple ballot method from four secondary schools. A researcher-constructed a 20-item test, with a reliability indicator of 0.86; it was used to collect data from both a control and an experimental group. An independent *t* test was conducted to determine if there was a statistically significant difference between high school students' science proficiency when some degree of instructional tools were embedded in their curriculum. The study found that some degree of embedded instructional tools increased the science proficiency of the students (Arop, Umanah, & Effiong, 2015). Çıbık (2016) conducted a quasi-experimental study to provide evidence that an instructional tool called the Project-Based History and Nature of Science training and Conventional Method, when utilized by preservice science teachers, exhibited greater gains in students’ understanding of science and scientific inquiry. Likewise, Bektaş and Kızkapan’s study (2017) provided a critical outlook on the way project-based learning approaches, similar to the interactive notebooks, could be used to increase student achievement on the structure and properties of matter.

The findings of the Arop, Umanah, and Effiong (2015), Çıbık (2016), and Bektaş and Kızkapan (2017) studies demonstrated measurable differences in student academic achievement in science concepts when students utilized various instructional tools. These findings indicated that it is beneficial to study the effect of similar instructional tools, such as interactive notebooks, on students' science proficiency (Arop, Umanah, & Effiong, 2015; Bektaş and Kızkapan, 2017; Çıbık, 2016). This study addressed the local problem by comparing standardized science proficiency between two groups of high school biology students dependent on their curriculum-embedded use of interactive notebooks. This project study can make an original contribution to the curriculum, instruction, and assessment literature by focusing on interactive notebooks used as a curriculum-embedded instructional tools. This current study can help those making policy decisions at the Local High School and Local County School District about whether interactive notebooks should be used in all Biology 1 curricula. The results from this project study are important, as they have the potential to inform educational policy makers at the local level, as well as, help address a gap in practice.

Research Question(s) and Hypotheses

This project study used the IDT (2010) and the MMECCA framework (2002) as its theoretical framework. Influenced by the works of Skinner, Bloom, Merrill, and Sweller, the IDT (2010) centers on *how* students are going to learn rather than on *what* the students are going to learn. It promotes the use of instructional methods or tools purposely constructed to ascertain learning in the classroom. This theory hinges on the indication that students will learn more efficiently (a) when the instruction is structured and presented in a way that resonates with the students' needs and (b) when the students can naturally interact with and use the instructional materials or tools provided for the lesson.

The MMECCA framework (2002) is a standards-based framework centered on universal design, sheltered instruction, multicultural education, and differentiated instruction. Composed of six components, the MMECCA framework emphasizes materials or tools of instruction. It defines instructional materials or tools as tangible items that used to reinforce teaching and generate results for all students. The MMECCA framework deems that various instructional materials or tools give students ways to demonstrate concepts, numerous methods of participating in learning, and several ways to demonstrate what they have learned.

IDT (2010) informed the development of the research questions by substantiating how information is learned, such as with interactive notebooks. This is an important issue for research with regard to curriculum design. The MMECCA framework connects the research question, study purpose, and problem within the peer-reviewed literature of standards-based curricula and learning. The following research questions and hypotheses drove this quantitative project study:

RQ_1- Is there a statistically significant difference in science proficiency levels, as evidenced by Biology 1 students' SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum?

RQ_2- Is there a statistically significant difference among the six categories or competencies of the SATP Biology 1 Assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum?

$H_0 1$: No statistically significant difference exists in science proficiency levels, as evidenced by Biology 1 students' SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

$H_1 1$: A statistically significant difference exists in science proficiency levels, as evidenced by Biology 1 students' SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

H_02: No statistically significant difference exists in science proficiency levels among the six categories or competencies of the SATP Biology 1 assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

H_12: A statistically significant difference exists in science proficiency levels among the six categories or competencies of the SATP Biology 1 assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

Review of the Literature

This section contains a review of the literature relevant to the variables explored in this study. This literature review was completed by examining scholarly, peer-reviewed journals, articles, dissertations and theses, and books during the period of 2017-2018. The searched databases include ProQuest, ERIC, Google Scholar, Academic Search Premier, EBSCOHost, and ProQuest Dissertations and Theses. The following pertinent terms were used: *No Child Left Behind, Common Core State Standards, science education, science curriculum, science proficiency, high stakes testing, accountability models, instructional tools,* and *interactive notebooks.*

This literature review consists of four sections. The first part focuses on past and current curriculum reforms, such as the No Child Left Behind Act and the Common Core

State Standards, and their effects on student achievement in science. Part 2 consists of a discussion of science proficiency. This section also includes information on the historical perspective of science education in the United States and other countries. Part 3 discusses extant paradigms from research studies on the influence of using various instructional tools, including the interactive notebook, on students' achievement in science. Part 4 of the review discusses quasi-experimental design and methodology as an established practice in peer-reviewed, recent, educational research.

Curriculum Reform

Change and reform is an inescapable and necessary element of schooling and education. According to Rodney-Londari (2009) curriculum reform "often involves adopting a new way of thinking with the introduction of new teaching practices" (p.45). Many countries emphasize curriculum reform to improve student proficiency and competence and fortify national and global competitiveness (Chang, Kao, Lin, & Tsai, 2015). The success of implementing new curriculum reform is dependent upon exposing the weaknesses and failures of the former system and the buy-in of the staff, students, and other stakeholders for the development (Banner & Ryder, 2013; Rodney-Londari, 2009). Since the launching of Sputnik in the 1950's by the Soviet Union to the recent influx of careers and businesses in Science, Technology, Engineering, and Mathematics (STEM), the United States has made drastic curriculum reform efforts to its school science programs (Banner & Ryder, 2013; Jianjun, 2012). Although many gains have been made in assisting students to achieve scientific literacy and proficiency, many inadequacies in the system remain (Education questions, 2016; Fensham, 2013; Teo, 2012). However, recent curriculum reform efforts, such the NCLB Act of 2001 and the CCSS in 2010, hold great promise of improving science education in K-12 schools (Drake, 2014; Lavery, 2016; Torres, 2014).

No Child Left Behind

The passing of the No Child Left Behind Act changed the face of science education in America (Czerniak et al., 2012; Johnson, Kahle, & Zhang, 2012). A revision of the Elementary and Secondary Education Act (ESEA) of 1965, NCLB was a federal policy that attached federal funding to school accountability (Mahoney & Zigler, 2006). With a primary goal of eliminating achievement gaps resulting from social and economic biases and inequalities in education, NCLB relied on high-stakes testing to achieve this end (Lavery, 2016; Marx & Harris 2006; Neil 2003). Initially, NCLB focused on growth and testing in language arts and mathematics only, but in 2007 modifications were made to the policy to include social studies and science to the testing requirements (Lavery, 2016; Marx & Harris 2006; Neil 2003). These changes led to reforms in science curriculum and pedagogical practices in science classrooms across the nation (Lavery, 2016; Mahoney & Zigler, 2006; Marx & Harris 2006; Neil 2003).

After realizing that other nations surpassed the U.S. in science and technology related innovations and advancements, politicians pushed to make science and technology education a top priority in American classrooms (The Obama-Biden plan, 2009). While in the past, science once took the back seat to language arts and mathematics in classrooms across the country, with the passing of NCLB it was now in the forefront for grades K-12 (Czerniak et al., 2012). Goal recommendations made by government leaders, educators, and organizations such as the National Research Council and Academy of Science and the American Association for the Advancement of Science, have been set to prepare the workforce to be scientifically literate. The end goal is to compete in a progressively scientific and technologically focused global economy (Asturias et al., 2013; Czerniak et al., 2012; Jewett, Johnson, Lowery, & Stiles, 2015; National Science Teachers Association, 2002; Sandova, 2014). Through NCLB, all states are required to establish rigorous academic science content standards for all students, and all students are expected to understand the content of the science curriculum and then demonstrate that understanding on state exams (Johnson, Kahle, & Zhang, 2012).

Contrastingly, according to Johnson, Kahle, and Zhang (2012) and Johnson (2013), the ramifications of NCLB have been detrimental to science education and instruction. For example, instruction in state-tested classrooms is often reduced to memorization of facts and regurgitation of information and terms (Coats & Xu, 2013; Daniels & Sun, 2013; Johnson, 2007; Johnson, 2013; Johnson, Kahle, & Zhang, 2012). However, Romano (2013) and Willard (2013) deem the Common Core State Standards (CCSS), which were adopted by most states in 2010, will secure a much better place for science in American classrooms.

Common Core State Standards

To ensure all K-12 students across the nation achieve proficient standards in mathematics and literacy/English language arts, the Council of Chief State School Officers (CCSSO) and the National Governors Association Center for Best Practices (NGA Center) developed the Common Core State Standards in 2009 (CCSSO & NGAC, 2010; Torres, 2014). These standards define the skills and knowledge students should have before they exit high school. The CCSS calls for all students to be scientifically literate by becoming mathematically and scientifically proficient before graduating high school and entering the workforce (Koballa & Mayes, 2012). The adoption of the CCSS by many states has given rise to state-developed College and Career Readiness Standards (CCRS) for mathematics, literacy/English language arts, science, and social studies (DCS, 2017; MDE, 2017; NSSG, 2017, Willard, 2017). These standards will address and integrate the dimensions of science and engineering practices, disciplinary core ideas, and crosscutting concepts into a single performance expectation (Asturias et al., 2013; Fang, Santos, & Hakuta, 2013; Lead States, 2013, NSSG, 2017). Unlike the 2010 Curriculum Framework, the newly developed 2018 CCRS standards outline what knowledge students should obtain, and the skills students must master upon successful completion of each grade level or subject area (MDE, 2017; DCS, 2017).

The 2018 Mississippi CCRS for Science reflects what students should know and be able to do. The 2018 Mississippi CCRS for Science builds on the progression of disciplinary core ideas from one grade level to the next (MDE, 2017). The new standards are saturated with Science and Engineering Practices (SEP), cross-cutting concepts, and the utilization of technology to help students understand scientific knowledge and the work of engineers, and the relationship between engineering and science. The SEPs include asking questions, developing and utilizing models, conducting investigations, analyzing data, utilizing computational thinking, constructing solutions, engaging in scientific arguments, and communicating information (DCS, 2017, MDE, 2017). Adopted from the National Research Council's Framework for K-12 Science Education (2012), the seven crosscutting concepts of patterns, cause and effect, scale, systems, energy and matter, structure and function, and stability and change are designed to help students see the unity of the sciences and should be integrated into instruction for every grade level and in every science course (MDE, 2017). To compete globally and deliver competent students into colleges or careers, technology must be utilized in the classroom to reflect the modern workplace and to enhance the progressive learner (Jewett, Johnson, Lowery, & Stiles, 2015). According to Asturias et al. (2013) and Sandova (2014), the development, adoption, and implementation of the CCSS has positively changed the playing field for science education in America. The CCSS draw attention to science's effect on society and has the capability of motivating students to engage in Science, Technology, Engineering, and Mathematics (STEM) topics and activities and pursue STEM-related careers (Asturias et al., 2013; Sandova, 2014).

Science Education

Research on learning and teaching science indicate that learners are goal-focused and pursue knowledge and information actively (Chiappetta & Koballa, 2014; Clay-Chambers, Krajcik, Marx, & Singer, 2000; Eilks & Hofstein, 2017). According to Abell, Appleton, and Hanuscin (2013), the nature and purpose of science education are labeled into three categories: the Conceptual Change Tradition, the Sociocultural Tradition, and the Critical Tradition. These three traditions share an understanding that science is more than a body of knowledge or a set of methods for developing new knowledge (Abell, Appleton, & Hanuscin, 2013). All three traditions view science as a subculture with specialized language, value, and practices but differ in their views of the learner in the science classroom (Abell, Appleton, & Hanuscin, 2013).

Based on the works of Piaget (1953), the Conceptual Change Tradition has the longest historical background and the most influence on the science education community. In accordance with the Conceptual Change Tradition of science education, students fail to learn science in the classroom because they come to school with alternative conceptual frameworks that influence their insights and understandings toward the science they are taught (Abell, Appleton, & Hanuscin, 2013; Gong, Iun, Huang, & Liu, 2010; Koot & Rideout, 2009; Pring, 2012). It is deemed that students must be given the freedom to guide their own educational journey in science through self-actualization, self-involvement, and self-evaluation in order to appreciate and retain scientific information (Abell, Appleton, & Hanuscin, 2013; Gong, Iun, Huang, & Liu, 2010; Koot & Rideout, 2009; Pring, 2012). However, the Sociocultural Tradition's foundation is grounded in the works of Vygotsky (1962). The Sociocultural Tradition of science education proposes that science education and instruction is only effective if the learner participates in scientific dialogue, discussion, and study with others (Abell, Appleton, & Hanuscin, 2013; Fensham, Fensham, Gunstone, & Gunstone, 2013; Kalina & Powell, 2009; Yang, 2014). Students learn science when they are actively involved in a learning community with peers with which they share similar linguistic and social norms and values (Abell, Appleton, & Hanuscin, 2013; Fensham, Fensham, Gunstone, & Gunstone, 2013; Kalina & Powell, 2009; Yang, 2014). Whereas, the Critical Tradition is based on Plato's views of education and curriculum. The Critical Tradition of science education suggests that although science education is imperative for the well-being of the individual and society, it is manipulated and controlled by the dominant class, gender, and the elite (Abell, Appleton, & Hanuscin, 2013; Baker, 2016; Null, 2011). Students that are not members of the dominant classes are disregarded and ostracized, not having a science education and scientific careers as available options or possibilities for them to pursue or partake in (Abell, Appleton, & Hanuscin, 2013; Baker, 2016; Null, 2011). Inquiry and active learning are at the center of science education and curriculum (Chiappetta & Koballa, 2014). In a study done by Clay-Chambers, Krajcik, Marx, and Singer (2000), it was suggested that student learning as related to science instruction must be focused on assisting students with utilizing inquiry skills to find solutions to real-life problems. This process involves asking questions, constructing and carrying out investigations, collecting and analyzing data, drawing conclusions, and publishing or communicating findings or results. In an experimental study done by Abdi (2014), the effects of inquiry-based learning methods on students' academic achievement in science were investigated. The study indicated that students who were taught through inquiry-based techniques, such as the 5E Learning Cycle (Engagement, Exploration, Explanation, Elaboration, and Evaluation), achieve better in science courses than those instructed through traditional techniques (Abdi, 2014). In a Romanian study by Ciascai, Felezeu, and Haiduc (2014), it was suggested that inquiry-based learning allows students to be engaged in the learning process in science classes and connect what they have learned in school with what they encounter in their daily lives. Ciascai, Felezeu, and Haiduc (2014) also suggested that experimentation, observations, and hands-on activities should be used to enhance conceptual learning in science education. Although conceptual learning is the foundation for understanding the processes and makeup of science, inquiry-based learning provides a deeper understanding and a venue through which learning information can be applied to make real-life connections (Ciascai, Felezeu, and Haiduc, 2014). Savery (2015) esteemed inquiry-based learning with empowering science learners to learn scientific information and data through conducting research, integrating theory and practice, and applying knowledge and skills to find solutions to science-related issues. Cheng and Tsai (2013) maintained the key to teaching science is in using the five inquiry phases of Orientation, Conceptualization, Investigation, Conclusion, and Discussion. By using these and other inquiry skills, learning environments can make significant gains to building scientifically literate and proficient learning communities (Abdi, 2014; Cheng & Tsai, 2013; Savery, 2015).

Eilks, Hofstein, Mamlok-Naaman, and Stuckey (2013) proposed that the primary goal of science education should be to educate students about the fundamentals of the biological, chemical, and physical world that science presents and about the way science works and operates. Eilks, Hofstein, Mamlok-Naaman, and Stuckey (2013) also recommended that science courses with learning objectives designed to provide a foundational education for future scientists and engineers be offered and promoted. In a European study by Akilli and Genc (2017), it was suggested that the purpose of science education is to educate each student to become science-literate by equipping them with scientific reasoning skills and knowledge. According to Akilli and Genc (2017), a student is science-literate if they are inquisitive, decisive, problem-solvers, effective communicators, and have knowledge, skills, and positive perceptions concerning science and its influence on society. Ferrerira and Morais (2013) conducted a mixed-methods study in Portugal addressing the complexity of practical work in science curricula. According to Ferrerira and Morais (2013), the primary goal of science education curricula should be to provide students with learning experiences where they interact with scientific information and materials to gain processing skills that result in scientific knowledge to better understand the natural world. Clough (2011) investigated incorporating the nature of science as a component of science education. Clough (2011) concluded that teaching students to understand the nature of science should be the primary goal of science education. By doing so, public issues involving science and technology will be better understood by the general public, instead of being misconstrued due to most individuals' lack of knowledge concerning the nature and mechanisms of science (Clough, 2011; Combs, Slate, & Vijil, 2012).

Teacher proficiency is a critical component in science education. According to Basile, Kimbrough, Koellner, and Swackhamer (2009), teachers should be proficient and skilled in the content area in which they teach. Koehler and Mishra (2006) deemed pedagogical content knowledge as significant to science education and curriculum. A Saudi Arabian study done by Almazroa and Al-Shamrani (2015) concluded that teacher quality and subject area expertise are the keys to successful learning and teaching in science. According to Beijaard, Van Driel, and Verloop (2001), pedagogical content knowledge is crucial to the reformation of science education and is achieved through long-term professional development programs aimed at proliferating teachers' practical knowledge of science. In a study done by Abd-El-Khalick, Destefano, and Houseal (2014), pedagogical content knowledge was found to not only be essential to the effectiveness of science education, but it was also deemed influential to students' and teachers' attitudes, motivation, and perspectives towards science.

Science Proficiency

The current reformation of science education and curricula emphasizes improving the science proficiency of students and learners. Science proficiency is defined as the scientific understanding and abilities that students need to thrive in a progressively data-driven culture (Ceccucci, Jones, & Tamarkin, 2015; Enderle, Grooms, Sampson, & the Society for Research on Educational Effectiveness, 2013). Being scientifically proficient suggests that an individual can recognize scientific concerns motivating federal and state decisions and communicate ideas and viewpoints that are both scientifically and technologically driven. A scientifically proficient learner should be able to assess the significance of scientific data based on its source and the approaches utilized to produce it (Ceccucci, Jones, & Tamarkin, 2015). As Enderle, Grooms, Sampson, and the Society for Research on Educational Effectiveness (2013) described:

> Individuals that are scientifically proficient can: (a) understand and use scientific explanations of the natural world; (b) understand the nature and development of scientific knowledge; (c) create and evaluate scientific explanations and arguments, and (d) productively participate in the practices and discourse of the scientific community. (p.1)

According to the NSSG (2017), the four strands of science proficiencies consist of (1) students identifying scientific rationalizations, (2) students composing scientific data, (3) students deliberating on scientific information, and (4) students contributing constructively in science. The first strand, identifying scientific rationalizations, centers on the interdependence between subject matter comprehension and the formation of scientific understandings as a result of the connections of the concepts (Im & Kim, 2014; NSSG, 2017). The second strand, composing scientific data, involves the expertise and abilities required for the development and assessment of scientific data (Buxton & Lee, 2013; NSSG, 2017). The nature of science is the focus of the third strand, students deliberating on scientific information. The nature of science is that it is ever changing and; therefore, scientific knowledge must be reviewed as these changes happen. The fourth strand and final strand is contributing constructively to science. This strand encompasses opportunities to participate in demonstrating concepts and examining and deliberating delineations of those concepts with members of the scientific community (NSSG, 2017; Straits & Zwiep, 2013).

In a quasi-experimental study done by Alston and Marshall (2014), the results concluded that higher levels of science proficiency were achieved among high school students when teachers utilize inquiry-based instruction. The inquiry-based instruction requires students to be actively engaged in the process of learning science that can proliferate their science proficiency and literacy (Abdi, 2014; Alston & Marshall, 2014). Hogrebe and Tate (2010) used a quantitative multiple regression designs to investigate factors that could influence the science proficiency of 10^{th}-grade students in Missouri. It was found that dynamics such as school climate, teacher qualification and certification, and geographic location are predictive factors of science proficiency in high school students (Hogrebe & Tate, 2010). In schools with positive school climate and highly qualified teachers with advanced degrees, the science proficiency levels of the students, no matter their demographics, were higher as measured by the state test in science (Hogrebe & Tate, 2010). Clark, Martinez-Garza, and Nelson (2013) suggested that digital, educational games could proliferate students' science proficiencies. For these games to be deemed effective, they must result in the improvement of students' science learning outcomes, increasing students' motivation to participate in activities of science learning, and increasing students' engagement with specific scientific learning tasks (Clark, Martinez-Garza, & Nelson, 2013).

Instructional Tools

Instructional tools are defined as any resources used to assist teachers in improving students’ knowledge, skills, and abilities in a subject area or course (Chingos & Whitehurst, 2012). Instructional tools are used to aid in instruction and learning to meet the learning needs and preferences of every student (Cicco, 2015). According to Hussain, Rifat, Safdar, and Shah (2012) instructional tools provide meaning connections between concepts and prepositions.

Various instructional tools such as textbooks, workbooks, graphic organizers, videos, laboratory equipment, and computers can be utilized by teachers in all disciplines to improve students’ proficiencies and understanding of content-related coursework. The federal government mandates the use of technology in the modern classroom; therefore, in recent years, Facebook has been utilized as an instructional tool. As explained by Iqbal, Khushi, and Rehman (2016):

> Facebook can be utilized in the delivery of information, reference books, cluster assignments, and course sessions. Teachers and students can send materials, locations of sites, and videos concerning courses on Facebook and shows, assignments, and different documents of the scholars that may be shared by

> forming links to Google documents. Facebook may be used to share materials (video files, audio files, pictures, computer programmed, presentation, database, websites, etc.). (p. 171)

In current classrooms, blogging is used as an instructional tool. Blogs can be used in the classroom to involve students in dialogue, encourage peer learning and tutoring, and proliferate students' literacy skills (DiGregorio & Featro, 2016). In a quasi-experimental study, Kayaoglu and Turgut (2015) investigated the effectiveness of using rubrics as instructional tools in English as a Foreign Language (EFL) courses. The results revealed that utilizing rubrics as an instructional tool helped students to use correct grammar and exhibit stronger writing skills. In a Malaysian study done by DeWitt, Kaur, Yong, and Zin (2014), the effects of using videos as instructional tools in tertiary English as a Second Language (ESL) classrooms were examined. DeWitt, Kaur, Yong, and Zin (2014) found that using videos as an instructional tool increases students' retention of subject content and supports cognitive stimulation. The use of Interactive Whiteboards as instructional tools has increased in recent years. Interactive Whiteboards, developed specifically for teachers, can be utilized to increase learner motivation and engagement, develop thinking skills, increase retention of information, and promote interaction between students (Abuhmaid, 2014). Annan-Coultas (2012) studied the effects of utilizing laptops as instructional tools on student learning. Although laptops can impair student learning used during class for non-educational intentions, they bolster student achievement when used for notetaking, operating the course-related software, accessing course information, completing online assessments, and conducting research (Annan-Coultas, 2012; Biancarosa & Griffiths, 2012; Iqbal, Khushi, & Rehman, 2016). Arop, Umanah, and Effiong's quasi-experimental study (2015) provided quantitative evidence that the use of instructional tools, similar to interactive notebooks, can have favorable effects on students' achievement in science concepts

Interactive Notebooks

Many educators across the nation are currently using interactive notebooks daily as an instructional tool to record and model course information and notes, process ideas and make connections, accommodate multiple learning styles, and demonstrate content learned through reflective writing and discussion (Meyer, 2014; Shen, 2014; Shepard, 2016). Interactive notebooks are defined as instructional tools that provide students with personal, organized, and documented learning records usually encompassed in composition notebooks (Crippen & Waldman, 2009). The interactive notebook also helps students organize their thinking and take ownership of their learning through creativity and color (Meyer, 2014; Shen, 2014; Shepard, 2016). Through the utilization of interactive notebooks, teachers can perform continuous formative assessments that can be used to navigate their lesson planning and pedagogical practices (Nichols, 2015).

In a study done by Daley et al. (2013), it was found that utilizing interactive notebooks result in higher levels of interest, feelings of competence, and autonomy in students in science courses. A study by Curtis, Derksen, and Roscoe (2013) also provided a rationale for integrating interactive notebooks into middle school science lessons to engage students in learning and to assist in their comprehension of core scientific concepts. Frels et al. (2011) established that utilizing interactive notebooks with doctoral students and instructors increased or improved their teaching and learning of rigorous qualitative research. Crippen and Waldman (2009), Dickinson and Summers (2011), Fulton (2017), Stencel (1998), and Young (2003) deemed the utilization of interactive notebooks imperative to the inquiry-based learning approach in science education and curriculum. The use of interactive notebooks can increase students' science proficiency by allowing them to ask questions, collect and analyze data, conduct statistical analysis, interpret data, and draw conclusions (Crippen & Waldman, 2009; Dickinson & Summers, 2011; Fulton, 2017; Stencel, 1998; Young, 2003). Heilbronner and Mallozzi (2013) examined whether the consistent use of metacognitive strategies embedded in an Interactive Student Notebook (ISN) would affect science process skills of 7^{th}-grade students. Their results suggested that utilizing interactive notebooks in science classrooms could improve students' processing skills and cognitive thinking; therefore increasing students' science proficiency and achievement (Heilbronner & Mallozzi, 2013).

Quasi-Experimental Research Design

This study, quantitative in nature, will use a quasi-experimental research design. The phrase "quasi-experiment" arose from the work of Campbell and Stanley (1963). The use of the quasi-experimental design in educational research has increased significantly over the last 30 years (Feser, 2013). Experimental design methodologies are suitable for determining the effect that independent variables have on the dependent variable in studies. The additional use of a quasi-experimental design will allow for the non-random assignment of subjects. Under the quasi-experimental design, the participants can be in existing groups in educational settings (Creswell, 2012; Lodico, Spaulding, & Voegtle, 2010). Therefore, according to Feser (2013), when using the quasi-experimental design "nonrandom selection means that observed effects for any untreated group are a likely biased estimate of counterfactual outcomes and thus special care must be taken to mitigate that bias" (p.45). Particularly important for this study, a quasi-experimental design allows minimal disruption of the learning environment by assigning existing groups as either experimental or control (Cook, 2015; Creswell, 2012; Dong & Maynard, 2013; Krishnan & Sitaraman, 2013; Lodico, Spaulding, & Voegtle, 2010). Existing data will be used to compare the two groups of students' science proficiency.

There are identified advantages and disadvantages of the quasi-experimental design. Benefits of this research reducing ethical concerns involved with the pre-selection and random assignment of public school students (Cook, 2015; Creswell, 2012; Dong & Maynard, 2013; Feser, 2013; Krishnan & Sitaraman, 2013; Lodico, Spaulding, & Voegtle, 2010). Disadvantages of non-randomized sampling include limited generalizability and increased threats to internal validity due to pre-existing factors within the environment (Cook, 2015; Creswell, 2012; Dong & Maynard, 2013; Feser, 2013; Krishnan & Sitaraman, 2013; Lodico, Spaulding, & Voegtle, 2010).

Many studies in education have utilized the quasi-experimental research design to carry out investigations. Bentsen, Nielsen, Schipperijn, and Schneller (2017) employed the quasi-experimental design to investigate the effects of education outside of the classroom or the movement integration on children's physical activities as measured by using accelerometers taped to the lower back. Berberoglu and Koksal (2014) utilized the quasi-experimental design to investigate the effectiveness of the guided-inquiry approach in science classes when compared to present science and technology curriculum in initiating content-based science achievement, science process skills, and attitude toward science of sixth-grade students in Turkey. A quasi-experimental study of the effectiveness of an early intervention health education campaign to positively influence knowledge, intention, and performance among females of a reproductive age was conducted by Bigham, Bland, Marshall, and Melton (2016). Chiang, Hwu, and Lin (2013) used a quasi-experimental design to explore the effects of a multimedia interactive DVD on improving nurse learning and disability assessment skills on nursing students. The quasi-experimental pretest-posttest design was utilized in Bulunuz's study (2013) to find that kindergarten children taught science through play had a greater understanding of science concepts than kindergarten children taught science through direct instruction. Aimed at characterizing the attitudes of Portuguese university students towards same-sex couples adopting, Fontaine and Gato (2016) used the quasi-experimental design to carry out their investigation. As shown, the use of quasi-experimental design has been established in the educational research literature.

Implications

This quasi-experimental study analyzed student scores from two existing groups at Local High School to determine if there was a statistically significant difference associated with the curriculum. The experimental group participated in a Biology 1 curriculum where interactive notebooks were embedded and the control group participated in a Biology 1 curriculum without the use of interactive notebooks. Existing scores from the SATP Biology 1 assessment were analyzed to determine if students' science proficiency scores were statistically different based on the curriculum. Therefore, this study has a direct implication on a suburban high school, with stagnant science proficiency performance levels, located in a state with declining science proficiency performance levels (DCS, 2017; MDE, 2017). This study supplied evidence to support or not support the use of interactive notebooks to raise student proficiencies in science at Local High School, Local County School District, and possibly public high schools across the state of Mississippi (DCS, 2017; MDE, 2017). In 2018, all science curricula in Mississippi is being restructured and the push for improving student achievement is prevalent (MDE, 2017). Given these factors, this study has potential for identifying a possible new curriculum-embedded instructional strategy for improving students' science proficiencies.

Consequently, this study investigated the effect of using interactive notebooks on students' science proficiencies with a quantitative research design. Assessment data from two parallel Biology 1 classrooms, one where interactive notebooks were embedded into the curriculum and one where they were not embedded in the curriculum, were tested to determine if there was a statistically significant difference in science proficiency levels. This study aimed to reveal the influence of a curriculum-embedded instructional tool on the science proficiency of high school Biology 1 students in a suburban school district in Mississippi.

Summary

This quantitative project study used IDT (2010) to inform the development of the research question by substantiating that *how* information is learned, such as with interactive notebooks, is an important issue for research with regard to curriculum design. The MMECCA framework (2002) further connected the research question, study purpose, and problem within the peer-reviewed literature of standards-based curriculum and learning. This study examined the use of a curriculum-embedded instructional tool on students' science proficiency as measured by a standardized assessment (Arop, Umanah, & Effiong, 2015; Bektaş & Kızkapan, 2017: Çıbık, 2016). The results can help bridge the gap in practice of different existing Biology 1 curricula at Local High School without research-based understanding of the impact on science proficiency. The results from this project study can help those making policy decisions for the local school district to determine if interactive notebooks should be encouraged in all Biology 1 curricula. The results from this project study have potential for social change as this information can be used to inform educators of a possible instructional tool to increase science proficiency.

Section 2: The Methodology

Research Design and Approach

The approach to this study was quantitative with a quasi-experimental research design. Consistent with this approach, ex post facto data were used for analysis. The existing data, students' 2016-2017 Biology 1 SATP assessment scores, were readily available to employees from the state and school district's databases (DCS, 2017; MDE, 2017). Experimental design methodologies are useful for determining the effect that an independent variable has on a dependent variable. The additional use of a quasi-experimental design allowed for the non-random assignment of subjects. Under the quasi-experimental design, the participants were already in existing groups within their educational setting (Creswell, 2012; Lodico, Spaulding, & Voegtle, 2010). Additionally, a quasi-experimental design allowed the study to proceed with minimal disruption of the learning environment by assigning existing groups as either experimental or control (Cook, 2015; Creswell, 2012; Dong & Maynard, 2013; Krishnan & Sitaraman, 2013; Lodico, Spaulding, & Voegtle, 2010).

The 2016-2017 science proficiency mean scores from a pretest and a posttest taken by two parallel groups of Biology 1 students were compared in this study. The experimental group consisted of Biology 1 students at Local High School who were in a course where interactive notebooks were regularly used (embedded) as an instructional tool from August 2016 until May 2017. The control group consisted of Biology 1 students whose curriculum included only traditional instructional tools (textbooks and

PowerPoint notes) during the same time period (Creswell, 2012; Dong & Maynard, 2013; Krishnan & Sitaraman, 2013).

To protect the internal validity of the quasi-experiment, both the experimental and control groups were: (a) taught from the same Mississippi Biology 1 framework; (b) followed the same pacing guide as set by the Local County School District, (c) assessed according to the same standards; and (d) were in semesters of the same length (Cook, 2015; DCS, 2017; Dong & Maynard, 2013; Krishnan & Sitaraman, 2013, MDE, 2017).

Data from the CASE 21 assessment, a district-issued assessment, were used to establish whether the experimental and control groups started out equally in science proficiency (Cook, 2015; Creswell, 2012; Krishnan & Sitaraman 2013).

Setting and Sample

This study used existing student scores from two groups of students at Local High School located in Northwest Mississippi. Local High School is a suburban public school that serves almost 1,200 students in Grades 9-12 (DCS, 2017; MDE, 2017). Eighty of the student population at Local High School is White, with only 26% receiving free or reduced lunch (DCS, 2017; MDE, 2017). Existing student scores from eight Biology 1 classrooms were used in the study. A teacher using traditional tools of instruction taught four of the classes and a teacher using interactive notebooks as the main instructional tool taught the other four. The sample size was $N = 184$; with $n = 93$ for the control group and $n = 91$ for the experimental group (DCS, 2017; MDE, 2017).

Instrumentation and Materials

Data from two instruments were used for this study. The first instrument was the CASE 21 assessment. Data from the CASE 21, a district-issued diagnostic assessment patterned to resemble the SATP Biology 1 assessment, was used to establish whether the experimental and control groups started out equally in science proficiency (DCS, 2017; MDE, 2017). This test is a paper-pencil, untimed assessment administered in parallel academic environments as the SATP Biology assessment (DCS, 2017; MDE, 2017).

Data from the SATP Biology 1 assessment was used to compare the science proficiency of the Biology 1 students from both the control and experimental groups after two semesters (DCS, 2017; MDE, 2017). The SATP Biology 1 assessment is a computer adaptive, untimed assessment, administered at the closure of each semester to measure students' science proficiencies (DCS, 2017; MDE, 2017). There are six individual categories or competencies on the SATP Biology 1 assessment. These categories or competencies are Inquiry, Biochemical Basis of Life, Living Organisms and Their Environment, Biological Organization, Heredity, and Diversity and Biological Change.

Data Collection and Analysis

The study employed ex post facto strategy in that preexisting data was used. The data, readily available to district employees, were the raw scores of Biology 1 students at Local High School collected from two different instruments. Since the archival data contained the names of the students, the school administrators agreed to encode the students' identities by assigning a unique ID number to each test score. By doing this, the confidentiality of the students was protected, and the researcher did not know the identity of the students (Creswell, 2012; Triola, 2012).

Proposed Statistical Analysis. First, an independent samples *t* test was performed on data from the pretest (CASE 21) to establish if the two groups began the study with similar science proficiencies. Second, an independent samples *t* test was conducted using overall mean scores from the SATP Biology 1 Assessment to determine if there was a statistically significant difference in the overall science proficiency of the two groups (Creswell, 2012; Triola, 2012). Third, independent *t* tests were conducted using student data broken down by category or competency to determine if there was a statistically significant difference between the two groups for each of the six category of the SATP Biology 1 Assessment. The alpha level for the study was preestablished at .05 (Creswell, 2012).

Protection of Participants' Rights

The researcher did not access the data until official approval from the IRB at Walden University was received (IRB approval number 03-20-18-0499937). The researcher obtained written permission from both the Local School District's superintendent and Local High School's administration. Once the data was obtained, the researcher safeguarded the data in a password-protected file, secured on a personal computer housed in a locked room (Creswell, 2012; Triola, 2012). Necessary practices were in place to protect the well-being and rights of all participants in the study (Creswell, 2012; Triola, 2012). Given that this study was quantitative and its data came from archival information, it did not constitute a high level of risk for the participants (Creswell, 2012; Triola, 2012). There was always some risks involved for human participants of this research study, however. Consequently, student identifiers were removed before the researcher accesses the data. Specifically, the school administration removed all student identifiers from the data before releasing it to the researcher. The score reports given to the researcher had only the teacher's names identified as the means to categorize the control group from the experimental group.

Assumptions, Limitations, Scope, and Delimitations

Due to the quantitative nature of this study, there were several assumptions regarding this research. This study was based on the assumption that the quality of instruction that the students of both groups received within each semester of the school year was equivalent. It was also assumed that the students can be equitably compared because they share similar socioeconomic status backgrounds, demographics, and educational environment.

Due to the use of non-randomized sampling, this study has limited generalizability past implications made for Local High School. However, this study can serve as a catalyst concerning the utilization of various instructional tools, such as the interactive notebooks, in science education as a mean to proliferate science proficiency.

This study has a narrow scope of analysis. Addressing two research questions, this study investigated the way the independent categorical variable of embedded interactive notebooks in the Biology 1 curriculum affected the dependent interval variable of science proficiency within the 2016-2017 school year. Ultimately, this study has evident limitations of investigating the effect of utilizing the curriculum embedded interactive notebooks on students’ science proficiency at a solitary setting, Local High School.

This study was purely quantitative by investigating the possible effect the interactive notebooks had on the science proficiency of Biology 1 students as measured by their scores on the SATP Biology 1 assessment. The qualitative features of utilizing the curriculum embedded interactive notebooks or utilizing traditional methods of instruction were not considered in this study. This study's sole concentration was to measure the influence that the utilization of curriculum embedded interactive notebooks as an instructional tool had on students' science proficiency as evidenced by students' performance on the SATP Biology 1 assessment.

Data Analysis Results

Through a quasi-experimental design, this quantitative study examined the effect of utilizing curriculum embedded interactive notebooks on the science proficiency of Biology 1 students as measured by their performance on the SATP Biology 1 assessment during the 2016-2017 school year. The foundation of this study rested upon using interactive notebooks as an instructional tool to proliferate students’ science literacy and proficiency in science curriculum and courses. Local High School had in place two differing Biology 1 curricula; in one curriculum, the students regularly used interactive notebooks, and they did not in the other curriculum. These two curricula were established and preexisted before the inception of this study and were not influenced or altered by the researcher. There were two cohorts for this study, a group utilizing interactive notebook in the Biology 1 curriculum (experimental) and a group not utilizing interactive notebooks in the Biology 1 curriculum but traditional methods of instruction instead (control). The sample size was N = 184; with n = 93 for the control group and n = 91 for the experimental group (DCS, 2017; MDE, 2017). The qualitative properties of utilizing the curriculum embedded interactive notebooks or utilizing traditional methods of instruction were not investigated in this study.

The CASE 21 and SATP Biology 1 assessments were used as the comprehensive benchmarks for science proficiency in this study. A district-issued diagnostic assessment patterned to resemble the SATP Biology 1 assessment, the CASE 21 assessment was used to establish whether the experimental and control groups started out equally in science proficiency (DCS, 2017; MDE, 2017). The SATP Biology 1 assessment is a state-issued, computer adaptive, untimed assessment administered at the closure of each semester to measure students' science proficiencies (DCS, 2017; MDE, 2017). The findings of the study are presented in the following section.

The mean scores of the Biology 1 students in the control (students not utilizing interactive notebooks) and experimental (students utilizing interactive notebooks) groups on the CASE 21 assessment were analyzed to determine if the two groups began on the same level of science proficiency. An independent samples t test was conducted to compare the science proficiency of students on the CASE 21 assessment from classrooms where the interactive notebook was utilized in the curriculum and in classrooms where the interactive notebooks were not utilized in the curriculum. There was no significant statistical difference in the scores pertaining to science proficiency for students utilizing interactive notebooks (*M* = 655.60, *SD* = 6.65) and students not utilizing interactive notebooks (*M* = 653.80, *SD* = 9.45); $t(182) = 1.50$, $p = .136$. Specifically, these results indicate that students in both the control and experimental groups began roughly on the same levels of science proficiency as measured by the CASE 21 assessment. Table 5 presents the group statistics of the science proficiencies for the two groups of students on the CASE 21 assessment. The average score for students utilizing interactive notebooks within the curriculum, the experimental group, on the CASE 21 assessment was 655.60 and the average score for students not utilizing the interactive notebooks within the curriculum, the control group, was 653.80. Table 6 demonstrates the statistical difference between the two groups of students on the CASE 21 assessment as presented on the independent samples *t* test ($F = 11.542$, $p = .136$). Figure 1 exhibits the mean score comparison between the control and the experimental group. Conclusively, Figures 2 displays the raw CASE 21 score distribution of the students' science proficiency for the control and the experimental group.

Table 5

Group statistics of control and experimental groups for CASE 21 assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	653.80	9.452	.980
With Interactive Notebooks (Experimental)	91	655.60	6.653	.697

Table 6

Independent samples t test for science proficiency: Control and experimental group on CASE 21 assessment

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Case 21 Scores	Equal variances assumed	11.542	.001	1.498	182	.136	1.809	1.207	-.574	4.191
	Equal variances not assumed			1.504	165.406	.135	1.809	1.203	-.566	4.184

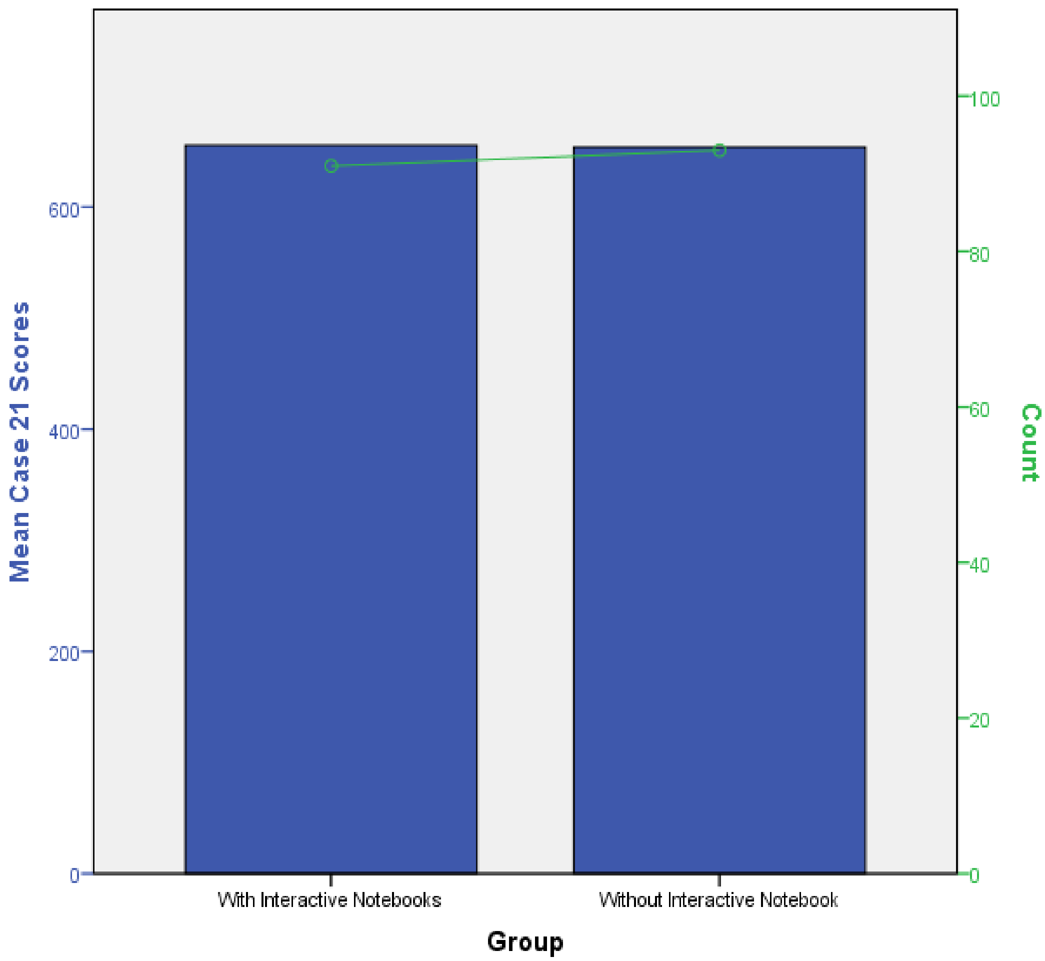

Figure 1. Mean scores: $M_{experimetal}$ = 655.60, $M_{control}$ = 653.83.

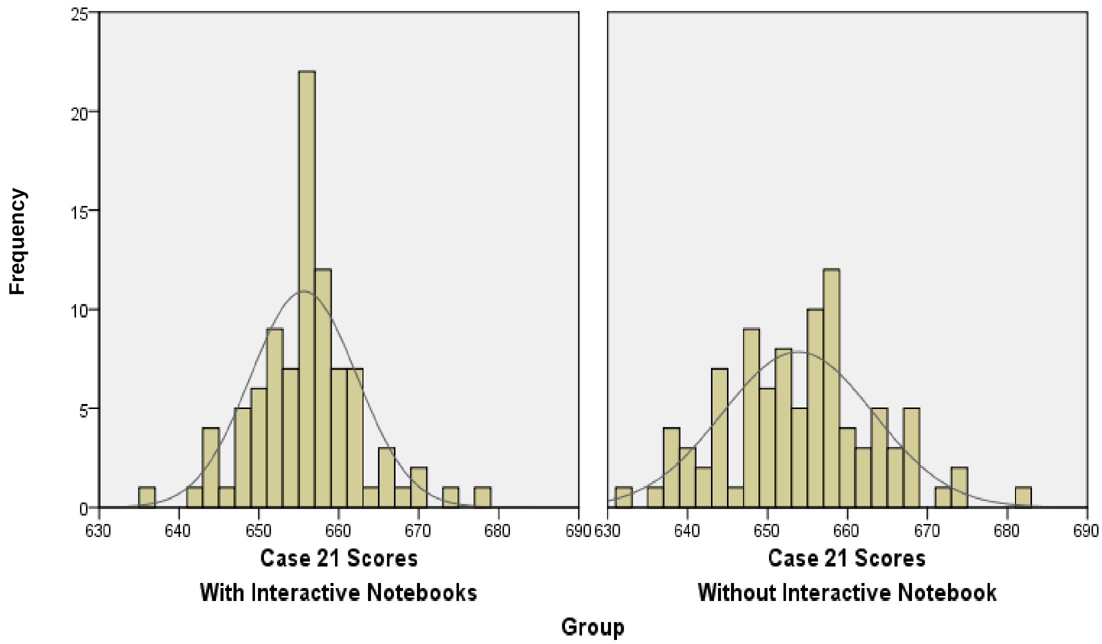

Figure 2. CASE 21 scores of the experimental and control group.

a. Experimental: Mean = 655.60, Standard Deviation = 6.65, *N*= 91
b. Control: Mean = 653.83, Standard Deviation = 9.45, *N*= 93

RQ_1: Science Proficiency Based on Standardized Biology 1 Scores between Classes Utilizing and Not Utilizing Interactive Notebooks

To investigate the influence of utilizing curriculum embedded interactive notebooks on the science proficiency of students on the SATP Biology 1 assessment, the study analyzed the mean scores of students from Local High School from the 2016-2017 school year (RQ_1). This research question was answered using pre-existing, ex post facto student scores supplied by the data provider, Local County School District. To compare the science proficiency of students on the Biology 1 SATP assessment from classrooms where the interactive notebook was utilized in the curriculum and in classrooms where the interactive notebooks were not utilized in the curriculum, an independent samples *t* test was conducted (Creswell, 2012; Triola, 2012).

Hypotheses. $H_0 1$: No statistically significant difference exists in science proficiency levels, as evidenced by Biology 1 students' SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

$H_1 1$: A statistically significant difference exists in science proficiency levels, as evidenced by Biology 1 students' SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

Results. The experimental group, the group using interactive notebooks within the curriculum, had a higher level of science proficiency than the control group, the group not using interactive notebooks, as measured by the Biology1 SATP assessment ($M_{experimental}$= 659.92, *SD* = 7.65, $M_{control}$ = 656.13, *SD* = 10.49). The *F* ratio, calculated as the mean square between groups divided by the mean square within groups is 4.72 and it is associated with a *p* value of .006. Given the necessary significance threshold of .05, I rejected the null hypothesis and found that there was a statistical significant effect of utilizing interactive notebooks on the students' science proficiency. Table 7 presents the group statistics of the science proficiencies for the two groups of students on the Biology 1 SATP assessment. The average score for students utilizing interactive notebooks within the curriculum on the Biology 1 SATP assessment was 659.92 and the average score for students not utilizing the interactive notebooks within the curriculum was 656.13. Table 8 demonstrates the statistical difference between the two groups of students on the Biology 1 SATP assessment as presented by an independent samples *t* test ($F = 4.72$, $p = .006$). There is a 95% confidence that the true difference between Biology 1 SATP scores from students utilizing interactive notebooks and those students not utilizing the interactive notebook is captured between (1.12, 6.47), claiming to support that there is a significant difference between students with and without interactive notebooks. Students utilizing the interactive notebook performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students without interactive notebooks with 95% confidence. Figure 3 exhibits the mean score comparison between the control and the experimental group on the Biology 1 SATP assessment. Figure 4 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group. Conclusively, Figure 5 utilizes a box plot graph to illustrate the median, lowest value, highest value, and the 2nd and 3rd quartiles of the scores of the two groups on the Biology 1 SATP assessment.

Table 7

Group statistics of control and experimental groups for Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	656.13	10.50	1.088
With Interactive Notebooks (Experimental)	91	659.92	7.647	.802

Table 8

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Biology 1 SATP Scores	Equal variances assumed	4.723	.031	2.798	182	.006	3.794	1.356	1.119	6.469
	Equal variances not assumed			2.808	165.302	.006	3.794	1.351	1.126	6.462

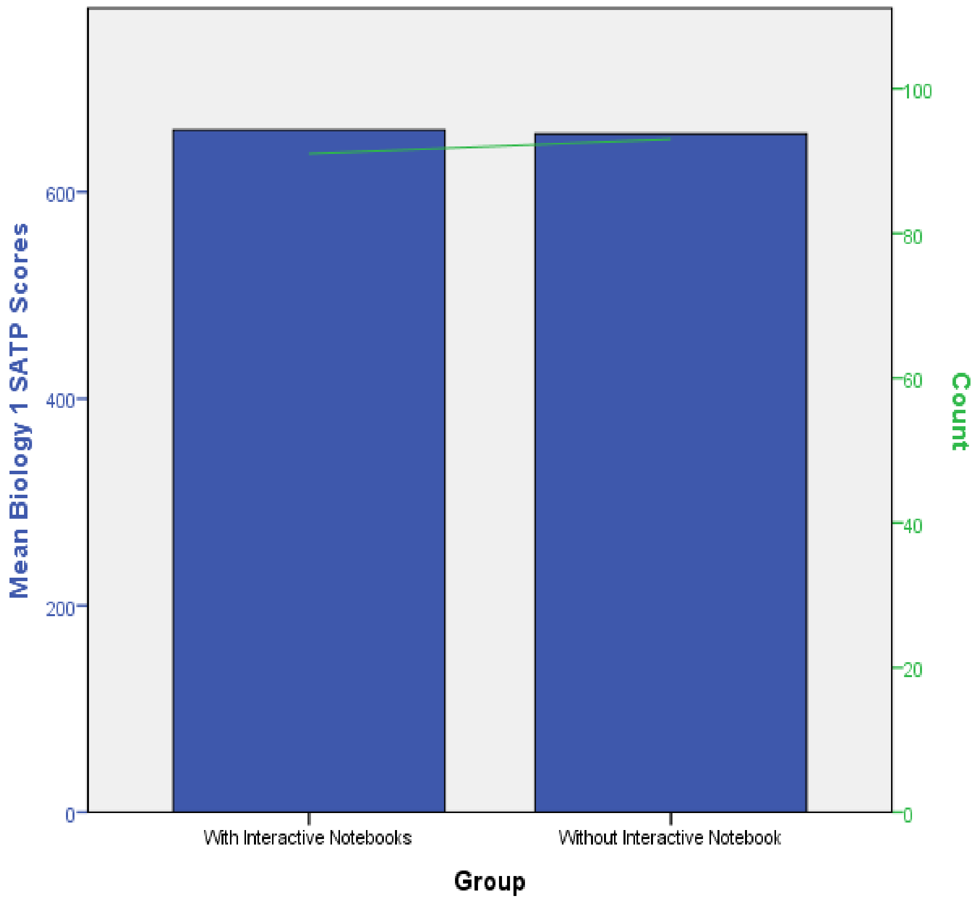

Figure 3. Means score: $M_{experimetal}$ = 659.92, $M_{control}$ = 656.13.

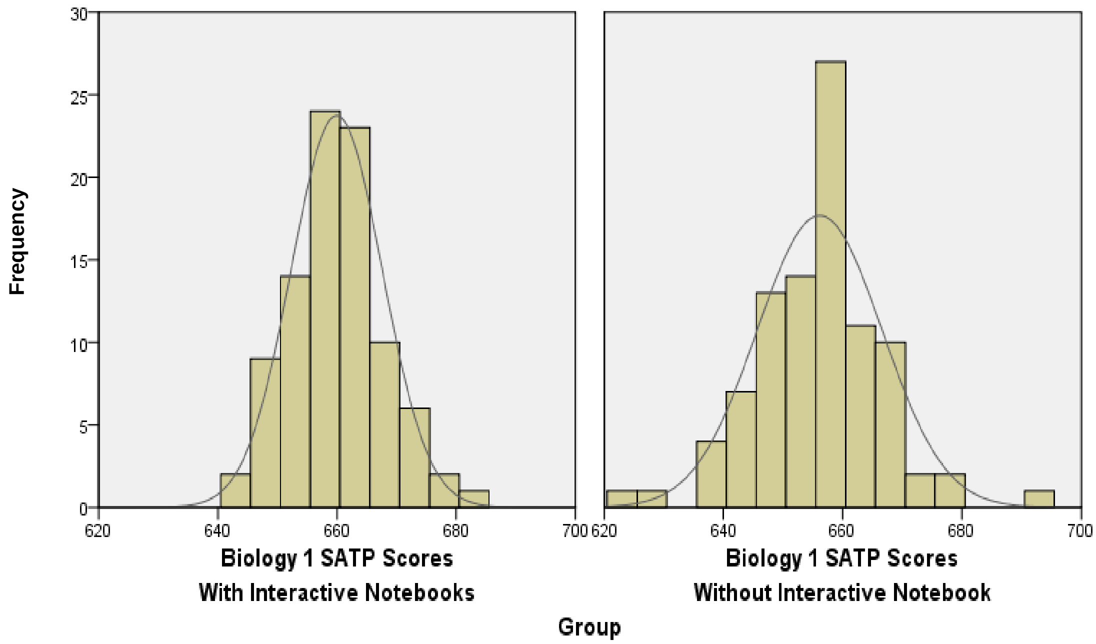

Figure 4. Biology 1 SATP scores of the experimental and control group.

a. Experimental: Mean= 659.92, Standard Deviation=7.65, *N*=91
b. Control: Mean =656.13, Standard Deviation= 10.50, *N*=93

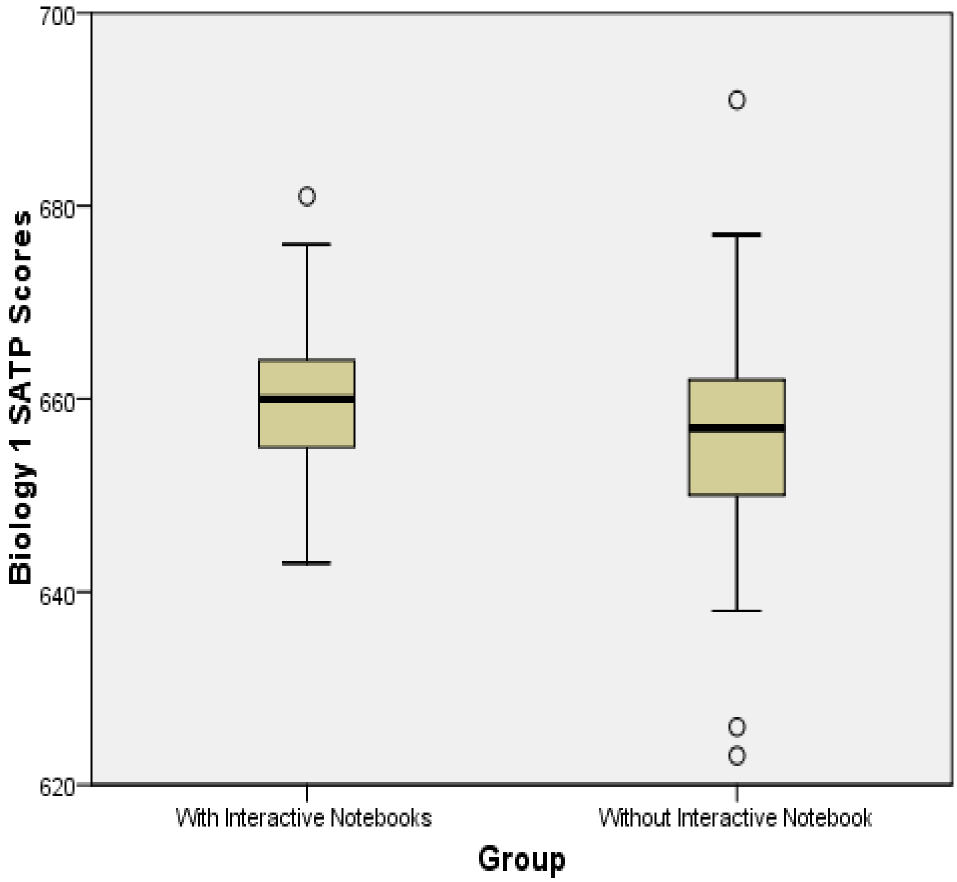

Figure 5. Box plot showing values, quartiles, and variability of Biology 1 SATP scores for the experimental and control group.

Discussion: How interactive notebooks impacted the science proficiency of the students on the Biology 1 SATP assessment? In this quasi-experimental study, the mean scores of two different groups for the Biology 1 SATP assessment were compared. As indicated in the aforementioned section, both groups started each semester on roughly similar science proficiency levels as measured by their performance on the CASE 21 assessment ($M_{control}$ = 653.83, *SD* = 9.45; $M_{experimental}$ = 655.60, *SD* = 6.65).

However, the mean scores of the Biology 1 SATP assessment suggested that there was a statistical significant difference in the science proficiency of students utilizing the interactive notebook (experimental group) when compared to those not utilizing the interactive notebook (control group) ($M_{experimental}$ = 659.92, *SD* = 7.65, $M_{control}$ = 656.13, *SD* = 10.49). The *F* ratio was 4.72 and *p* = .006. The mean difference is significant at the 0.05 level. Given this α value, I rejected the null hypothesis and establish that there was a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for the Biology 1 SATP assessment. Students utilizing the interactive notebook performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students without interactive notebooks with 95% confidence.

***RQ₂*- Statistical Significant Difference among the Six Categories of the SATP Biology 1 Assessment between Classes Utilizing and Not Utilizing Interactive Notebooks**

To investigate the influence of utilizing curriculum embedded interactive notebooks on the science proficiency of students on the six competencies or categories of the SATP Biology 1 assessment, the study analyzed the mean scores of the students for each competency from Local High School for the 2016-2017 school year by conducting multiple independent samples *t* tests (Creswell, 2012; RQ_2; Triola, 2012). This research question was answered using pre-existing, ex post facto student scores supplied by the data provider, Local County School District. The theme or main focus for competency 1 was scientific inquiry, while, competency two's focal point was the biochemical basis of life. The nucleus for competency 3 was living things and their environment, however, competency four's focal point was biological organization. Competency 5 emphasized heredity, whereas, competency 6 highlighted diversity and biological changes. The maximum score for competency 1 is a 7, competency 2 is a 7, competency 3 is an 11, competency 4 is a 14, competency 5 is a 14, and competency 6 is a 7 (DCS, 2017; MDE, 2017).

Hypotheses. *$H_0$2:* No statistically significant difference exists in science proficiency levels among the six categories of the SATP Biology 1 assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

$H_1$2: A statistically significant difference exists in science proficiency levels among the six categories of the SATP Biology 1 assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

Competency 1 Results. The experimental group, the group using interactive notebooks within the curriculum, had about an equal level of science proficiency as the control group, the group not using interactive notebooks, for competency 1 as measured by the Biology1 SATP assessment ($M_{experimental}$ = 4.64, *SD* = 1.22, $M_{control}$ = 4.59, *SD* = 1.43). The *F* ratio, calculated as the mean square between groups divided by the mean square within groups was 1.67 and it was associated with a *p* value of .815. Given the necessary significance threshold of .05, I accepted the null hypothesis and found that there was not a statistically significant difference of utilizing interactive notebooks on the students' science proficiency for competency 1. Table 9 presents the group statistics of the science proficiencies for the two groups of students for competency 1 on the Biology 1 SATP assessment. The average score for students utilizing interactive notebooks within the curriculum on the Biology 1 SATP assessment for competency 1 was 4.64 and the average score for students not utilizing the interactive notebooks within the curriculum was 4.59. Table 10 demonstrates the statistical difference between the two groups of students on the Biology 1 SATP assessment for competency 1 as presented by an independent samples t test ($F = 1.67$, $p = .815$). There is a 95% confidence that the true difference between Biology 1 SATP scores from students utilizing interactive notebooks and those students not utilizing the interactive notebook is captured between (-.341, .433), claiming to support that there is not a significant difference between students with and without interactive notebooks for competency 1. Students utilizing the interactive notebook performed .341 points worse to .433 points better on the Biology 1 SATP assessment for competency 1 than students without interactive notebooks with 95% confidence. Figure 6 exhibits the mean score comparison between the control and the experimental group on the Biology 1 SATP assessment for competency 1. Figure 7 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 1. Conclusively, Figure 8 utilizes a box plot graph to illustrate the median, lowest value, highest value, and the 2nd and 3rd quartiles of the scores of the two groups on the Biology 1 SATP assessment for competency 1.

Table 9

Group statistics of control and experimental groups for competency 1 of the Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	4.59	1.431	.148
With Interactive Notebooks (Experimental)	91	4.64	1.216	.127

Table 10

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 1

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 1	Equal variances assumed	1.672	.198	.235	182	.815	.046	.196	-.341	.433
	Equal variances not assumed			.235	178.493	.815	.046	.196	-.340	.432

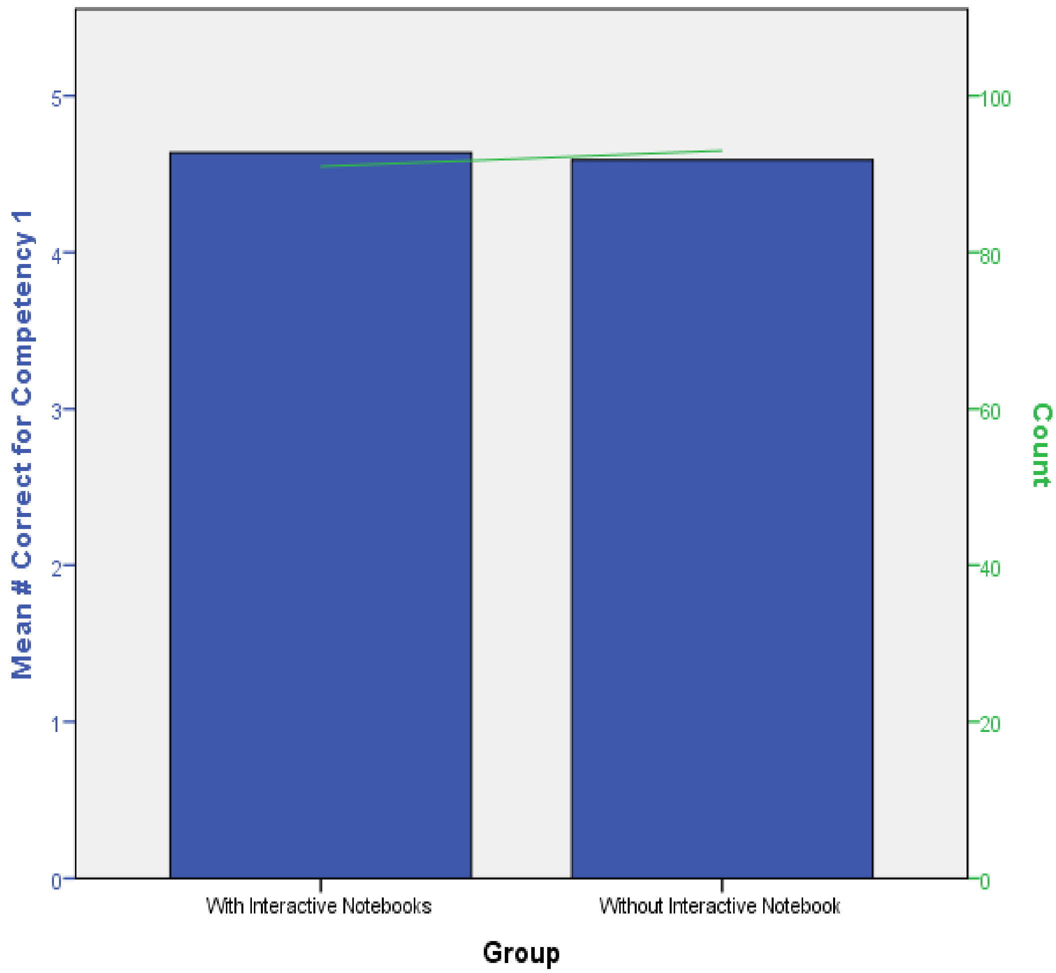

Figure 6. Mean scores: $M_{experimetal}$ = 4.64, $M_{control}$ = 4.59.

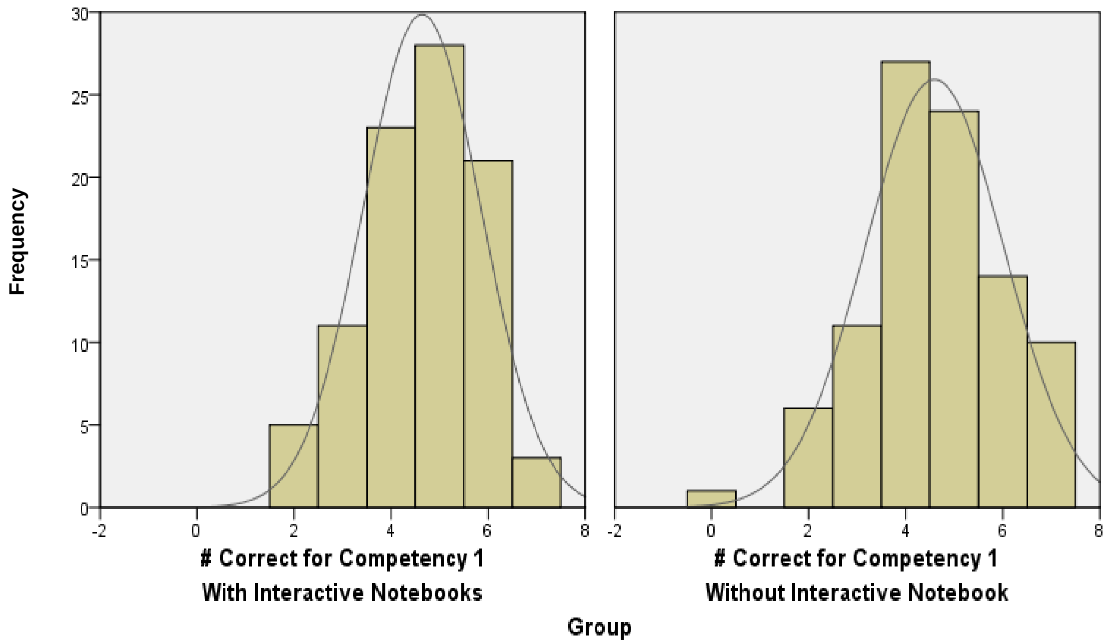

Figure 7. The experimental and control groups' Biology 1 SATP scores for competency 1

a. Experimental: Mean = 4.64, Standard Deviation = 1.22, *N* = 91
b. Control: Mean = 4.59, Standard Deviation = 1.43, *N* = 93

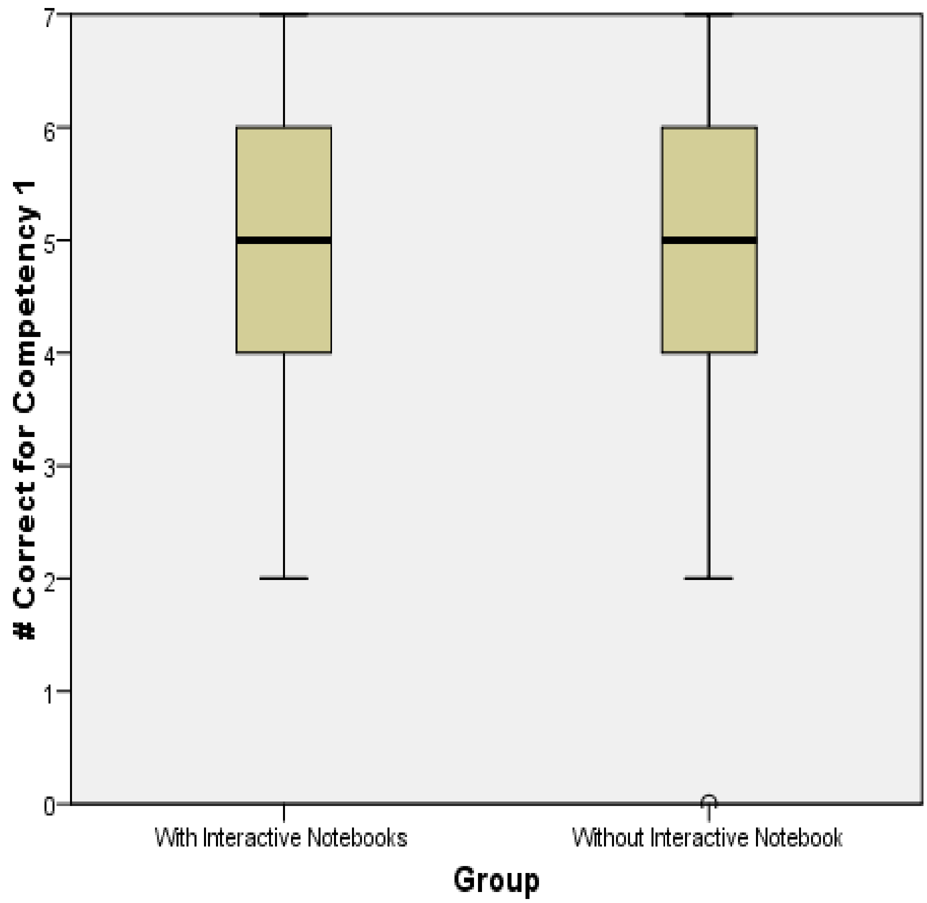

Figure 8. Box plot showing highest and lowest values, quartiles, and variability of competency 1 of the Biology 1 SATP scores for the experimental and control group.

Discussion: How interactive notebooks impacted the students' science proficiency on Competency 1? Although the results suggested no statistical significant difference between students utilizing the interactive notebook and students not utilizing the interactive notebook for competency 1 of the Biology 1 SATP assessment, it is necessary to affirm the impact utilizing interactive notebooks had on the science proficiency of the students as measured by the raw Biology 1 SATP scores. The experimental group had roughly the same level of science proficiency as the control group for competency 1 as measured by the Biology 1 SATP assessment ($M_{experimental}$ = 4.64, *SD* = 1.22, $M_{control}$ = 4.59, *SD* = 1.43). The *F* ratio was 1.67 and *p* = .815. The mean difference is significant at the 0.05 level. Given this α value, I accepted the null hypothesis and found that there was not a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 1. Students utilizing the interactive notebook performed .341 points worse to .433 points better on the Biology 1 SATP assessment for competency 1 than students without interactive notebooks with 95% confidence.

Competency 2 Results. The experimental group, the group utilizing interactive notebooks within the curriculum, had greater levels of science proficiency than the control group, the group not utilizing interactive notebooks, for competency 2 as measured by the Biology 1 SATP assessment ($M_{experimental}$ = 4.88, *SD* = 1.61, $M_{control}$ = 3.97, *SD* = 1.79). The *F* ratio, calculated as the mean square between groups divided by the mean square within groups was .989 and it was associated with a *p* value of .000. Given the necessary significance threshold of .05, I rejected the null hypothesis and found that there was a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 2. Table 11 presents the group statistics of the science proficiencies for the two groups of students for competency 2 on the Biology 1 SATP assessment. The average score for students utilizing interactive notebooks within the curriculum on the Biology 1 SATP assessment for competency 2 was 4.88 and the average score for students not utilizing the interactive notebooks within the curriculum was 3.97. Table 12 demonstrates the statistical difference between the two groups of students on the Biology 1 SATP assessment for competency 2 as presented by an independent samples *t* test ($F = .989$, $p = .000$). There is a 95% confidence that the true difference between Biology 1 SATP scores from students utilizing interactive notebooks and those students not utilizing the interactive notebook is captured between (.416, 1.41), claiming to support that there is a significant difference between students with and without interactive notebooks for competency 2. Students utilizing the interactive notebook performed .416 to 1.41 points better on the Biology 1 SATP assessment for competency 2 than students without interactive notebooks with 95% confidence. Figure 9 exhibits the mean score comparison between the control and the experimental group on the Biology 1 SATP assessment for competency 2. Figure 10 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 2. Conclusively, Figure 11 utilizes a box plot graph to illustrate the median, lowest value, highest value, and the 2nd and 3rd quartiles of the scores of the two groups on the Biology 1 SATP assessment for competency 2.

Table 11

Group statistics of control and experimental groups for competency 2 of the Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	3.97	1.790	.186
With Interactive Notebooks (Experimental)	91	4.88	1.611	.169

Table 12

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 2

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 2	Equal variances assumed	.989	.321	3.627	182	.000	.911	.251	.416	1.407
	Equal variances not assumed			3.631	180.747	.000	.911	.251	.416	1.407

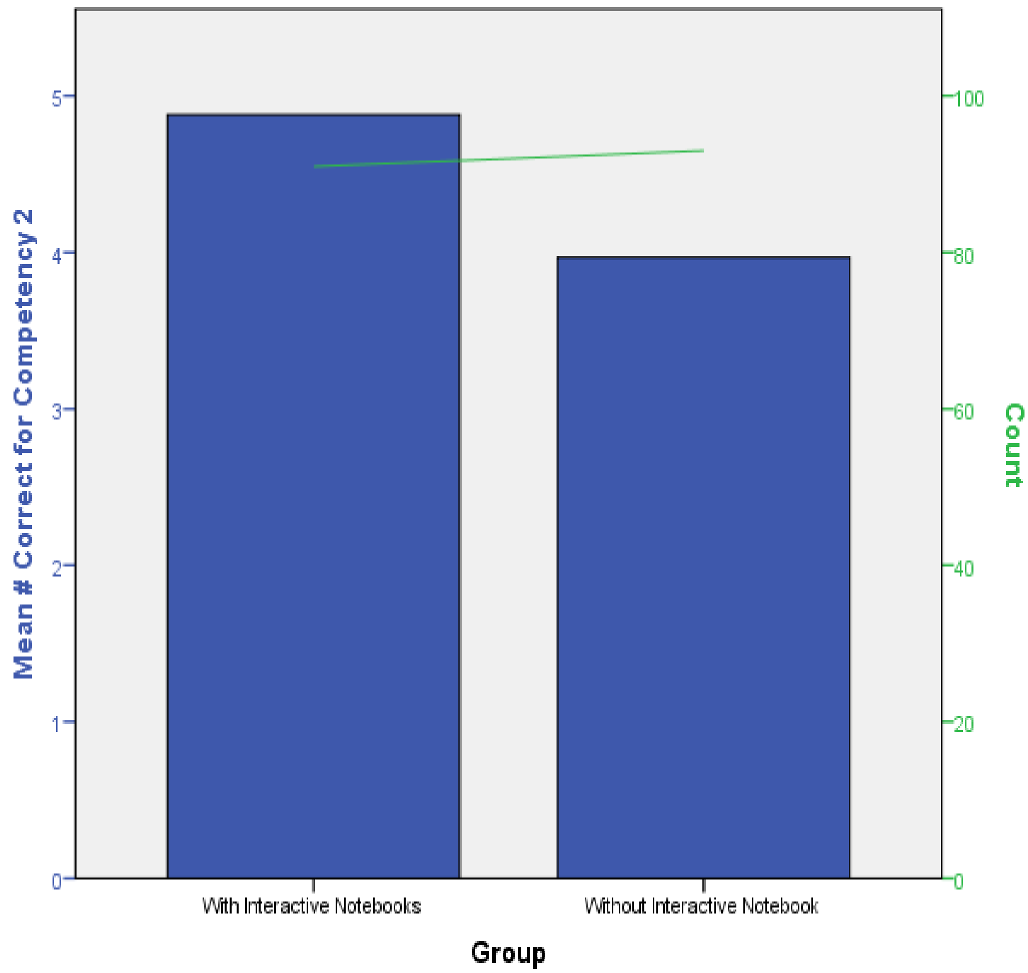

Figure 9. Means scores: $M_{experimetal}$ = 4.88, $M_{control}$ = 3.97.

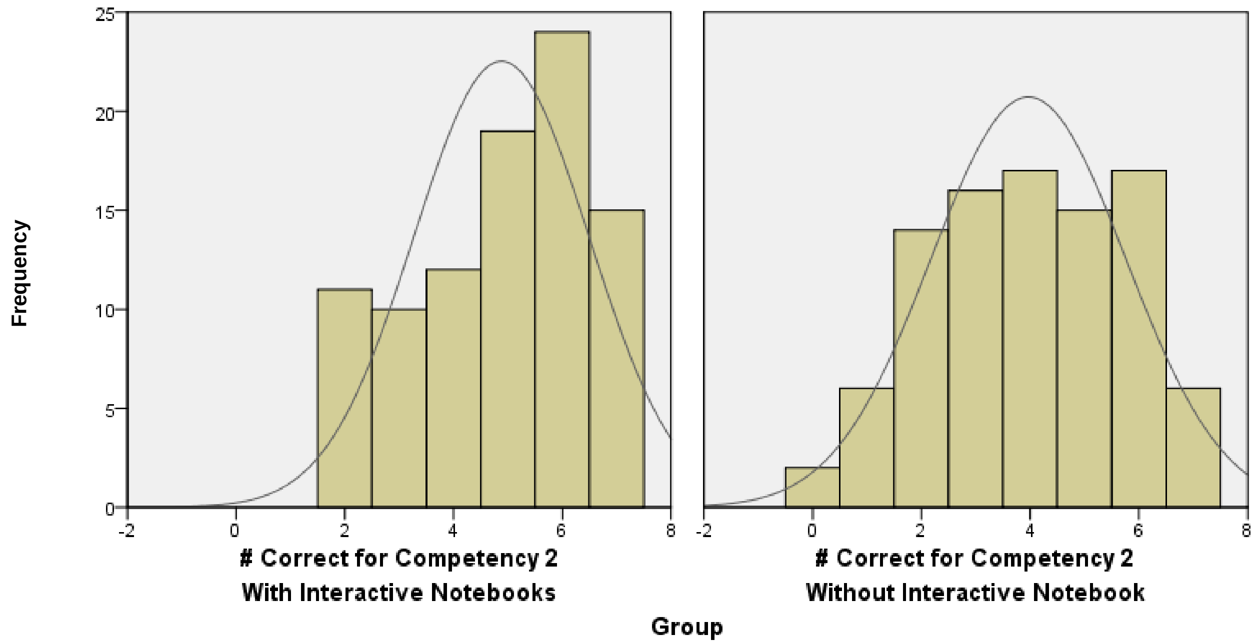

Figure 10. The experimental and control groups' Biology 1 SATP scores for competency 2

a. Experimental: Mean = 4.88, Standard Deviation = 1.61, $N = 91$
b. Control: Mean = 3.97, Standard Deviation = 1.79, $N = 93$

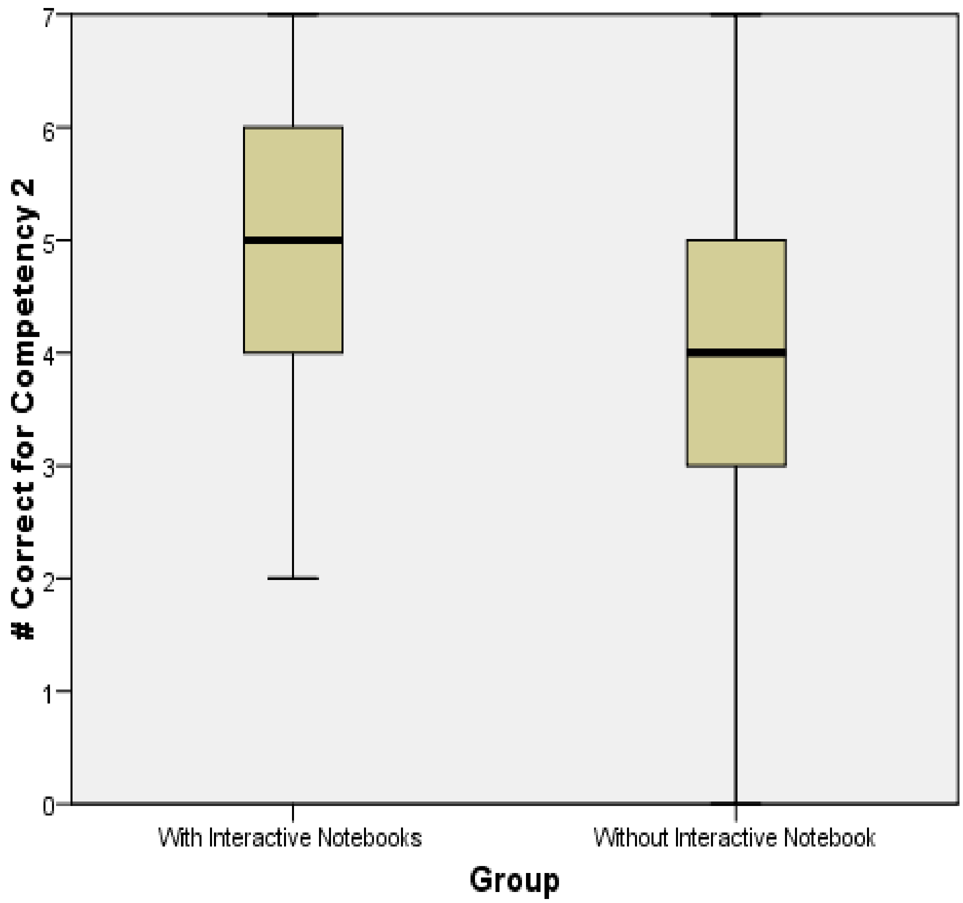

Figure 11. Box plot showing highest and lowest values, quartiles, and variability of competency 2 of the Biology 1 SATP scores for the experimental and control group.

Discussion: How interactive notebooks impacted the students' science proficiency on Competency 2? The results indicated that there was a statistical significant difference between students utilizing the interactive notebook and students not utilizing the interactive notebook for competency 2 of the Biology 1 SATP assessment, similarly to the results demonstrating the impact utilizing interactive notebooks had on the science proficiency of the students as measured by the raw Biology 1 SATP scores. The experimental group had a greater level of science proficiency than the control group for competency 2 as measured by the Biology1 SATP assessment ($M_{experimental}$ = 4.88, *SD* = 1.61, $M_{control}$ = 3.97, *SD* = 1.79). The *F* ratio was .989 and *p* = .000. The mean difference is significant at the 0.05 level. Given this α value, I rejected the null hypothesis and found that there was a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 2. Students utilizing the interactive notebook performed .416 to 1.41 points better on the Biology 1 SATP assessment for competency 2 than students without interactive notebooks with 95% confidence.

Competency 3 Results. The experimental group, the group using interactive notebooks within the curriculum, had greater levels of science proficiency than the control group, the group not using interactive notebooks, for competency 3 as measured by the Biology1 SATP assessment ($M_{experimental}$ = 8.03, *SD* = 2.23, $M_{control}$ = 7.33, *SD* = 2.45). The *F* ratio, calculated as the mean square between groups divided by the mean square within groups was .877 and it was associated with a *p* value of .044. Given the necessary significance threshold of .05, I rejected the null hypothesis and found that there was a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 3. Table 13 presents the group statistics of the science proficiencies for the two groups of students for competency 3 on the Biology 1 SATP assessment. The average score for students utilizing interactive notebooks within the curriculum on the Biology 1 SATP assessment for competency 3 was 8.03 and the average score for students not utilizing the interactive notebooks within the curriculum was 7.33. Table 14 demonstrates the statistical difference between the two groups of students on the Biology 1 SATP assessment for competency 3 as presented by an independent samples *t* test (F=.877, p = .044). There is a 95% confidence that the true difference between Biology 1 SATP scores from students utilizing interactive notebooks and those students not utilizing the interactive notebook is captured between (.019, 1.381), claiming to support that there is a significant difference between students with and without interactive notebooks for competency 3. Students utilizing the interactive notebook performed .019 to 1.38 points better on the Biology 1 SATP assessment for competency 3 than students without interactive notebooks with 95% confidence. Figure 12 exhibits the mean score comparison between the control and the experimental group on the Biology 1 SATP assessment for competency 3. Figure 13 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 3. Conclusively, Figure 14 utilizes a box plot graph to illustrate the median, lowest value, highest value, and the 2nd and 3rd quartiles of the scores of the two groups on the Biology 1 SATP assessment for competency 3.

Table 13

Group statistics of control and experimental groups for competency 3 of the Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	7.33	2.447	.254
With Interactive Notebooks (Experimental)	91	8.03	2.228	.234

Table 14

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 3

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 3	Equal variances assumed	.877	.350	2.027	182	.044	.700	.345	.019	1.381
	Equal variances not assumed			2.029	181.078	.044	.700	.345	.019	1.380

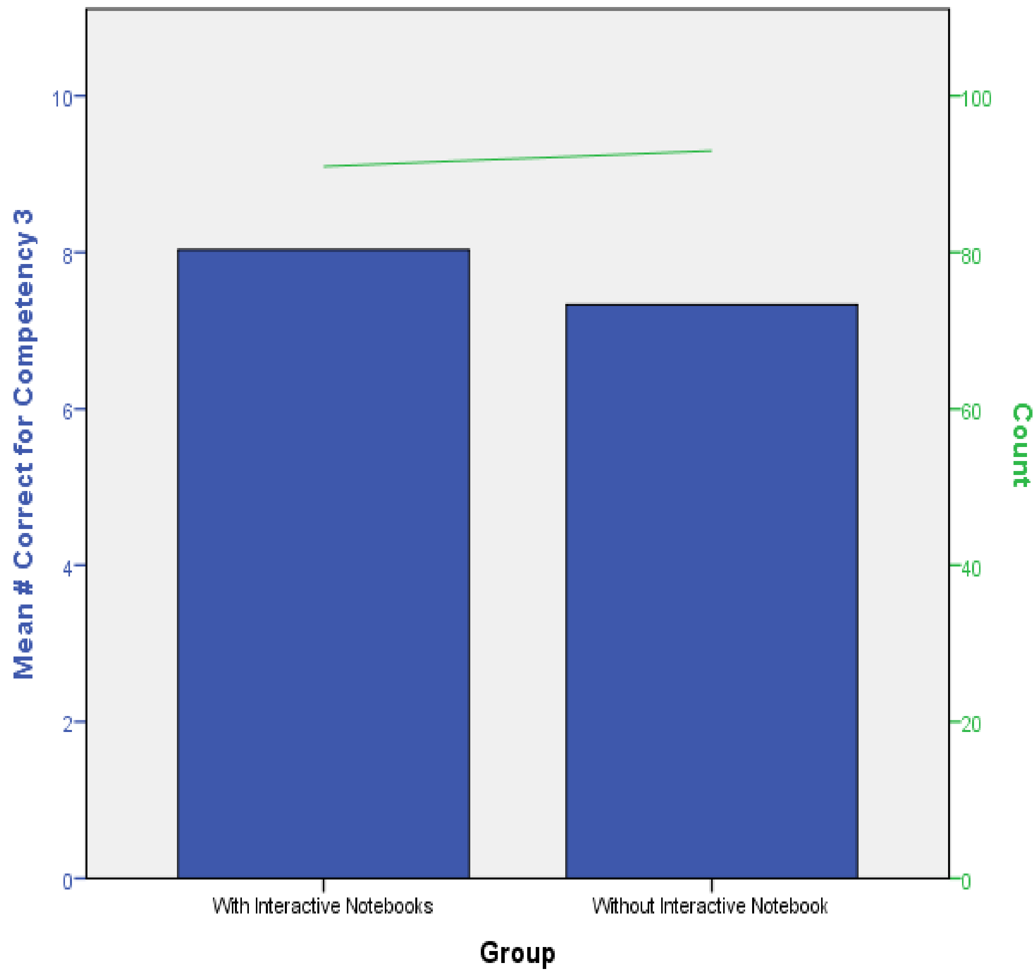

Figure 12. Mean scores: $M_{experimetal}$ = 8.03, $M_{control}$ = 7.33.

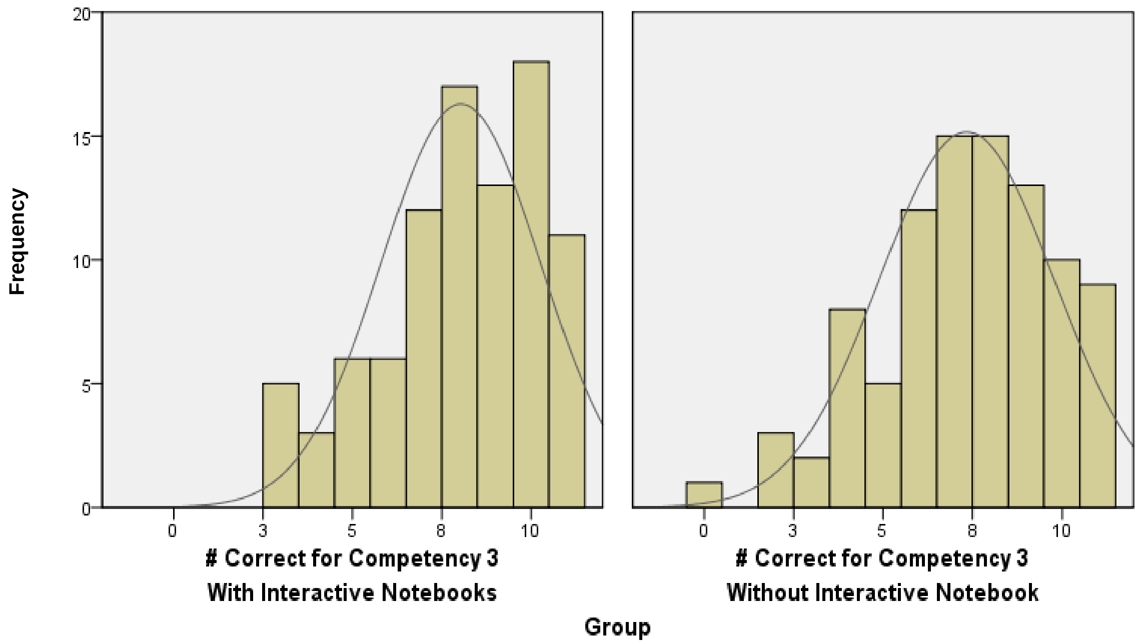

Figure 13. The experimental and control groups' Biology 1 SATP scores for competency 3

a. Experimental: Mean = *8.03*, Standard Deviation = *2.23, N = 91*
b. Control*:* Mean =*7.33,* Standard Deviation = *2.45, N = 93*

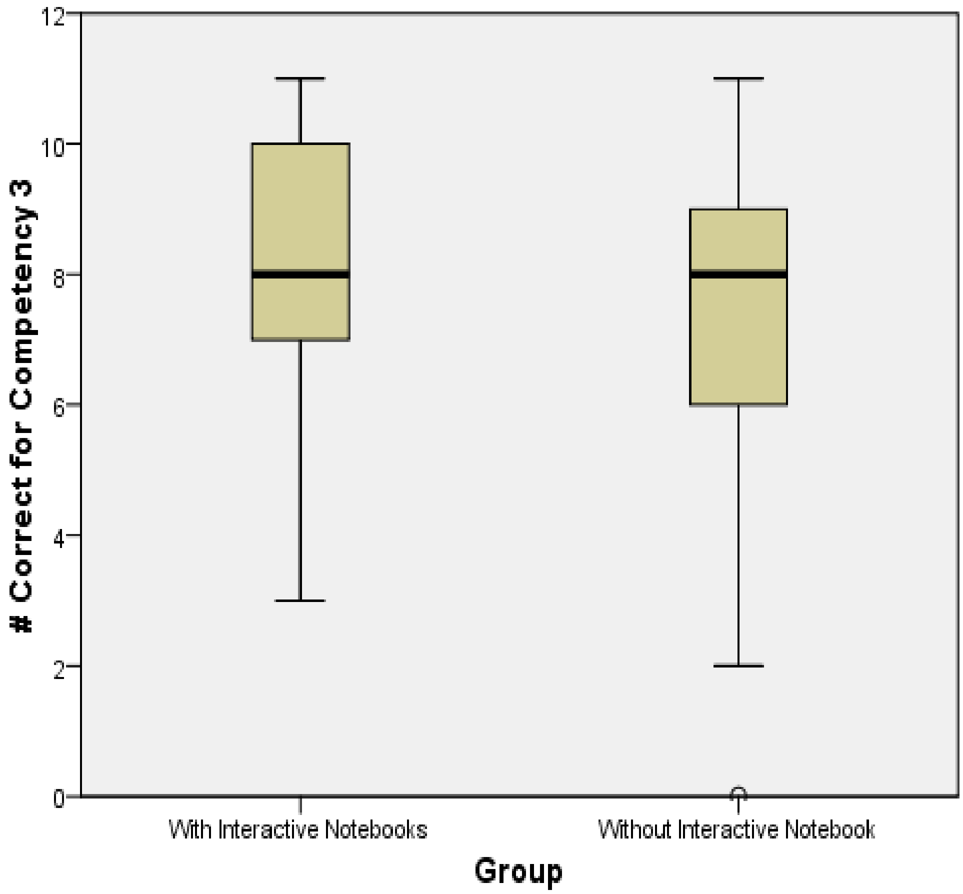

Figure 14. Box plot showing highest and lowest values, quartiles, and variability of competency 3 of the Biology 1 SATP scores for the experimental and control group.

Discussion: How interactive notebooks impacted the students' science proficiency on Competency 3? The results indicated that there was a statistical significant difference between students utilizing the interactive notebook and students not utilizing the interactive notebook for competency 3 of the Biology 1 SATP assessment, similarly to the results demonstrating the impact utilizing interactive notebooks had on the science proficiency of the students as measured by the raw Biology 1 SATP scores. The experimental group had a greater level of science proficiency than the control group for competency 3 as measured by the Biology 1 SATP assessment ($M_{experimental}$ = 8.03, *SD* = 2.23, $M_{control}$ = 7.33, *SD* = 2.45).The *F* ratio was .877 and *p* = .044. The mean difference is significant at the 0.05 level. Given this α value, I rejected the null hypothesis and found that there was a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 3. Students utilizing the interactive notebook performed .019 to 1.38 points better on the Biology 1 SATP assessment for competency 3 than students without interactive notebooks with 95% confidence.

Competency 4 Results. The experimental group, the group using interactive notebooks within the curriculum, had greater levels of science proficiency than the control group, the group not using interactive notebooks, for competency 4 as measured by the Biology1 SATP assessment ($M_{experimental}$ = 10.21, *SD* = 2.24, $M_{control}$ = 8.61, *SD* = 2.94). The *F* ratio, calculated as the mean square between groups divided by the mean square within groups was 7.09 and it was associated with a *p* value of .000. Given the necessary significance threshold of .05, I rejected the null hypothesis and found that there was a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 4. Table 15 presents the group statistics of the science proficiencies for the two groups of students for competency 4 on the Biology 1 SATP assessment. The average score for students utilizing interactive notebooks within the curriculum on the Biology 1 SATP assessment for competency 4 was 10.21 and the average score for students not utilizing the interactive notebooks within the curriculum was 8.61. Table 16 demonstrates the statistical difference between the two groups of students on the Biology 1 SATP assessment for competency 4 as presented by an independent samples *t* test (F=7.09, p = .000). There is a 95% confidence that the true difference between Biology 1 SATP scores from students utilizing interactive notebooks and those students not utilizing the interactive notebook is captured between (.834, 2.36), claiming to support that there is a significant difference between students with and without interactive notebooks for competency 4. Students utilizing the interactive notebook performed .834 to 2.36 points better on the Biology 1 SATP assessment for competency 4 than students without interactive notebooks with 95% confidence. Figure 15 exhibits the mean score comparison between the control and the experimental group on the Biology 1 SATP assessment for competency 4. Figure 16 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 4. Conclusively, Figure 17 utilizes a box plot graph to illustrate the median, lowest value, highest value, and the 2^{nd} and 3^{rd} quartiles of the scores of the two groups on the Biology 1 SATP assessment for competency 4.

Table 15

Group statistics of control and experimental groups for competency 4 of the Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	8.61	2.942	.305
With Interactive Notebooks (Experimental)	91	10.21	2.239	.235

Table 16

Independent Samples t test for Science Proficiency: Control and Experimental Group on Biology 1 SATP Assessment for Competency 4

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 4	Equal variances assumed	7.093	.008	4.135	182	.000	1.596	.386	.834	2.357
	Equal variances not assumed			4.135	171.663	.000	1.596	.385	.836	2.356

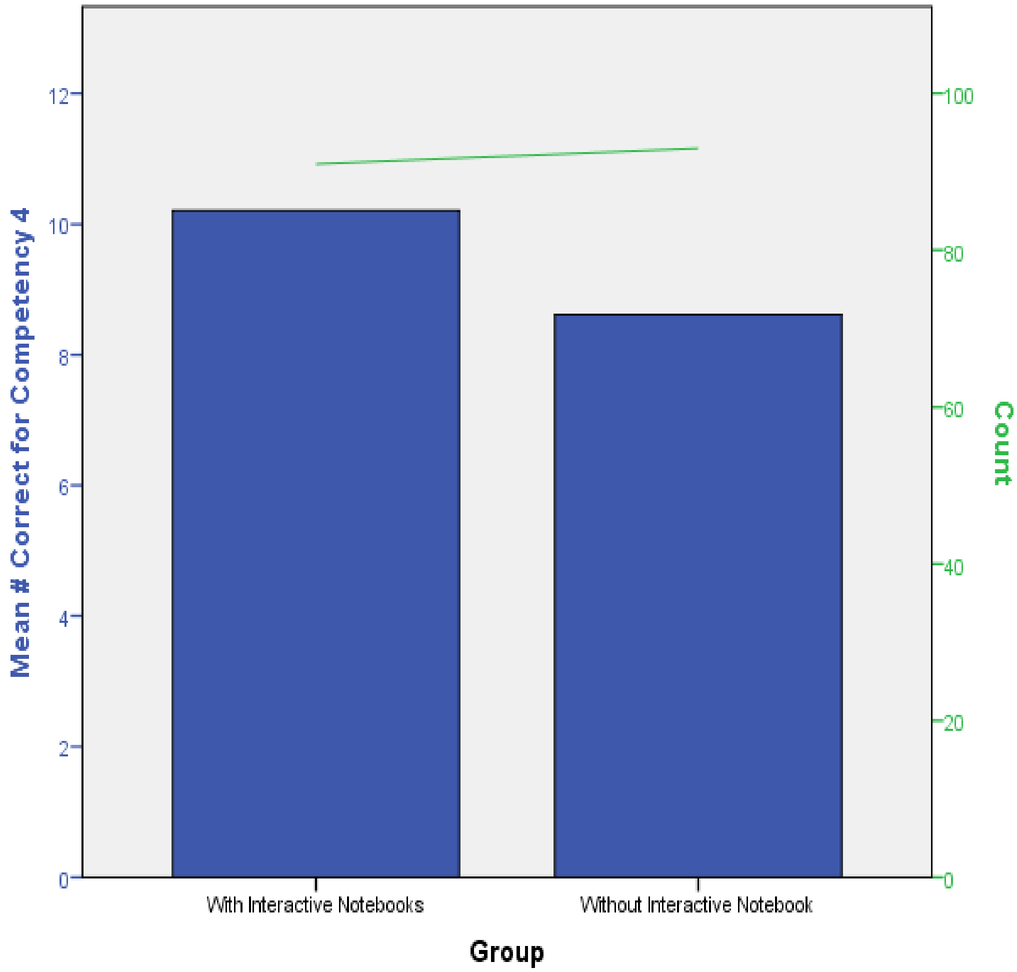

Figure 15. Mean scores: $M_{experimetal}$ = 10.21, $M_{control}$ = 8.61.

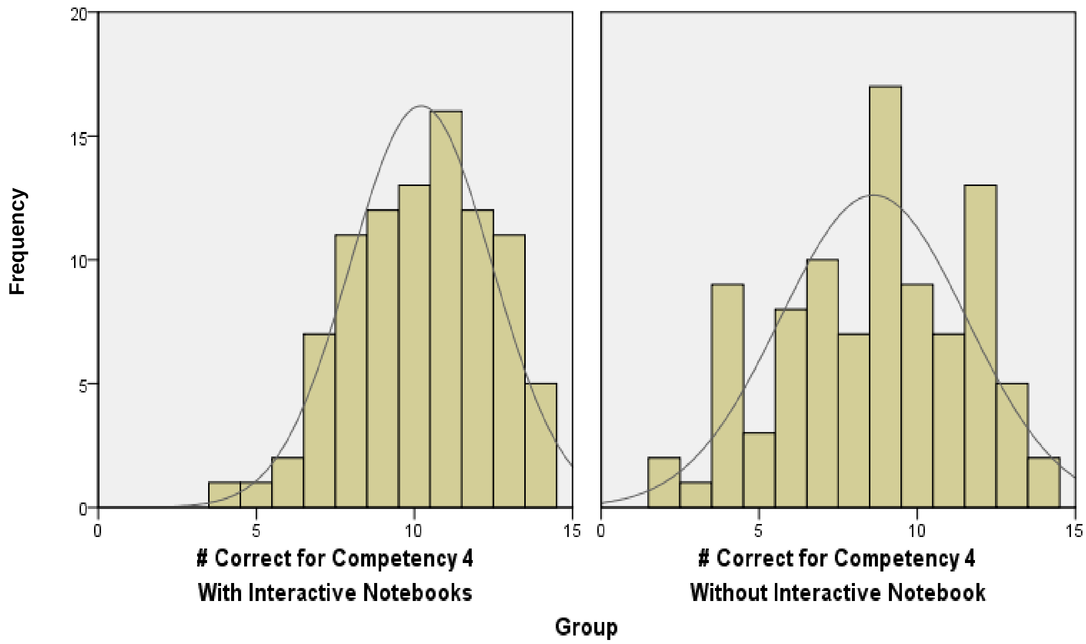

Figure 16. The experimental and control groups' Biology 1 SATP scores for competency 4

a. Experimental: Mean = 10.21, Standard Deviation = 2.24, *N* = 91
b. Control: Mean = 8.61, Standard Deviation = 2.94, *N* = 93

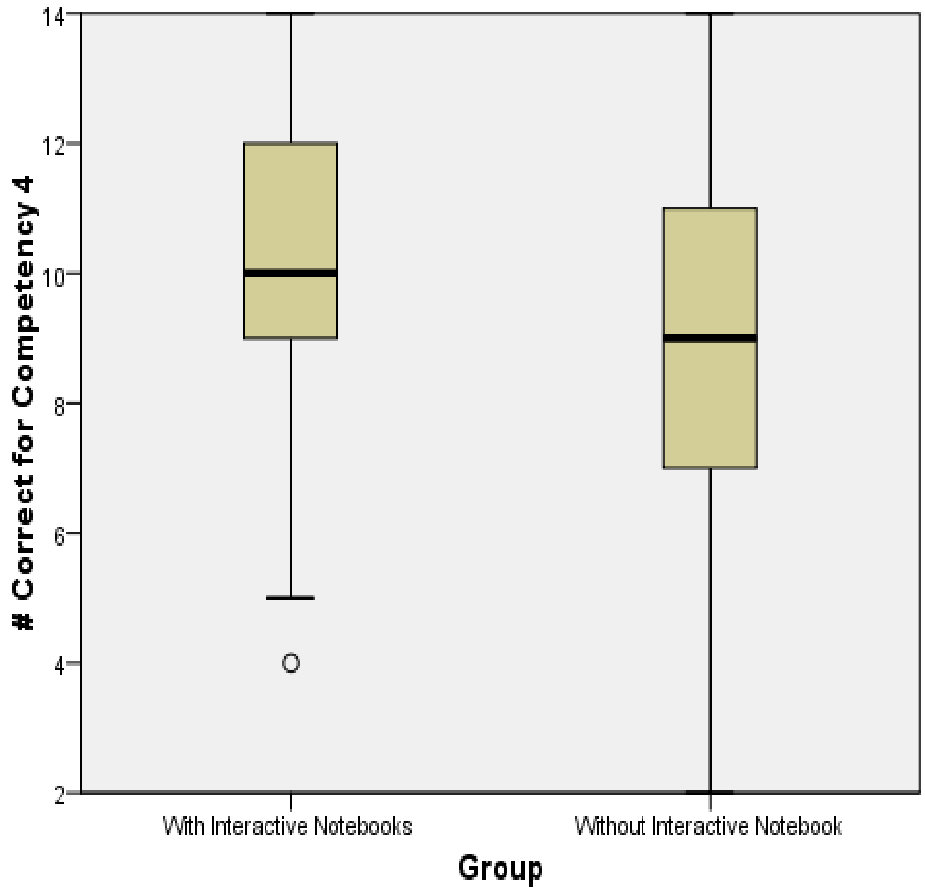

Figure 17. Box plot showing highest and lowest values, quartiles, and variability of competency 4 of the Biology 1 SATP scores for the experimental and control group.

Discussion: How interactive notebooks impacted the students' science proficiency on Competency 4? The results indicated that there was a statistical significant difference between students utilizing the interactive notebook and students not utilizing the interactive notebook for competency 4 of the Biology 1 SATP assessment, similarly to the results demonstrating the impact utilizing interactive notebooks had on the science proficiency of the students as measured by the raw Biology 1 SATP scores. The experimental group had a greater level of science proficiency than the control group for competency 4 as measured by the Biology1 SATP assessment ($M_{experimental}$ = 10.21, *SD* = 2.24, $M_{control}$ = 8.61, *SD* = 2.94). The *F* ratio was 7.09 and *p*= .000. The mean difference is significant at the 0.05 level. Given this α value, I rejected the null hypothesis and found that there was a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 3. Students utilizing the interactive notebook performed .834 to 2.36 points better on the Biology 1 SATP assessment for competency 4 than students without interactive notebooks with 95% confidence.

Competency 5 Results. The experimental group, the group using interactive notebooks within the curriculum, had roughly equal levels of science proficiency as the control group, the group not using interactive notebooks, for competency 5 as measured by the Biology 1 SATP assessment ($M_{experimental}$= 10.44, *SD* = 2.40, $M_{control}$ = 9.84, *SD* = 2.82). The *F* ratio, calculated as the mean square between groups divided by the mean square within groups was 2.26 and it was associated with a *p* value of .122. Given the necessary significance threshold of .05, I accepted the null hypothesis and found that there was no statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 5. Table 17 presents the group statistics of the science proficiencies for the two groups of students for competency 5 on the Biology 1 SATP assessment. The average score for students utilizing interactive notebooks within the curriculum on the Biology 1 SATP assessment for competency 5 was 10.44 and the average score for students not utilizing the interactive notebooks within the curriculum was 9.84. Table 18 demonstrates the statistical difference between the two groups of students on the Biology 1 SATP assessment for competency 5 as presented by an independent samples *t* test (F=2.26, p= .122). There is a 95% confidence that the true difference between Biology 1 SATP scores from students utilizing interactive notebooks and those students not utilizing the interactive notebook is captured between (-.162, 1.36), claiming to support that there is no significant difference between students with and without interactive notebooks for competency 5. Students utilizing the interactive notebook performed .162 points worse to 1.36 points better on the Biology 1 SATP assessment for competency 5 than students without interactive notebooks with 95% confidence. Figure 18 exhibits the mean score comparison between the control and the experimental group on the Biology 1 SATP assessment for competency 5. Figure 19 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 5. Conclusively, Figure 20 utilizes a box plot graph to illustrate the median, lowest value, highest value, and the 2nd and 3rd quartiles of the scores of the two groups on the Biology 1 SATP assessment for competency 5.

Table 17

Group statistics of control and experimental groups for competency 5 of the Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	9.84	2.822	.293
With Interactive Notebooks (Experimental)	91	10.44	2.400	.252

Table 18

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 5

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 5	Equal variances assumed	2.259	.135	1.554	182	.122	.601	.387	-.162	1.364
	Equal variances not assumed			1.557	178.554	.121	.601	.386	-.161	1.362

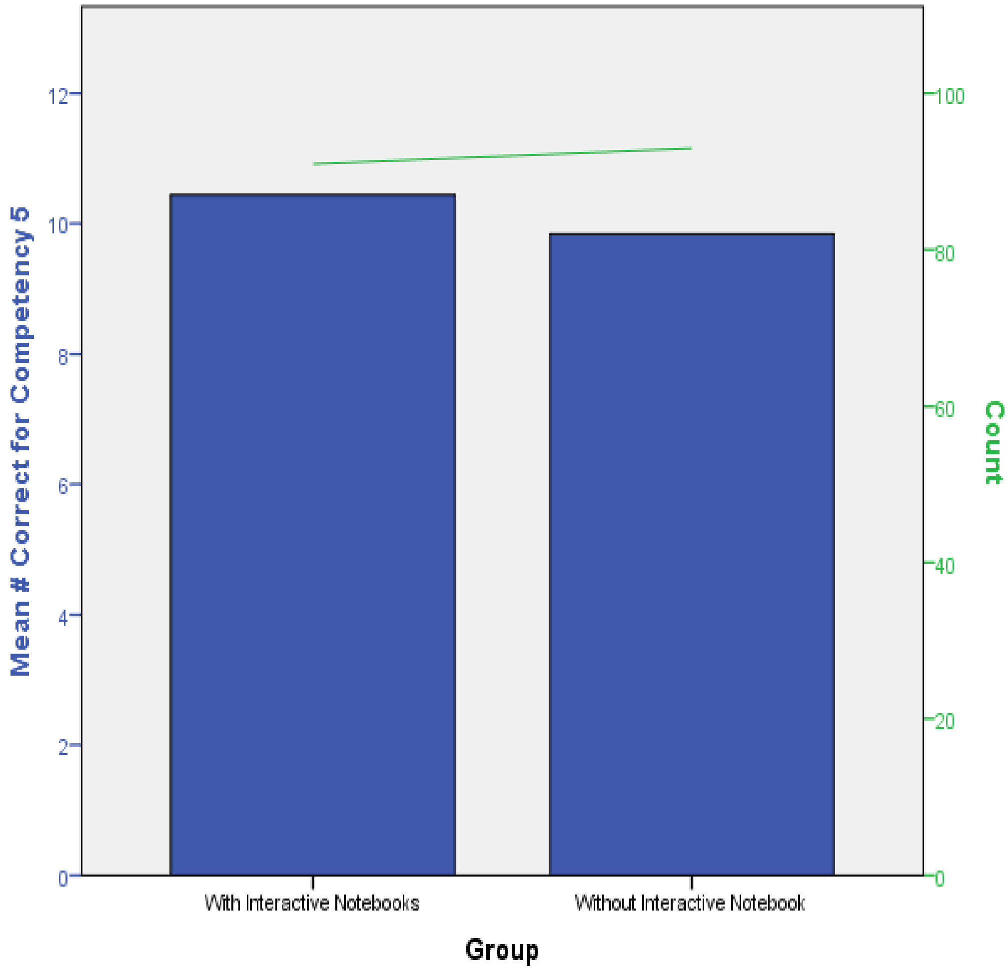

Figure 18. Mean scores: $M_{experimetal}$ = 10.44, $M_{control}$ = 9.84.

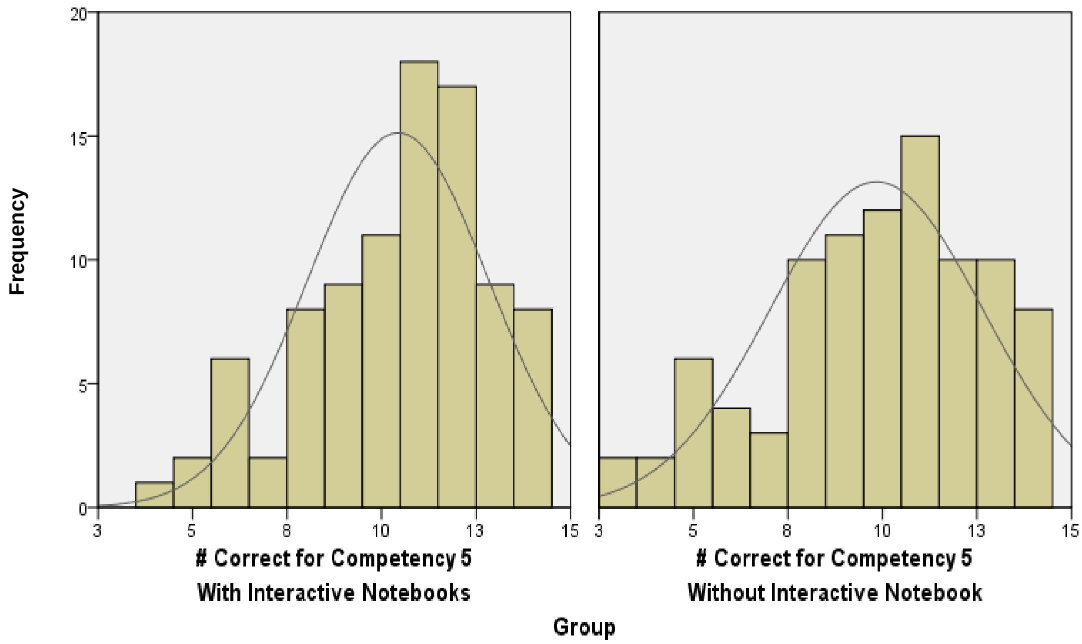

Figure 19. The experimental and control groups' Biology 1 SATP scores for competency 5

a. Experimental: Mean= 10.44, Standard Deviation=2.40, *N*=91
b. Control: Mean =9.84, Standard Deviation= 2.82, *N*=93

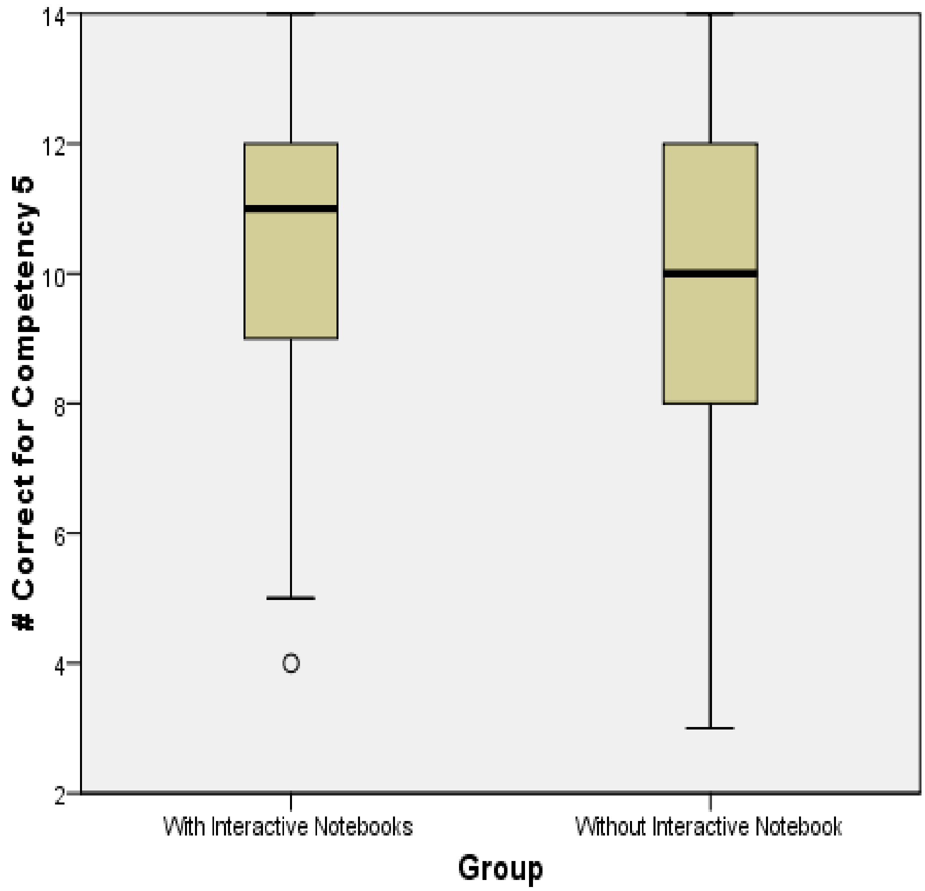

Figure 20. Box plot showing highest and lowest values, quartiles, and variability of competency 5 of the Biology 1 SATP scores for the experimental and control group.

Discussion: How interactive notebooks impacted the students' science proficiency on Competency 5? Although the results indicated no statistical significant difference between students utilizing the interactive notebook and students not utilizing the interactive notebook for competency 5 of the Biology 1 SATP assessment, it is necessary to affirm the impact utilizing interactive notebooks had on the science proficiency of the students as measured by the raw Biology 1 SATP scores. The experimental group had roughly the same level of science proficiency as the control group for competency 5 as measured by the Biology 1 SATP assessment ($M_{experimental}$= 10.44, *SD* = 2.40, $M_{control}$ = 9.84, *SD* = 2.82). The *F* ratio was 2.26 and *p*= .122. The mean difference is significant at the 0.05 level. Given this α value, I accepted the null hypothesis and found that there was not a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 5. Students utilizing the interactive notebook performed .162 points worse to 1.36 points better on the Biology 1 SATP assessment for competency 5 than students without interactive notebooks with 95% confidence.

Competency 6 Results. The experimental group, the group using interactive notebooks within the curriculum, had roughly equal levels of science proficiency as the control group, the group not using interactive notebooks, for competency 6 as measured by the Biology 1 SATP assessment ($M_{experimental}$= 5.05, *SD* = 1.52, $M_{control}$ = 4.73, *SD* = 1.60). The *F* ratio, calculated as the mean square between groups divided by the mean square within groups was 1.14 and it was associated with a *p* value of .160. Given the necessary significance threshold of .05, I accepted the null hypothesis and found that there was no statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 6. Table 19 presents the group statistics of the science proficiencies for the two groups of students for competency 6 on the Biology

1 SATP assessment. The average score for students utilizing interactive notebooks within the curriculum on the Biology 1 SATP assessment for competency 6 was 5.05 and the average score for students not utilizing the interactive notebooks within the curriculum was 4.73. Table 20 demonstrates the statistical difference between the two groups of students on the Biology 1 SATP assessment for competency 6 as presented by an independent samples *t* test (F=1.14, p= .160). There is a 95% confidence that the true difference between Biology 1 SATP scores from students utilizing interactive notebooks and those students not utilizing the interactive notebook is captured between (-.129, .777), claiming to support that there is no significant difference between students with and without interactive notebooks for competency 6. Students utilizing the interactive notebook performed .129 points worse to .777 points better on the Biology 1 SATP assessment for competency 6 than students without interactive notebooks with 95% confidence. Figure 21 exhibits the mean score comparison between the control and the experimental group on the Biology 1 SATP assessment for competency 6. Figure 22 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 6. Conclusively, Figure 23 utilizes a box plot graph to illustrate the median, lowest value, highest value, and the 2nd and 3rd quartiles of the scores of the two groups on the Biology 1 SATP assessment for competency 6.

Table 19

Group statistics of control and experimental groups for competency 6 of the Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	4.73	1.596	.165
With Interactive Notebooks (Experimental)	91	5.05	1.516	.159

Table 20

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 6

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 6	Equal variances assumed	1.141	.287	1.411	182	.160	.324	.230	-.129	.777
	Equal variances not assumed			1.411	181.840	.160	.324	.229	-.129	.776

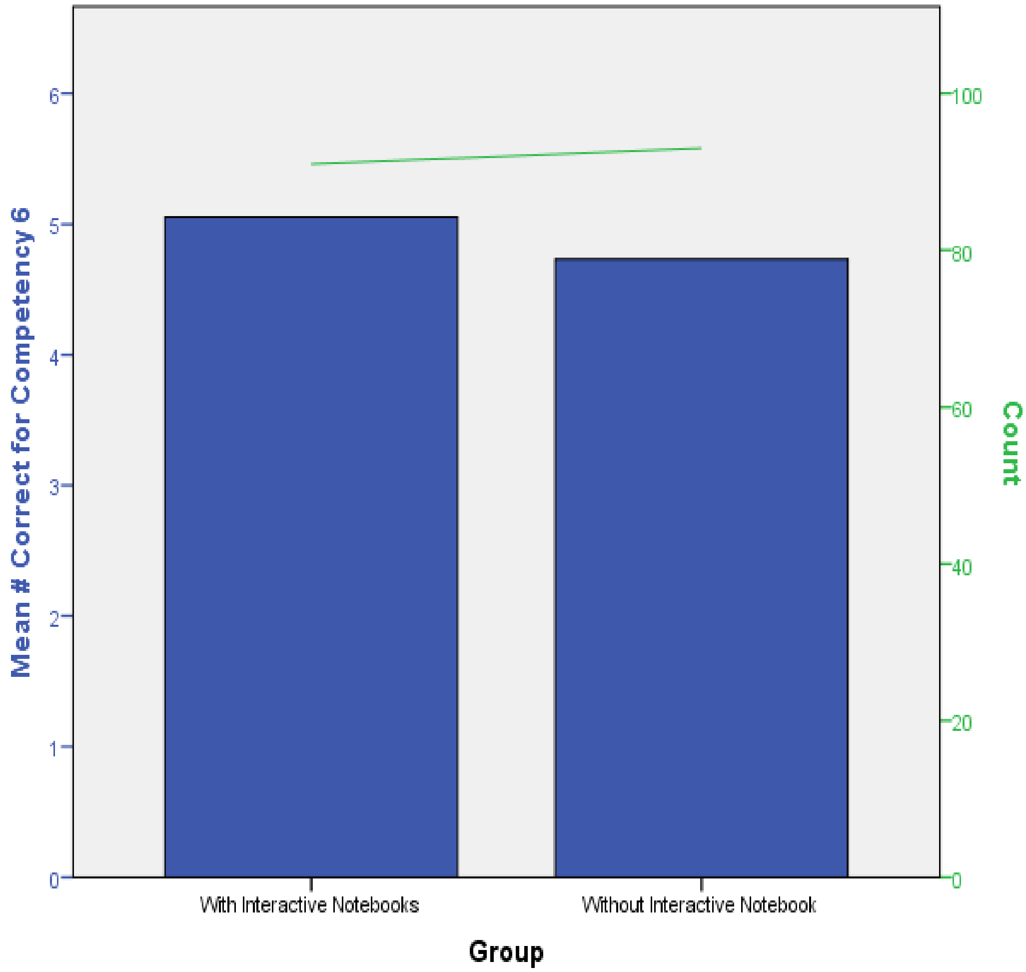

Figure 21. Mean scores: $M_{experimetal}$ = 5.05, $M_{control}$ = 4.73.

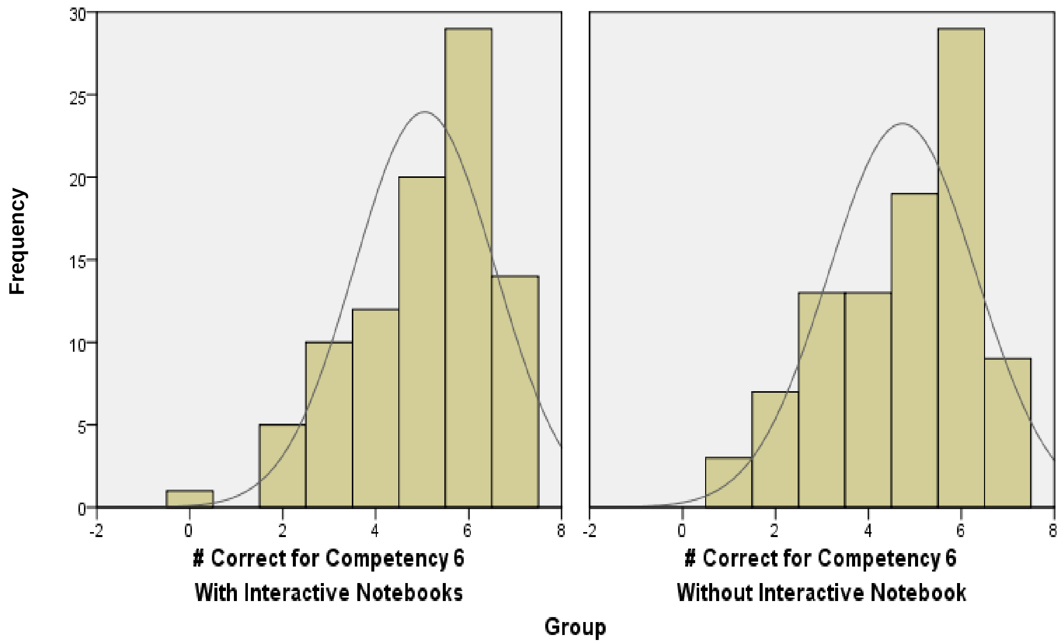

Figure 22. The experimental and control groups' Biology 1 SATP scores for Competency 6

a. Experimental: Mean= 5.05, Standard Deviation=1.52, *N*=91
b. Control: Mean =4.73, Standard Deviation= 1.60, *N*=93

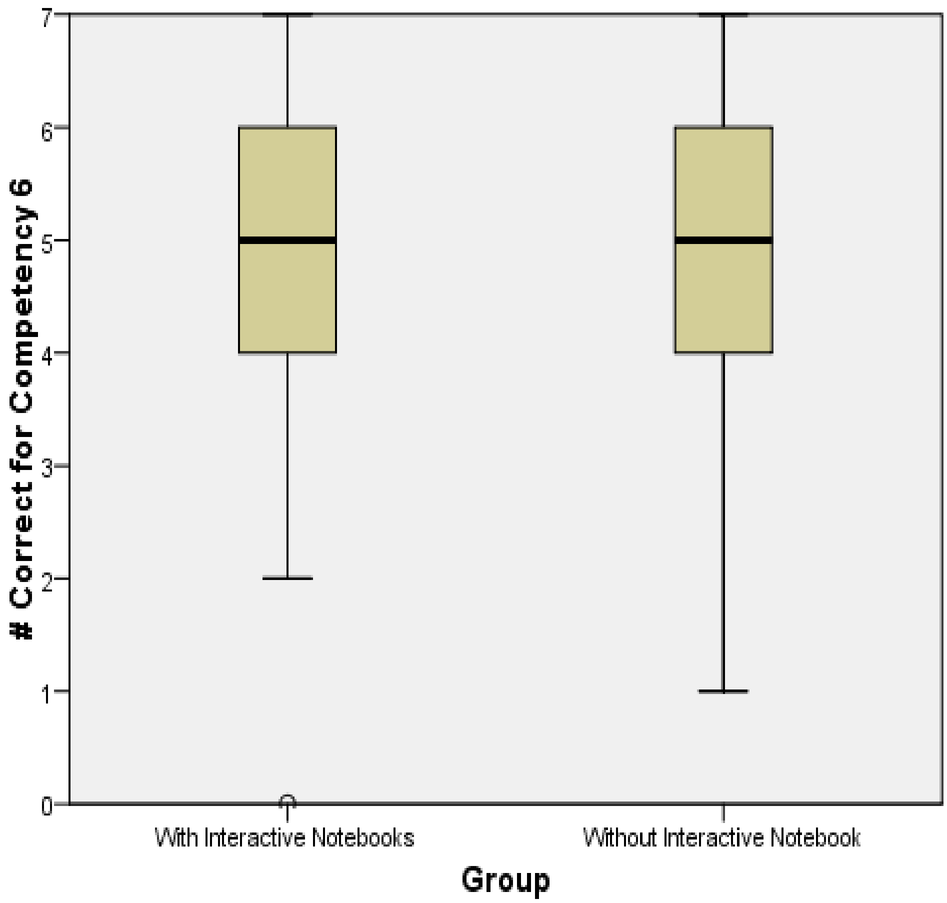

Figure 23. Box plot showing highest and lowest values, quartiles, and variability of competency 6 of the Biology 1 SATP scores for the experimental and control group.

Discussion: How interactive notebooks impacted the students' science proficiency on Competency 6? Although the results presented no statistical significant difference between students utilizing the interactive notebook and students not utilizing the interactive notebook for competency 6 of the Biology 1 SATP assessment, it is necessary to affirm the impact utilizing interactive notebooks had on the science proficiency of the students as measured by the raw Biology 1 SATP scores. The experimental group had roughly the same level of science proficiency as the control group for competency 6 as measured by the Biology1 SATP assessment ($M_{experimental}$= 5.05, *SD* = 1.52, $M_{control}$ = 4.73, *SD* = 1.60). The *F* ratio was 1.14 and *p*= .160. The mean difference is significant at the 0.05 level. Given this α value, I accepted the null hypothesis and found that there was not a statistical significant difference of utilizing interactive notebooks on the students' science proficiency for competency 6. Students utilizing the interactive notebook performed .129 points worse to .777 points better on the Biology 1 SATP assessment for competency 6 than students without interactive notebooks with 95% confidence.

Data Analysis Summary

This quantitative study employed a quasi-experimental design to examine the effect of utilizing interactive notebooks as instructional tools on the science proficiency of high school Biology 1 students at Local High School. The study used the archival ex post facto 2016-2017 scores from the two group of students, *n = 93* students in the classroom where interactive notebooks were not embedded in the curriculum and not utilized (control group), and *n* = 91 students in the classroom where interactive notebooks were embedded in the curriculum and were utilized daily (experimental group) (*N* = 184). The CASE 21 and Biology 1 SATP assessments served as the instruments that provide the data for this study. From the data supplied by these instruments, the dependent variable, science proficiency was produced. With the independent variable, utilization of interactive notebooks as instructional tools, the study used independent samples *t* tests to compare the mean scores from both instruments between the control and experimental groups for statistical significant differences.

The results of the independent samples *t* test on the 2016-2017 CASE 21 scores demonstrated no statistical significant difference between the control (*M*= 653.80, *SD*= 9.45) and experimental group (*M*=655.60, *SD*= 6.65); *t*(182)= 1.50, *p*=.136. These results indicated that students in both the control and experimental groups began roughly on the same levels of science proficiency. The results of the independent samples *t* test for the mean scores of the 2016-2017 Biology 1 SATP assessment demonstrated statistical significant difference between the control (*M*= 656.13, *SD*= 10.49) and experimental group (*M*=659.92, *SD*= 7.65); *t*(182)= 2.80, *p*=.006. Students utilizing the interactive notebook within the Biology 1 curriculum performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. In relation to exploring more effective instructional tools for proliferating achievement and proficiency levels, this study was able to demonstrate that utilizing interactive notebooks within the curriulum has the capability to advance and improve the science proficiency and achievement of students.

To measure an even deeper understanding of the science proficiency of the students from the two groups, the study compared the mean scores of the six individual categories or competencies of the Biology 1 SATP assessment by conducting multiple independent samples *t* tests. The results of the *t* test on competency 1 suggested no statistical significant difference between students utilizing the interactive notebook (M= 4.64, *SD* = 1.22) and students not utilizing the interactive notebook (M= 4.59, *SD* = 1.43); *t*(182)= .235, *p*=.815. The experimental group had roughly the same level of science proficiency as the control group for competency 1 as measured by the Biology1 SATP assessment. The results of the *t* test on competency 2 suggested a statistical significant difference between students utilizing the interactive notebook (*M*= 4.88, *SD* = 1.61) and students not utilizing the interactive notebook (M= 3.97, *SD* = 1.79); *t*(182)= 3.63, *p*=.000. Students utilizing the interactive notebook within the Biology 1 curriculum performed .416 to 1.41 points better on the Biology 1 SATP assessment for competency 2 than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. The results of the *t* test on competency 3 suggested a statistical significant difference between students utilizing the interactive notebook (*M*= 8.03, *SD* = 2.23) and students not utilizing the interactive notebook (M= 7.33, *SD* = 2.45); *t*(182)= 2.03, *p*=.044. Students utilizing the interactive notebook within the Biology 1 curriculum performed .019 to 1.38 points better on the Biology 1 SATP assessment for competency 3 than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. The results of the *t* test on competency 4 suggested a statistical significant difference between students utilizing the interactive notebook (*M*= 10.21, *SD* = 2.24) and students not utilizing the interactive notebook (M= 8.61, *SD* = 2.94); *t*(182)= 4.14, *p*=.000. Students utilizing the interactive notebook within the Biology 1 curriculum performed .834 to 2.36 points better on the Biology 1 SATP assessment for competency 4 than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. The results of the *t* test on competency 5 suggested no statistical significant difference between students utilizing the interactive notebook (*M*= 10.44, *SD* = 2.40) and students not utilizing the interactive notebook (M= 9.84, *SD* = 2.82); *t*(182)= 1.55, *p*=.122. The experimental group had roughly the same level of science proficiency as the control group for competency 5 as measured by the Biology 1 SATP assessment. The results of the *t* test on competency 6 suggested no statistical significant difference between students utilizing the interactive notebook (*M*= 5.05, *SD* = 1.52) and students not utilizing the interactive notebook (M= 4.73, *SD* = 1.60); *t*(182)= 1.41, *p*=.160. The experimental group had roughly the same level of science proficiency as the control group for competency 6 as measured by the Biology 1 SATP assessment. A breakdown of these competencies for students utilizing and not utilizing the interactive notebook is shown in Table 21.

Table 21

Breakdown of competencies with and without statistical significant differences between students utilizing interactive notebooks and students not utilizing interactive notebooks

	Competencies Number	***p value***
NO Statistical Significant Difference	1	.815
	5	.122
	6	.160
Statistical Significant Difference	2	.000
	3	.044
	4	.000

This study offers quantitative data that support utilizing interactive notebooks as an instructional tool to increase the science proficiency of Biology 1 students as shown in Table 21. Therefore, findings from this study serve as a platform for policy recommendations centering on implementing and utilizing effective instructional tools that can convert into programs that have the capability to proliferate student proficiency and close the achievement gap. Conclusively, this study gives way to many qualitative studies that can investigate the psychosomatic, intellectual, and perceptive components of utilizing interactive notebooks as instructional tools and the way they affect teachers' pedagogical practices and students' sense of competence and self-efficacy.

Section 3: The Project

Introduction

Under the authority of the No Child Left Behind Act of 2001 and the 2009 Common Core State Standards Initiative and their aspiration for universal readiness, proficiency, and literacy for all American students, this doctoral project study examined the effect of using curriculum-embedded interactive notebooks on the science proficiency of Biology 1 students as measured by their performance on the SATP Biology 1 assessment during the 2016-2017 school year at Local High School (Agamba & Jenkins, 2013; Furrer, Pitzer, & Skinner, 2014; Howard, 2015; Hoy, 2012; National Governors Association Center, 2012; Valencia & Wixson, 2013; Webb & Williams, 2016). The foundation of this study was based on using interactive notebooks as an instructional tool to increase students' science literacy and proficiency in science curriculum and courses. The study utilized the quantitative methodology of a quasi-experimental research design by analyzing ex post facto data to investigate the specific interactional tool, interactive notebooks. and their use in the Biology 1 classroom to assist teachers in improving students' knowledge, skills, and abilities in a subject area or course (Chingos & Whitehurst, 2012). The core purpose of this project was to examine the effect of instructional tools, such as the interactive notebook, on the science proficiency of high school students when compared to traditional methods of instruction. Parallel to other studies (Arop, Umanah, & Effiong, 2015; Bektaş and Kızkapan, 2017; Çıbık, 2016), findings from this study demonstrated measurable differences in students' science proficiency when students utilized instructional tools other than traditional methods of instruction.

To measure the students' science proficiency, I utilized the comprehensive, diagnostic assessment data from the CASE 21 assessment and the comprehensive, standardized assessment data from the Biology 1 SATP assessment for 2016-2017 school year. During the 2016-2017 school year, both fall and spring semesters, Local High School had two different Biology 1 curricula in place. In one curriculum, the experimental group, the students regularly used interactive notebooks as the primary instructional tool. In the other curriculum, the control group, the interactive notebook was not used, only traditional methods of instruction (textbooks and PowerPoint notes) were used (Creswell, 2012; Dong & Maynard, 2013; Krishnan & Sitaraman, 2013; Meyer, 2014; Shen, 2014; Shepard, 2016). Through the use of the SPSS Statistics software program, I was able to conduct several independent samples *t* tests on the CASE 21 assessment data and the Biology 1 assessment data. I discovered that the CASE 21 assessment data analysis suggested there was no significant statistical difference in the students' scores pertaining to science proficiency for students utilizing interactive notebooks (M= 655.60, SD= 6.65) and students not using interactive notebooks (M= 653.80, SD= 9.45)); $t(182) = 1.50$, p= .136. These results indicated that students in both the control and experimental groups began roughly on the same levels of science proficiency as measured by the CASE 21 assessment. Conversely, I found that at the end of the semester the experimental group, the group that utilized interactive notebooks within the curriculum, had a higher level of science proficiency than the control group, the group that did not utilize interactive notebooks, as measured by the mean scores of the Biology1 SATP assessment ($M_{experimental}$= 659.92, $M_{control}$ = 656.13; p=.006). Several independent samples *t* tests were conducted on the mean scores of the six individual categories or competencies of the Biology 1 SATP assessment as well. Despite the difference in the mean ratio for the two groups, I discovered there was no statistical significant difference between the two cohorts ($M_{experimental}$= 4.64, $M_{control}$= 4.59; p=.815) for competency 1, competency 5 ($M_{experimental}$= 10.44, $M_{control}$= 9.84; p=.122), and competency 6 ($M_{experimental}$= 5.05, $M_{control}$= 4.73; p=.160). These results suggest students that utilized the interactive notebook in the Biology 1 curriculum had roughly the same science proficiency for competencies 1, 5, and 6 as the students that did not utilize the interactive notebook in the curriculum. However, I found there was a statistical significant difference between the two cohorts for competency 2 ($M_{experimental}$= 4.88, $M_{control}$= 3.97; p=.000), competency 3 ($M_{experimental}$= 8.03, $M_{control}$= 7.33; p=.044), and competency 4 ($M_{experimental}$= 10.21, $M_{control}$= 8.61; p=.000). Students in the experimental group performed .416 to 1.41 points better on the Biology 1 SATP assessment for competency 2 than students in the control group; students in the experimental group performed .019 to 1.38 points better on the Biology 1 SATP assessment for competency 3 than students in the control group; and students in the experimental group performed .834 to 2.36 points better on the Biology 1 SATP assessment for competency 4 than students in the control group with 95% confidence.

Succinctly, this project study utilized quantitative approaches to measure the effect instructional tools, specifically the interactive notebook, can have on students' science proficiency. Encompassed with quantitative evidence, this study supports the use of the interactive notebook as an instructional tool to proliferate science proficiency. Functioning as the cornerstone for a policy recommendation, this project study places the utilization of interactive notebooks as an instructional tool to proliferate science proficiency at the heart of policy structures, curriculum reforms, and assessment frameworks in education.

Rationale

Taking into consideration the No Child Left Behind Act's inability to meet its goal of universal readiness, proficiency, and literacy by 2014 and the recent educational reform in the construct of the College and Career Readiness Standards for mathematics, literacy/English language arts, science, and social studies, this project offers an alternate means to traditional, generic instructional practices (Coats & Xu, 2013; Daniels & Sun, 2013; DCS, 2017; Johnson, 2007; Johnson, 2013; Johnson, Kahle, & Zhang, 2012; MDE, 2017; NSSG, 2017, Willard, 2017). Although research and literature support the use of various enhanced and engaging instructional tools by teachers to differentiate instruction and increase students' proficiencies in science and other subject areas, there is a gap in the literature and research regarding the effect of curriculum embedded interactive notebooks as a specific instructional tool on high school biology students' science proficiency (Chingos & Whitehurst, 2012; Dee, Jacob, & Schwartz, 2012; Fraser, 2015;

Furrer, Pitzer, & Skinner, 2014; Howard, 2015; Lee & Reeves, 2012; Linn, 2013; Webb & Williams, 2016; Wilson, 2013). This project study has the facility to present quantitative evidence that substantiates the utilization of interactive notebooks as instructional tools to proliferate students' science proficiency. Furthermore, analogously parallel to the current initiative of data driven curriculum, instruction, and assessment practices, the quantitative project described in this study also utilizes data obtained from state mandated, standardized assessments to examine the effect instructional tools, specifically the interactive notebook, can have on students' science proficiency. The use of a position paper (Appendix A) will provide the stakeholders of Local County School District and Local High School with the policy recommendation in a summarized format that communicate the key components of the study needed to assist in policy changes and decision-making.

Review of the Literature

The goal of this doctoral project study was to compile quantifiable evidence of the treatment of interactive notebooks in a high school Biology 1 course and its effect on the students' science proficiency. The product of this project study is a position paper that offers a new instructional solution to proliferate students' science proficiency and improve student achievement. The following literature review contains a discussion of a position paper and the key components it includes; as well as, a discussion of policy recommendations in education and other fields. This literature review was completed by examining scholarly, peer-reviewed journals, articles, dissertations and theses, and books found in the Walden Library. The searched databases include ProQuest, ERIC, Google Scholar, Academic Search Premier, EBSCOHost, and Dissertations and Theses. I researched terms such as *position papers, policy papers, instructional tools, policy recommendations, science education,* and *science proficiency*.

Position Paper

The outcome of this doctoral project study is a position paper that proposes utilizing interactive notebooks as an instructional tool to proliferate science proficiency. Position papers are reports or informative narratives that convey a person, organization, or nation's data- guided opinions, recommendations, or positions about an issue (Franklin, 2014; Golden, Katzman, Ornstein, & Sawyer, 2015; Harwood & Knight, 2015). Designed with the intent to persuade the audience to follow or comply with the opinions, recommendations, or positions of the presenter, position papers are authored by officials in education, government, medicine, law, and other fields of study (Aapro, Arends, Bozzetti, Fearon, Grunberg, Herrstedt, & Strasser, 2014; Austin, McEvoy, & Singleton, 2016; Eckhardt & Poletti, 2016).

The majority of position papers written, despite the domain or discipline, are composed of the following six components: an introduction detailing the history and demographics of the participants and their environment; the problem(s) and how it affects the participants and their landscape; evidence of the problem in the local setting and literature; a review of literature pertaining to the problem and the participants; recommendations to address the problem, and the implications of the suggested recommendations to the participants and the environment (Ansre, 2017; Crowley, 2015; Daniel & Sulmasy, 2015; Ghallab, Nau, & Traverso, 2014). These components assist with organizing the author's ideas, establishing credibility, analyzing the strengths and weaknesses of the author's position, and presenting the argument in a multi-faceted and informative manner (Casali, 2014; Cox & Hodgkinson-Williams, 2015; MacDonald & Roetert, 2015). Typically, there are four types of position papers and each type has its own objective. The four types of position papers include: 1) comparative, which discusses the commonalities and differences between positions; 2) constructive, which entails responding to tangible or possible objections to an existing position; 3) evaluative, which deliberates the credibility of a position; and 4) expositive, which involves expounding on the varying positions on an issue by a single theorist (Carpeggiani & Picano, 2016).

The position paper encompassed within this project study offers an analytical framework for the discussion of utilizing more innovative, interactional instructional tools to proliferate student achievement and proficiency. The enclosed position paper also offers assistance to educational researchers and stakeholders, locally and nationally, concerned with discovering diverse instructional tools to assist with reducing the achievement gap. This position paper also proposes an adjuvant nexus to potential studies in educational programs and policies, instructional strategies, learning styles, student-centered learning, and educational psychology.

Position Papers and Policy Recommendations in Education

The literature offers various position papers and policy recommendations in the field of education. Connor, Honan, and Snowball (2017) wrote a position paper to argue the need for an assessment instrument to measure literacy and numeracy achievement for kindergarteners in Australia. They recommended the use of an assessment solution known as the UK Phonics Check to measure the Year 1 students' achievement levels (Connor, Honan, & Snowball, 2017). Der Beer, Steyn, and Vos (2018) used a position paper to discuss the dependency between modern society and educational systems. They suggested that educational systems are responsible for differentiating learning for students to effectively serve in society and the international world; whereas, society is accountable for providing the necessary subsidy for the educational exigencies of its members (der Beer, Steyn, & Vos, 2018). The moral and diplomatic extrapolations of solipsistic implementation among preservice teachers was investigated in a position paper done by LaBelle (2017). In a position paper by Bynum (2015), informal mentoring was discussed and recommended as a solution to proliferate the professional and personal progression of women in educational leadership. To address the issue of professional competence among counselors, Hill, Raskin, and Rust (2013) presented a position paper that offered guidelines for policies and procedures concerning competent training, ethics, and addressing psychosomatic concerns that may influence their capacity to deliver sufficient counseling services.

Burkett and Smith (2016) investigated the disparity between virtually-simulated laboratories and hands-on laboratories in science education. In their position paper, they recommended virtually-simulated laboratories be utilized to supplement instead of substituting hands-on laboratories (Burkett & Smith, 2016). English (2017) examined the systems and methods of progressing STEM (Science, Technology, Engineering, and Mathematics) education in elementary and middle schools. In the position paper, it was suggested that STEM incorporate the arts (instead of STEM, it would be STEAM, Science, Technology, Engineering, Arts, and Mathematics) to address the multifaceted learning styles and interests of the learners and to support equitable access to all learners (English, 2017). Through a position paper, Schultz (2014) argued for multidimensional engagement in science with morals and social objectivity, achieved through case studies, discussion, and debate for undergraduate science majors. De Carvalho (2016) studied the interrelationships between science education and religion which is a situation known as superdiversity. Through a position paper, De Carvalho (2016) recommended the reframing, restructuring, and reconceptualizing of science teacher training programs and scientific epistemological frameworks to take into account pedagogics for superdiversity and superdiverse classrooms.

Position Papers and Policy Recommendations in Other Fields

In the same way position papers have been used to support and recommend changes in the educational landscape, they have also been utilized in other professional disciplines to advocate for change. Based on the biopolitical theory, Hellberg and

Knutsson (2018) wrote a position paper to examine sustainable development of the global neoliberal government. They argued against the gulf that divides affluent mass procurers from underprivileged subsistence- level populaces and advocate for neoliberal and biopolitical homogenization (Hellberg & Knutsson, 2018). Shared political physiognomies such as: developments like communities, anti- autocratic childcare facilities, and solidary sub- financial systems were used by Loick (2017) to defend a politicization of forms of life against a liberal appraisal. By utilizing a position paper, Macpherson and McCoy (2015) proposed homogeneous standards for stabilized and distinct investigational animal microbiotas to produce replicable prototypes of human infection that are appropriate for methodical research and are replicable throughout various bodies or vectors. Rajtar (2016) used a position paper to investigate the medical landscape of Germany by studying Jehovah's Witness patients and their positions concerning their refusals due to their religious beliefs to receive blood transfusions. Blandizzi, Gatta, Scarpignato, and Zullo (2016) developed a position paper to address the advantages and possible physical damages of acid suppression in proton pump inhibitor medications. They recommend that although proton pump inhibitors can have adverse side effects, they are irreplaceable medicines in the management of acid-related ailments and its benefits surpass the prospective dangers (Blandizzi, Gatta, Scarpignato, & Zullo, 2016).

A position paper was written by Bigras, Bonev, Joubair, and Long (2016) to report changes made to improve the calibration and accuracy of a six degree of freedom medical robot. The proposed positioning accuracy was improved from "12 mm to 0.320 mm, for the maximum values, and from 9 mm to 0.2771 mm, for the mean errors" (p.1). Evaluating the inflammatory markers in endotoxins induced root canal infections, Devi, Gayathri, and Priya (2018) composed a position paper to report their findings. They reported that root canal treatments increase the release of endotoxins which can lead to inflammation, infection, and treatment failure (Devi, Gayathri, & Priya, 2018). As shown, the use of position papers has been established in educational and other research literature.

Project Description

Resources, Supports, and Barriers

This quantitative project study is founded upon the instructional antidotes in a suburban high school located in Northwest Mississippi that occurred during the 2016-2017 school year. During this time, the researcher served in the science department as an Earth and Science teacher at the school-elect. Before utilizing interactive notebooks as an instructional tool to teach Biology 1 courses, this school utilized the Holt-McDougal textbook and its corresponding curriculum solutions as its chief instructional implements as it offered vertical, horizontal, and direct alignment of instruction to the state's science standards and framework (DCS, 2017; Kuykendall, 2017; MDE, 2017). In the years preceding the utilization of the interactive notebook, the state issued an accountability model that mandated that all public school students be college or career ready before completing high school as measured by completion of coursework and levels of proficiency on standardized assessments (DCS, 2017; Kuykendall, 2017; MDE, 2017). Accordingly, many schools, including Local High School, pursued instructional and curriculum based tools and practices that could aid in proliferating science proficiency (Dulfer, Polesel, & Rice, 2014; Furrer, Pitzer, & Skinner, 2014; Lee & Reeves, 2012). The instructional solution of utilizing interactive notebooks was supported by the idea of increasing students' proficiencies due to students taking onus of their learning through creativity, writing, and exploration (Heilbronner and Mallozzi, 2013). The only requirements needed to implement the use of interactive notebooks as an instructional tools were composition notebooks, glue, colored pencils, and the reorganization of the extant resources.

The bilateral curriculum for the Biology 1 courses at Local High School was employed by instituting several solutions (Borko et al., 2003; Love, 2009; Schlechty, 2009). Although it wasn't a requirement, the teacher utilizing the interactive notebook took a professional development workshop offered by the school district on setting up and maintaining interactive notebooks in the science classroom. Additionally, I gathered the support I needed from the school's administration to repurpose the Holt-McDougal resources. The teacher in the control group (non-interactive notebook users) utilized the textbook, PowerPoints, worksheets, digital media, and power notes as key instructional instruments. However, the teacher in the experimental group (interactive notebook users) used the interactive notebook as the primary instructional instrument. Although Powerpoints, the textbook, and worksheets were used by the teacher in the experimental class, they were only used as entries or items within the interactive notebook. Lastly, I supplied the scope and sequence of the Next Generation Science Standards, the Common Core State Standards, and the Mississippi Science Framework to secure the consistent implementation of the science curriculum across the two cohorts (DCS, 2017; Kuykendall, 2017; MDE, 2017). The measurement of science proficiency, the Biology 1 SATP and CASE 21 assessments, were already in position and ready. The students in the sample for this study were also equitable-- sharing similar socioeconomic status backgrounds, demographics, and educational environment. Taking into account these qualitative uniformities amongst the two cohorts of students, the utilization of interactive notebooks as the primary instructional tools was the solitary treatment in this quasi-experimental study.

Timetable, Roles, and Responsibilities of Students and Others

This quasi-experiment was only conceivable as an ex post facto study as a result of the researcher's professional and personal attachment to the participating school district and school. Inside the structure of a quantitative study with a quasi-experimental research design, this project offers an innocuous opportunity to investigate the influence of utilizing interactive notebooks on the science proficiency of high school students without any ramifications, risks, dangers, or infringements of the students' welfare or safety. The data provider deleted all information that was identifiable or detectible, as well as provided a Letter of Cooperation and a completed Data Use Agreement Form. Using randomly created numbers, the data provider sorted the students according to their use or disuse of interactive notebooks. Any and all subjective and personal information related to any contributing teacher or student in this experiment was removed.

The participating school district provided the pacing guide and science standards, which were derived from the 2010 Mississippi Science Framework for Biology1, used by the participating Biology 1 teachers during the 2016-2017 school year. At the closure of the 2016-2017 school year, the Mississippi Department of Education adopted the 2018 Mississippi College and Career Readiness Standards for Biology 1, which is parallel in content but incongruent in rigor and application of content to the 2010 Mississippi Science Framework for Biology 1, to guide future science curriculum and programs of study (DCS, 2017; Kuykendall, 2017; MDE, 2017). A copy of the position paper or research summary detailing the success of utilizing interactive notebooks on students' science proficiencies will be provided to the participating school district and school at the conclusion of this doctoral project study. It is my intention to help the school district and school to discover and implement the most advantageous instructional solutions for the imminent school years.

Project Evaluation Plan

Type of Evaluation

This project study is designed using a quantitative ex post facto quasi-experimental methodology. This project study is not evaluative in nature despite the collective juxtaposition of the two group of students regarding their use or disuse of interactive notebook. Instead, this quasi-experiment achieves quantifiable evidence demonstrating the effect of utilizing interactive notebooks on the science proficiency of high school Biology 1 students. Being that this project study employed independent samples *t*- tests to compare the statistical difference between the mean test scores of the two groups of students and is a results-based summative experiment, it possesses an already ingrained evaluative component. This study accomplished the means to assign a p-value to the variance in levels of science proficiency of the two groups of students, therefore, quantifying the science proficiency levels of the Biology 1 students for Local High School within the 2016-2017 school year.

Additionally, this project study offers a position paper that recommends utilizing interactive notebooks as a possible instructional solution to raising students' science proficiencies. Outside of the participating school district and school, this project study provides a justification for utilizing various instructional tools, such as the interactive notebooks, in science education as a mean to proliferate science proficiency. This position paper provides a platform for support of curriculum reform, science education, science proficiency, and the use of interactive notebooks in science. Conclusively, the efficacy of the proposed position paper, which requires an in-depth and more comprehensive evaluation, takes time that goes well past the period of time for this project study. Upon completion of this doctoral project study, the researcher will communicate the findings to the participating contributors' educational and political stakeholders. Ultimately, the action of utilizing interactive notebooks and the subsequent proliferation of students' science proficiency will determine the true success of this project study.

Overall Goals and Stakeholders

Providing instructional solutions to improve science education and proliferate science proficiency were the overall goals of this position paper. Only the quantitative effects of utilizing interactive notebooks on students' science proficiency were reported in this position paper and not the qualitative aspects of using interactive notebooks or participants' perceptions of science proficiency and curriculum reform. This project study and its concluding position paper are informative. Their purpose is to inform the educational and political stakeholders of the participating school and school district, as well as, educational and political stakeholders of resident or distant schools and school districts across the U.S. that are in pursuit of instructional solution in science education. With the present curriculum reform initiative's directive for science proficiency and the current infiltration of professions and industries in Science, Technology, Engineering, and Mathematics (STEM), this project study has the opportunity to spark dialogues at municipal, state, and federal arenas. Despite its limited generalizability and narrow scope, this project study serves as a catalyst for more extensive and wide-ranging investigations concerning science education, instructional tools, and science proficiency.

Project Implications

Social Change Implications

The present-day focus on science proficiency and literacy stems from the passing of the No Child Left Behind (NCLB) Act of 2001, the adoption of the Common Core State Standards (CCSS) by many states in 2010, and the current influx of occupations and enterprises in the Science, Technology, Engineering, and Mathematics (STEM) domains (Banner & Ryder, 2013; Chang, Kao, Lin, & Tsai, 2015; Drake, 2014; Jianjun, 2012; Lavery, 2016; Torres, 2014). Both the NCLB and CCSS reform initiatives have prompted educators to seek pedagogical practices that better individualize instruction and aid students in processing scientific information to proliferate science proficiency (Ates & Yildirim, 2012; Demski, 2012; Hussain, Rifat, Safdar, & Shah, 2012). The administration and staff at the participating school and school district have a formidable desire to help all students achieve and be successful in school. They also have the desire to have all students ready to enter the workforce or prepared to excel in college upon graduation from high school. As such, one day these students will be active members of society and because of the high demand for current and upcoming STEM-related jobs, possessing the knowledge and effectual application of scientific information is required and promoted.

Local Stakeholders Implications

The administrators, teachers, supporting staff, students, parents, and the community are the local stakeholders in this doctoral study. The proliferation of science proficiency through the use of interactive notebooks yields various benefits for each stakeholder. The administration and staff benefit from increased science proficiency levels in that they achieve improved assessment data. Improved assessment scores and achievement levels have been proven to raise school morale, students and teachers' motivation, and a greater buy-in of the school's assessment programs, instructional practices, and curricular decisions from the parents and community (Cohen, Guffey, Higgins-D'Alessandro, &Thapa, 2013; Glanz, 2014; Petty, 2014; Skaalvik & Skaalvik, 2013). The administration and staff of the school and school district will also benefit from the improved assessment scores via their accountability model. Higher test scores equal a higher accountability standing for the school and school district (DCS, 2017; Lavery, 2016; Marx & Harris 2006; MDE, 2017; Neil 2003). Funding, grants, and other resources are also more readily available to improving or high-performing schools and school districts to nurture further improvement efforts (Hillman & Tandberg, 2014; Nisar, 2015; Rabovsky & Rutherford, 2014).

When students perform better in school and on standardized tests, their parents tend to notice an improvement of attitude and outlook towards every capacity of their life. Parents have reported that when their students perform better at school and on assessments, they display better conduct and behavior both in and out of the school environment and are involved in more extra-curricular activities life (Guerra & Nelson, 2014; Hopkins, 2013; Murphy, 2013). The parents of students that are doing better in school or have improved academically may see an improvement in their attitude not only towards school, but in other aspects of their life (Guerra & Nelson, 2014; Hopkins, 2013;

Murphy, 2013). Students also benefit from academic success in regards to being college and career ready. A higher salary or income and preparedness for college are possible when students graduate knowledgeable, proficient, and skillful in their areas of study (Andrews, Li, & Lovenheim, 2014; Avitabile & De Hoyos, 2015; Bettinger, Boatman, & Long, 2013).

Far-Reaching Implications

The aforementioned positive repercussions of increased academic proficiency can also have a direct effect on society. According to research, students want to learn and achieve proficiency in school; however, when they don't accomplish this intrinsic desire dropping out or chronic underachievement can become viable options (Ariës & Cabus, 2017; Egalite, 2016; Mallett, 2016). Greater frequencies of imprisonment are found among high school dropouts and underachievers. When compared to high school graduates, dropouts and underachievers are 4 times more likely to be arrested. On a national scale, a substantial 68 percent of all male prisoners are dropouts. Likewise, only 20 percent of California's male prisoners exhibit a rudimentary degree of proficiency in any subject area (Ariës & Cabus, 2017; Egalite, 2016; Mallett, 2016). The increase in science-related jobs and push for science literacy and proficiency has prompted many prison systems, such as the Arizona Department of Corrections, to offer science courses to inmates to foster scientific interest and increase science proficiency. Taught by graduate and select undergraduate students from Arizona State University, the prison biology education program can provide societal bonuses including reduction in the occurrence of re-offense and proliferation in the opportunity of securing work upon release for inmates (Ariës & Cabus, 2017; Egalite, 2016; Mallett, 2016).

Conclusion

The foundation of this project study is constructed upon a triangulation of scholastic sources. Firstly, the quasi-experimental studies of Arop, Umanah, and Effiong (2015), Çıbık (2016), and Bektaş and Kızkapan (2017) exhibited measurable differences in students' achievement levels of scientific concepts when students utilize various instructional tools, such as the interactive notebook. Additionally, the MMECCA (MMECCA) Framework (2002) indicated that various instructional materials or tools, comparable to the interactive notebook, give students agencies of demonstration of concepts, numerous methods of participating in learning, and several processes of manifestation to demonstrate what they have learned. Lastly, the IDT (2010) suggested that instructional tools, similar to the interactive notebook, are purposely constructed to meet the needs of the students; therefore, creating a natural interaction between the learner and the instructional tool leading to amplified learning. Resting on these three bastions, this project study used an ex post facto quasi-experiment research design to examine the effect of the instructional tool, the interactive notebook, on the science proficiency of high school Biology 1 students when compared to traditional tools or methods of instruction.

Encompassed with quantitative evidence, this study supports the use of the interactive notebook as an instructional tool to proliferate science proficiency. It was discovered that the group that utilized interactive notebooks within the curriculum, had a higher level of science proficiency than the control group, the group that did not utilize interactive notebooks, as measured by the mean scores of the Biology 1 SATP assessment ($M_{experimental}$= 659.92, $M_{control}$ = 656.13; p=.006). However, it was determined there was no statistical significant difference between the two cohorts ($M_{experimental}$= 4.64, $M_{control}$= 4.59; p=.815) for competency 1, competency 5 ($M_{experimental}$= 10.44, $M_{control}$= 9.84; p=.122), and competency 6 ($M_{experimental}$= 5.05, $M_{control}$= 4.73; p=.160). Conversely, it was found that there was a statistical significant difference between the two cohorts for competency 2 ($M_{experimental}$= 4.88, $M_{control}$= 3.97; p=.000), competency 3 ($M_{experimental}$= 8.03, $M_{control}$= 7.33; p=.044), and competency 4 ($M_{experimental}$= 10.21, $M_{control}$= 8.61; p=.000). Given the findings of this study and the parallel findings of studies done by Arop, Umanah, and Effiong (2015), Çıbık (2016), and Bektaş and Kızkapan (2017), the interactive notebook has the capacity to serve as an instructional solution to proliferate science proficiency and literacy.

Section 4: Reflections and Conclusions

Project Strengths and Limitations

The archival characteristic of the student assessment data was the most significant asset of this doctoral project study. With the readily available data from both semesters of the 2016-2017 school year, I utilized the quantitative methodology of ex post facto quasi-experimental design to investigate the effect of utilizing curriculum-embedded interactive notebooks on the science proficiency of Biology 1 students. This was measured by their performance on the SATP Biology1 assessment at Local High School with no direct or ongoing repercussions for the contributing teachers and students. Furthermore, through the use of encoded archival student data and parallel teaching practices and experiences, the findings of the study are reliable and valid and the study is completely replicable. The independent or manipulated variable was the utilization (experimental group) or non-utilization (control group) of the interactive notebooks. The dependent or responding variable was the students' scores on the SATP Biology 1 assessment. Through the use of the SPSS Statistics software program, I was able to conduct several independent samples *t* tests on the CASE 21 assessment data and the SATP Biology 1 assessment data. Through this dataset, it was found that both group of students began the course on the same proficiency level; however, the group that used interactive notebooks within the curriculum had a higher level of science proficiency than the control group, the group that did not utilize interactive notebooks, as measured by the mean scores of the Biology1 SATP assessment. Additionally, I discovered there were higher levels of science proficiency for the experimental group for several competencies on the assessment as well.. In addition, another strength of this study was the curricular and instructional consistencies across the two groups. The Local High School ensured that both the experimental and control groups were taught from the same Mississippi Biology 1 framework, followed the same pacing guide as set by the Local County School District, were assessed according to the same standards, had teachers with comparable teaching experience and quality, and were in semesters of parallel length. These analogous features helped increase the validity and reliability of this study's findings.

As mentioned, this doctoral project study has limited generalizability past implications made for Local High School due to its nonrandom sampling. This project study had a narrow scope of analysis. Addressing only two research questions, ultimately, this study has evident limitations of investigating the effect of utilizing the curriculum-embedded interactive notebooks on students' science proficiency at a solitary setting, Local High School. Another limitation of this project study was that it is purely quantitative. The qualitative features of utilizing the curriculum-embedded interactive notebooks or utilizing traditional methods of instruction were not considered in this study. This study's sole concentration was to measure the quantifiable influence that the utilization of curriculum-embedded interactive notebooks as an instructional tool had on students' science proficiency as evidenced by students' performance on the SATP Biology 1 assessment.

Recommendations for Alternative Approaches

Stemming from the study's limitations and central focus on the quantitative aspects of utilizing interactive notebooks, recommendations for alternative approaches include investigating the qualitative aspects of utilizing interactive notebooks. Conducted by means of an ex post facto quasi experimental design, this doctoral project study did not investigate any qualitative features of utilizing interactive notebooks. Therefore, a mixed-methods study investigating the quantitative aspects of utilizing interactive notebooks in conjunction with the students' experiences of utilizing interactive notebooks would offer a more comprehensive representation of the influence of interactive notebooks on science proficiency in high schools. Furthermore, a qualitative investigation into the long-term influence of utilizing interactive notebooks on the learners' perceptions of self as a scholar or the teachers' perceptions of self as a professional would definitely address the gap in the literature regarding the effect of curriculum embedded interactive notebooks as a specific instructional strategy on high school biology students' science proficiency.

Scholarship

The project study developed from my desire to grow as an educator. Although I lacked experience in research techniques and procedures, I had a zeal to proliferate student achievement through the improvement of instructional practices. The more knowledgeable I became about research and the more I pursued different instructional tools to increase the science proficiency of students, the more this project study became my driving force.

Finding recent peer reviewed resources relating to the influence of utilizing interactive notebooks on students' science proficiency was extremely hard. There is significant gap in literature concerning interactive notebooks as an instructional tool in high schools. Finding these gaps were a part of the research process and helped me to mature as a practitioner. Although there is a gap in literature concerning interactive notebook usage in high schools, I was able to find many scholarly articles on instructional tools similar to the interactive notebook and their effect on science proficiency in secondary education.

Through research and resources, I was able to identify the best research methodology and data analysis for the doctoral project study. As the project study progressed from the problem statement and rationale, to the research questions and hypotheses, to the design approach and data evaluation, to reflective and conclusive writing, so did my extensive understanding and knowledge of the research problem and the investigative modus operandi. Through this onerous journey of scholarship, I was able to make my own contribution to the standing collection of knowledge and scholarship concerning science proficiency, interactive notebooks, and student achievement.

Project Development and Evaluation

This project study began from discussions with my supervising principal and teachers in the science department. In the pursuit of effective instructional practices and tools, many teachers throughout the district and school in disciplines, other than science, have embedded interactive notebooks as an instructional tool into the curriculum. One Biology 1 teacher at Local High School participated in various professional development workshops focused on implementing interactive notebooks in the classrooms. After taking these workshops, the teacher decided to embed interactive notebooks into the Biology 1 curriculum in the classroom. My supervising principal, knowing I was pursing my doctorate in education, asked me to examine the effects of utilizing interactive notebooks on the science proficiency of Biology 1 students. Data for the project study was collected after the teacher piloted the utilization of curriculum embedded interactive notebooks for a year in the classroom. Actual use of the interactive notebooks by Biology 1 students at Local High School took place concomitantly with my graduate studies.

Considering my professional involvement as a Biology 1 teacher at the place of research for the project study, the need for ex post facto data analysis was a major aspect of the project development. In order to safeguard the protection of the students and the contributing teachers, the project study took place a year after the actual assessment data collection, once the assessment data became archival. Although direct contact with the participants was not required for the project study, the protection of the rights of the participants was once again safeguarded by the removal of all identifying information from the datasets. Specifically, the school's administration removed all student identifiers from the data before releasing it to me. The score reports given to me had only the teacher's names identified as a means to distinguish the control group from the experimental group.

Leadership and Change

All leaders, no matter the area of professional expertise, have the responsibility of balancing and meeting the needs of all the stakeholders in the environment. Some of the best leaders I have encountered and worked with made decisions and judgements based on the common good of everyone involved in the situation, as opposed to making selfish, one-sided, and egotistical choices. Effective leaders help stakeholders to understand and appreciate the differences in backgrounds and past experiences, while letting them know they are the most valuable determinant in implementing an efficacious initiative.

Effective leadership, especially in the educational setting, must seek to sustain and disrupt (Schlechty, 2009). The disruption of the existing social and pedagogical structures is the solution to many issues in education, however, this alone is not the entire solution. Instead, successful leaders must also ruminate and be willing to implement necessary and cyclic changes. They must also possess the ability to maintain equanimity in an ever-changing environment. This type of leadership necessitates a comprehensive understanding of scholarship and research concerning the particular occurrence. To stimulate the support of stakeholders, effective leadership must provide accurate, viable, and sustainable ancillaries to the present social and pedagogical systems.

Effective change and leadership also require progressive and futuristic thinking. Teamwork, inquiry, and evaluation are platforms upon which effective leadership and change are supported (Schlechty, 2009). Very rarely is change accomplished by the efforts of one person. Curriculum vicissitudes that deal with the integrating of instructional tools like the interactive notebook, will require progressive thinking and the buy-in of the faculty and staff, students, and parents. Having the support and assistance of stakeholders can steer leadership in the path of positive and effective change.

Reflection on the Importance of Work

Analysis of Self as Scholar

Throughout my journey at Walden University, I have really grown in scholarship and knowledge. I am naturally inquisitive, hence my decision to become a science teacher. However, throughout my doctoral studies, I have witnessed my growth in thinking, writing, and research. I have grown into a critical thinker and problem solver. I am now more conversant with theoretical frameworks and research studies pertaining to science education, instructional tools, and science proficiency. I am a much stronger and scholarly writer as a result of the rigorous standards for APA and peer-reviewed writing. Through the incessant cyclic actions of rewriting, correcting, proofreading, and redrafting, I became a scholar that venerates self- convalesce.

Analysis of Self as Practitioner

Due to the explosion of Science, Technology, Engineering, and Mathematics (STEM) related careers and courses of study, teachers are required to improve upon their pedagogical practices and resources to ensure the proliferation of their students' science proficiencies. Although content knowledge is imperative for effective instruction, knowing how to teach the content in a manner in which all students can retain, apply, and analyze it is the crux of student learning. As a practitioner, this study has taught me the importance of pedagogical resources and tools on student outcomes.

When I initially decided to pursue a doctoral degree, I thought about going the PhD route. However, after serving on school, district, and state level committees for the improvement of secondary sciences in classrooms, I developed an enthusiasm for practice application, implementation, and project evaluation. Nevertheless, practitioners can only make significant impacts when they are outfitted with knowledge to support and defend the change that they want to see in their educational setting. Throughout my doctoral journey, I discovered the need for peer-reviewed, scholarly sources of information to generate useful cases to support my own efforts of changing the pedagogical practices in my learning environment. Although many educational advocates may use subjective and unsanctioned data in their fights for change, I have learned that accurate and scholarly research must always be the basis of a practitioner's claim for change.

Analysis of Self as Project Developer

Due to my position as a solution- seeking educator in the participating school, I became a project developer prior to becoming a scholar practitioner. Working daily with administrators, teachers, and students, I was compelled to assist with designing pragmatic projects to proliferate students' improvement and proficiency in science courses.

Although curriculum-embedded interactive notebooks were being utilized by some teachers in the participating school before I began my doctoral studies, my coursework at Walden University helped to further augment my understanding of utilizing curriculum-embedded interactive notebooks to proliferate students’ science proficiencies. Throughout my studies, after gaining heterogeneous information and initiatives from various courses, I established a unified montage for utilizing interactive notebooks as an instructional solution to proliferate science proficiency and literacy.

In the early stages of my project study writing, I encountered various issues with CIA alignment. Initially, I sought to qualitatively examine teacher- student relationships and their effect on student achievement in science. Although I helped to develop the interactive notebook utilization project, it was not my first choice of study. Only after meeting with my supervising administrator and continuous dialogue with my doctoral chair did I see the power to stimulate change by examining interactive notebooks as a possible instructional solution to proliferate science proficiency and literacy.

The Project’s Potential Impact on Social Change

This project study utilized the quantitative methodology of a quasi-experimental research design by analyzing ex-post-facto data to investigate the specific interactional tool of interactive notebooks and their use in the Biology 1 classroom to assist teachers in improving students' knowledge, skills, and abilities in a subject area or course (Chingos & Whitehurst, 2012). The goal of this doctoral project study was to compile quantifiable evidence of the treatment of interactive notebooks in a high school Biology 1 course and its effect on the students' science proficiency. Students utilizing the interactive notebook within the Biology 1 curriculum performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. In relation to exploring more effective instructional tools for proliferating achievement and proficiency levels, this study was able to demonstrate that utilizing interactive notebooks within the curriulum has the capability to advance and improve the science proficiency and achievement of students.

The present-day focus on science proficiency and literacy stems from the passing of the No Child Left Behind (NCLB) Act of 2001, the adoption of the Common Core State Standards (CCSS) by many states in 2010, and the current influx of occupations and enterprises in the Science, Technology, Engineering, and Mathematics (STEM) domains (Banner & Ryder, 2013; Chang, Kao, Lin, & Tsai, 2015; Drake, 2014; Jianjun, 2012; Lavery, 2016; Torres, 2014). Both the NCLB and CCSS reform initiatives have prompted educators to seek pedagogical practices that better individualize instruction and aid students in processing scientific information to proliferate science proficiency (Ates & Yildirim, 2012; Demski, 2012; Hussain, Rifat, Safdar, & Shah, 2012). The administration and staff at the participating school and school district have a formidable desire to help all students achieve and be successful in school. They also have the desire to have all students ready to enter the workforce or prepared to excel in college upon graduation from high school. As such, one day these students will be active members of society and because of the high demand for current and upcoming STEM-related jobs, possessing the knowledge and effectual application of scientific information is required and promoted. This project study has the opportunity to spark dialogues at municipal, state, and federal arenas. Despite its limited generalizability and narrow scope, this project study serves as a catalyst for more extensive and wide-ranging investigations concerning science education, instructional tools, and science proficiency.

Implications, Applications, and Directions for Future Research

Implications

Due to the use of non-randomized sampling, this study has limited generalizability past implications made for Local High School. Addressing two research questions, this study has narrow scope of analysis. Encompassed with quantitative evidence, this study supports the use of the interactive notebook as an instructional tool to proliferate science proficiency. It was discovered that the group that utilized interactive notebooks within the curriculum, had a higher level of science proficiency than the control group, the group that did not utilize interactive notebooks, as measured by the mean scores of the Biology 1 SATP assessment ($M_{experimental}$= 659.92, $M_{control}$ = 656.13; p=.006). Students utilizing the interactive notebook performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students without interactive notebooks. Although this study has limited generalizability, it can serve as a catalyst concerning the utilization of various instructional tools, such as the interactive notebooks, in science education as a mean to proliferate science proficiency.

Applications

This study’s application is bilateral. Firstly, it is informative for Local High School and the Local School District in their decision to implement the utilization of curriculum-embedded interactive notebooks in all of its high school science courses. Secondly, it serves as an exemplification for the lack of research available on utilizing interactive notebooks as an instructional tool to proliferate student achievement. With the emphasis placed on student proficiency and college and career readiness by the No Child Left Behind Act of 2001 and the Common Core State Standards of 2010, this study can assist in directing others towards the need for more research and studies concerning instructional tools and pedagogical practices in secondary science education.

Directions for Future Research

This study was purely quantitative by investigating the possible effect the interactive notebooks had on the science proficiency of Biology 1 students as measured by their scores on the SATP Biology 1 assessment. The qualitative features of utilizing the curriculum embedded interactive notebooks or utilizing traditional methods of instruction were not considered in this study. This study's sole concentration was to measure the influence that the utilization of curriculum embedded interactive notebooks as an instructional tool had on students' science proficiency as evidenced by students' performance on the SATP Biology 1 assessment. Therefore, a mixed-methods study investigating the quantitative aspects of utilizing interactive notebooks in conjunction with the students’ or teacher’s experiences of utilizing interactive notebooks would offer a more comprehensive representation of the influence of interactive notebooks on science proficiency in high schools. Furthermore, a qualitative investigation into the long-term influence of utilizing interactive notebooks on the learners' perceptions of self as a scholar or the teachers' perceptions of self as a professional would definitely address the gap in the literature regarding the effect of curriculum embedded interactive notebooks as a specific instructional strategy on high school biology students' science proficiency and literacy.

Conclusion

Conclusively, at the completion my doctoral project study, I have a deeper understanding and appreciation of the incessant construction of solutions and initiatives. Solutions and initiatives reinforced by current, scholarly research and literature have the potential to make lasting contributions and to prompt action. As a researchers, it is my responsibility to discover diverse viewpoints, assiduously pursue evidence, and resiliently investigate paradigms and theories. Throughout my doctoral studies at Walden, I have learned that novice ideas and concepts can mature into multifaceted, informative research that have long-term effects on the educational landscape. Learning is a continuous process and as one door closes, another one opens.

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Appendix A: Position Paper

The Effect of Interactive Notebooks on the Science Proficiency of Biology 1 Students

Dates of Project:

August 2016-May 2017

Date of Report:

December 2018

Executive Summary

Both the passage of NCLB and the adoption of the CCSS has triggered the need for increased research-based information on which instructional tools better differentiate instruction and help students to better process the information presented in the classroom. At Local High School, a suburban public school that serves almost 1,200 students in grades 9-12, the students' Subject Area Testing Program science scores were stagnant and their performance on the ACT science subtest was marginal. To improve science proficiency and student achievement on standardized assessments in science, Local High School's administration examined the specific interactional tool of interactive notebooks and their use in the Biology 1 classroom to assist teachers in improving students' knowledge, skills, and abilities in a subject area or course. Interactive notebooks were used by the experimental group daily to record and model course information, process ideas and make connections, and demonstrate content learned through reflective writing and discussion (Meyer, 2014; Shen, 2014; Shepard, 2016). The teacher of the experimental group used interactive notebooks to administer ongoing formative assessments that helped navigate their lesson planning and pedagogical practices (Heilbronner & Mallozzi, 2013). The use of interactive notebooks was posited to assist students in expressing science-learning processes, assimilating science skills, and increase science reasoning (Heilbronner & Mallozzi, 2013).

Achieved as an ex post facto quasi-experiment with independent samples *t* tests, this instructional interpolation compared the science proficiency, as measured by the

Biology 1 SATP assessment, of Biology 1 students in the experimental group with the science proficiency, as measured by the Biology 1 SATP assessment, of Biology 1 students in the control group. The experimental group consisted of Biology 1 students at Local High School who were in a course where interactive notebooks were regularly used (embedded) as an instructional tool from August 2016 until May 2017. The results of the independent samples *t* test on the 2016-2017 CASE 21 scores demonstrated no statistical significant difference between the control (*M*= 653.80, *SD*= 9.45) and experimental group (*M*= 655.60, *SD*= 6.65); *t*(182)= 1.50, *p*=.136. These results indicated that students in both the control and experimental groups began roughly on the same levels of science proficiency. The results of the independent samples *t* test for the mean scores of the 2016-2017 Biology 1 SATP assessment demonstrated statistical significant difference between the control (*M*= 656.13, *SD*= 10.49) and experimental group (*M*= 659.92, *SD*= 7.65); *t*(182)= 2.80, *p*=.006. Students utilizing the interactive notebook within the Biology 1 curriculum performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. In relation to exploring more effective instructional tools for proliferating achievement and proficiency levels, these results demonstrated that utilizing interactive notebooks within the curriulum has the capability to advance and improve the science proficiency and achievement of students.

To prove the positive effect of utilizing interactive notebooks on students' science proficiency, future studies must examine the effect of utilizing interactive notebooks within various landscapes. To substantiate the solidity of the outcomes, future research should employ a mixed methods research design. In addition to the quantitative data that the current study found in regard to the science proficiency and student achievement, it is advantageous to gather qualitative data that examine the perceptions and subjective experience of the students and teachers when utilizing interactive notebooks in science curriculum and courses.

Introduction

Under the No Child Left Behind policy, high schools in the state of Mississippi implemented an accountability model that relied on the use of the Subject Area Testing Program (SATP) assessments. These assessments known as graduation exams are used to measure student academic growth and proficiency and facilitate school improvement in Mississippi high schools (MDE, 2017). The SATP testing program encompassed standardized tests in Biology 1, English 2, Algebra 1, and U.S. History that students must pass to receive their high school diploma. The Biology 1 and Algebra 1 tests are typically administered during the student's 9^{th} grade year. The English 2 assessment is administered during the students' 10^{th}-grade year and the U.S. History exam during their 11^{th} grade year. Passing scores on the exams vary depending on the subject area assessed (MDE, 2017). As a result of Mississippi adopting the Common Core State Standards in 2009, the American College Testing program (ACT) became a mandated, standardized test for all 11^{th}-grade students in the state of Mississippi (DCS, 2017; MDE, 2017). The ACT consists of four subtests in reading, mathematics, science, and language arts. Under the Mississippi Accountability Model of 2013, science proficiency accounts for 50 points (as measured by students' performance on the Biology 1 SATP assessment) on a possible 1,000-point growth scale (DCS, 2017; MDE, 2017). With high stakes accountability models similar to those in Mississippi, it is increasingly critical that all learners have access to apposite programs of study, including instructional modifications (Dulfer, Polesel, & Rice, 2014; Furrer, Pitzer, & Skinner, 2014; Lee & Reeves, 2012). One such instructional practice is the use of instructional tools, such as interactive notebooks.

This position paper rests upon three bodies of research: (a) the quasi-experimental study of Arop, Umanah, & Effiong (2015); (b) Bektaş and Kızkapan's (2017) quasi-experimental study on project-based learning approaches; and, (c) Çıbık's (2016) quasi-experimental study on the instructional tool called the Project-Based History and Nature of Science Training and Conventional Method. The paper further uses an original ex post facto quasi-experimental project study of comparing science proficiency in relation to the utilization and non-utilization of interactive notebooks to support its recommendation for more effective curricular and instructional solutions to proliferate students' science achievement and proficiency in science curriculum and courses.

Theoretical Framework

The project study used the IDT (2010) and the MMECCA Framework (MMECCA) (2002) as its theoretical framework. Influenced by the works of B.F. Skinner, Bloom, Merrill, and Sweller, the IDT (2010) centers on how students are going to learn rather than on *what* the students are going to learn. It promotes the use of instructional methods or tools purposely constructed to ascertain learning in the classroom. This theory hinges on the indication that students will learn more efficiently when the instruction is structured and presented in a way that resonates with the students' needs and when the students can naturally interact with and use the instructional materials or tools provided for the lesson.

The MMECCA Framework (2002) is a standards-based framework centered on universal design, sheltered instruction, multicultural education, and differentiated instruction. Composed of six components, the MMECCA Framework emphasizes materials or tools of instruction. It defines instructional materials or tools as tangible items that used to reinforce teaching and generate results for all students. The MMECCA Framework deems that various instructional materials or tools give students agencies of demonstration of concepts, numerous methods of participating in learning, and several processes of manifestation to demonstrate what they have learned.

IDT (2010) informed the development of the research questions for the project study by substantiating how information is learned, such as with interactive notebooks. This is an important issue for research with regard to curriculum design. The MMECCA Framework connects the research question, study purpose, and problem within the peer-reviewed literature of standards based curricula and learning.

Project Study: Utilizing Interactive Notebooks and Science Proficiency

An ex post facto quasi-experimental doctoral project study represents the quantitative nucleus of this position paper. Given the evidence from the previous research described in the previous section, this project study examines the effect of utilizing curriculum embedded interactive notebooks on the science proficiency of Biology 1 students as measured by their performance on the SATP Biology 1 assessment during the 2016-2017 school year. The foundation of this study rested upon using interactive notebooks as an instructional tool to proliferate students' science literacy and proficiency in science curriculum and courses. There were two cohorts for this study, a group utilizing interactive notebook in the Biology 1 curriculum (experimental) and a group not utilizing interactive notebooks in the Biology 1curriculum but traditional methods of instruction instead (control). To protect the interests of the school that provided an opportunity for this quasi-experiment, as well as the students who attended the school during 2016-2017 school year, the school will be referred to as *Local High School.*

Local High School Project Study

Local High School had in place two differing Biology 1 curricula; in one curriculum, the students regularly used interactive notebooks, and they do not in the other curriculum. As a part of this quasi-experiment, data from two instruments were used for this study. The first instrument was the CASE 21 assessment. Data from the CASE 21 was used to establish whether the experimental and control groups started out equally in science proficiency Data from the SATP Biology 1 assessment was used to compare the science proficiency of the Biology 1 students from both the control and experimental groups after two semesters. The student' mean scores and competency breakdown scores were both analyzed. There are six individual categories or competencies on the SATP

Biology 1 assessment. These categories or competencies are Inquiry, Biochemical Basis of Life, Living Organisms and Their Environment, Biological Organization, Heredity, and Diversity and Biological Change. From the data supplied by these instruments, the dependent variable, science proficiency was produced. With the independent variable, utilization of interactive notebooks as instructional tools, the study used independent samples *t* tests to compare the mean scores from both instruments between the control and experimental groups for statistical significant differences.

The following research questions and hypotheses drove the quantitative project study:

RQ_1- Is there a statistically significant difference in science proficiency levels, as evidenced by Biology 1 students' SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum?

RQ_2- Is there a statistically significant difference among the six categories or competencies of the SATP Biology 1 Assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum?

$H_0 1$: No statistically significant difference exists in science proficiency levels, as evidenced by Biology 1 students’ SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

$H_1 1$: A statistically significant difference exists in science proficiency levels, as evidenced by Biology 1 students’ SATP mean scores, between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

$H_0$2: No statistically significant difference exists in science proficiency levels among the six categories or competencies of the SATP Biology 1 assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

$H_1$2: A statistically significant difference exists in science proficiency levels among the six categories or competencies of the SATP Biology 1 assessment between classes utilizing and not utilizing interactive notebooks within the Biology 1 curriculum.

Sample and Protection of Participants' Rights

This project study took place a year after the 2016-2017 instructional interpolation was implemented at Local High School. Inherently, all of the student achievement data are archival. The researcher did not access the data until official approval from the IRB at Walden University was received (IRB approval number 03-20-18-0499937). To ensure the protection of the wellbeing of the students and the teaching staff at Local High School, the Local School District Central Office removed all identifiable information pertaining to the identity of the students and the teachers from Local High School during the school year. The Local School District Central Office used randomly generated numbers and codes in place of the actual student IDs, and listed the groups as utilized interactive notebook and did not utilize interactive notebooks in place of the information pertaining to the identity of the teachers of each group. Only the Local School District Central Office has the raw assessment data. The researcher received and analyzed only the encoded and de-identified data. The sample size for the study was N=184; with n=93 for the control group and n=91 for the experimental group.

Findings and Data Analysis

Parallel to other studies (Arop, Umanah, & Effiong, 2015; Bektaş and Kızkapan, 2017; Çıbık, 2016), findings from this study demonstrated measurable differences in students' science proficiency when students utilized instructional tools other than traditional methods of instruction ($M_{control}$= 656.13, *SD*= 10.49, $M_{experimental}$= 659.92, *SD*= 7.65); *t*(182)= 2.80, *p*=.006

Given the necessary significance threshold of .05, I rejected the Null Hypothesis 1 and found that there was a significant effect of utilizing interactive notebooks on students' science proficiency. (Table A1). According to the results in the Table A2, students utilizing the interactive notebook performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students without interactive notebooks with 95% confidence.

Table A1

Group statistics of control and experimental groups for Biology 1 SATP assessment

	N	Mean	Std. deviation	Std. Error Mean
Without Interactive Notebooks (Control)	93	656.13	10.50	1.088
With Interactive Notebooks (Experimental)	91	659.92	7.647	.802

Table A2

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment

		Levene's Test for Equality of Variances		t test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Biology 1 SATP Scores	Equal variances assumed	4.723	.031	2.798	182	.006	3.794	1.356	1.119	6.469
	Equal variances not assumed			2.808	165.302	.006	3.794	1.351	1.126	6.462

Also parallel to other studies (Arop, Umanah, & Effiong, 2015; Bektaş and Kızkapan, 2017; Çıbık, 2016), there were significant differences seen between the two cohorts for competencies 2, 3, 4 on the Biology 1 SATP assessment but not for competencies 1, 5, and, 6. Table A3, A4, A5, A6, A7, and A8 documents the independent samples *t* test results for each competency. According to the results in the Table A3, students utilizing the interactive notebook performed .341 points worse to .433 points better on the Biology 1 SATP assessment for competency 1 than students without interactive notebooks with 95% confidence. According to Table A4, students utilizing the interactive notebook performed .416 to 1.41 points better on the Biology 1 SATP assessment for competency 2 than students without interactive notebooks with 95% confidence. According to Table A5, students utilizing the interactive notebook performed .019 to 1.38 points better on the Biology 1 SATP assessment for competency 3 than students without interactive notebooks with 95% confidence. According to Table A6, students utilizing the interactive notebook performed .834 to 2.36 points better on the Biology 1 SATP assessment for competency 4 than students without interactive notebooks with 95% confidence. According to Table A7, students utilizing the interactive notebook performed .162 points worse to 1.36 points better on the Biology 1 SATP assessment for competency 5 than students without interactive notebooks with 95% confidence. According to Table A8, students utilizing the interactive notebook performed .129 points worse to .777 points better on the Biology 1 SATP assessment for competency 6 than students without interactive notebooks with 95% confidence.

Table A3

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 1

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 1	Equal variances assumed	1.672	.198	.235	182	.815	.046	.196	-.341	.433
	Equal variances not assumed			.235	178.493	.815	.046	.196	-.340	.432

Table A4

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 2

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 2	Equal variances assumed	.989	.321	3.627	182	.000	.911	.251	.416	1.407
	Equal variances not assumed			3.631	180.747	.000	.911	.251	.416	1.407

Table A5

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 3

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 3	Equal variances assumed	.877	.350	2.027	182	.044	.700	.345	.019	1.381
	Equal variances not assumed			2.029	181.078	.044	.700	.345	.019	1.380

Table A6

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 4

		Levene's Test for Equality of Variances		t test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 4	Equal variances assumed	7.093	.008	4.135	182	.000	1.596	.386	.834	2.357
	Equal variances not assumed			4.135	171.663	.000	1.596	.385	.836	2.356

Table A7

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 5

		Levene's Test for Equality of Variances		t test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 5	Equal variances assumed	2.259	.135	1.554	182	.122	.601	.387	-.162	1.364
	Equal variances not assumed			1.557	178.554	.121	.601	.386	-.161	1.362

Table A8

Independent samples t test for science proficiency: Control and experimental group on Biology 1 SATP assessment for competency 6

		Levene's Test for Equality of Variances		**t test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Competency 6	Equal variances assumed	1.141	.287	1.411	182	.160	.324	.230	-.129	.777
	Equal variances not assumed			1.411	181.840	.160	.324	.229	-.129	.776

Discussion: Local High School and Science Proficiency

The results of the independent samples *t* test for the mean scores of the 2016-2017 Biology 1 SATP assessment demonstrated statistical significant difference between the control (M= 656.13, SD= 10.49) and experimental group (M= 659.92, SD= 7.65); $t(182)$= 2.80, p=.006. Students utilizing the interactive notebook within the Biology 1 curriculum performed 1.12 to 6.47 points better on the Biology 1 SATP assessment than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. In relation to exploring more effective instructional tools for proliferating achievement and proficiency levels, this study was able to demonstrate that utilizing interactive notebooks within the curriulum has the capability to advance and improve the science proficiency and achievement of students.

To measure an even deeper understanding of the science proficiency of the students from the two groups, the study compared the mean scores of the six individual categories or competencies of the Biology 1 SATP assessment by conducting multiple independent samples *t* tests. The results of the *t* test on competency 1 suggested no statistical significant difference between students utilizing the interactive notebook (M= 4.64, *SD* = 1.22) and students not utilizing the interactive notebook (M= 4.59, *SD* = 1.43); *t*(182)= .235, *p*=.815. The experimental group had roughly the same level of science proficiency as the control group for competency 1 as measured by the Biology 1 SATP assessment. The results of the *t* test on competency 2 suggested a statistical significant difference between students utilizing the interactive notebook (*M*= 4.88, *SD* = 1.61) and students not utilizing the interactive notebook (M= 3.97, *SD* = 1.79); *t*(182)= 3.63, *p*=.000. Students utilizing the interactive notebook within the Biology 1 curriculum performed .416 to 1.41 points better on the Biology 1 SATP assessment for competency 2 than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. The results of the *t* test on competency 3 suggested a statistical significant difference between students utilizing the interactive notebook (*M*= 8.03, *SD* = 2.23) and students not utilizing the interactive notebook (M= 7.33, *SD* = 2.45); *t*(182)= 2.03, *p*=.044. Students utilizing the interactive notebook within the Biology 1 curriculum performed .019 to 1.38 points better on the Biology 1 SATP assessment for competency 3 than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. The results of the *t* test on competency 4 suggested a statistical significant difference between students utilizing the interactive notebook (*M*= 10.21, *SD* = 2.24) and students not utilizing the interactive notebook (M= 8.61, *SD* = 2.94); *t*(182)= 4.14, *p*=.000. Students utilizing the interactive notebook within the Biology 1 curriculum performed .834 to 2.36 points better on the Biology 1 SATP assessment for competency 4 than students not utilizing the interactive notebooks within the Biology 1 curriculum with 95% confidence. The results of the *t* test on competency 5 suggested no statistical significant difference between students utilizing the interactive notebook (*M*= 10.44, *SD* = 2.40) and students not utilizing the interactive notebook (M= 9.84, *SD* = 2.82); *t*(182)= 1.55, *p*=.122. The experimental group had roughly the same level of science proficiency as the control group for competency 5 as measured by the Biology 1 SATP assessment. The results of the *t* test on competency 6 suggested no statistical significant difference between students utilizing the interactive notebook (*M*= 5.05, *SD* = 1.52) and students not utilizing the interactive notebook (M= 4.73, *SD* = 1.60); *t*(182)= 1.41, *p*=.160. The experimental group had roughly the same level of science proficiency as the control group for competency 6 as measured by the Biology 1 SATP assessment.

This study offers quantitative data that support utilizing interactive notebooks as an instructional tool to increase the science proficiency of Biology 1 students. Therefore, findings from this study serve as a platform for policy recommendations centering on implementing and utilizing effective instructional tools that can convert into programs that have the capability to proliferate student proficiency and close the achievement gap. Conclusively, this study gives way to many qualitative studies that can investigate the psychosomatic, intellectual, and perceptive components of utilizing interactive notebooks as instructional tools and the way they affect teachers' pedagogical practices and students' sense of competence and self-efficacy.

Figure A1 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 1. Figure A2 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 2. Figure A3 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 3. Figure A4 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 4. Figure A5 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 5. Figure A6 displays the raw Biology 1 SATP score distribution of the students' science proficiency for the control and the experimental group for competency 6.

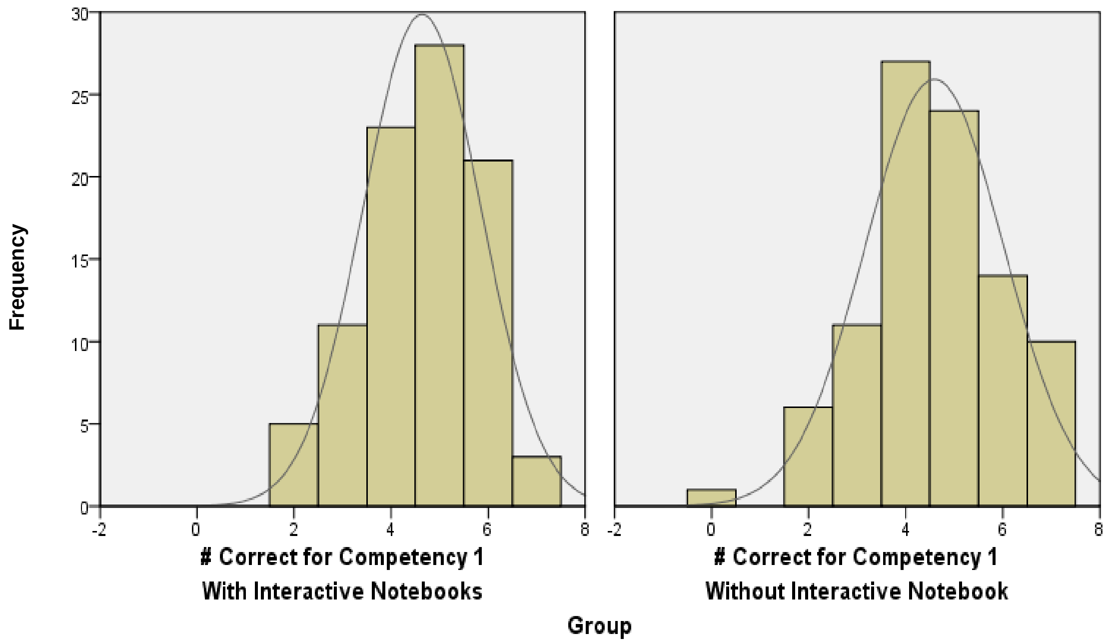

Figure A1. The experimental and control groups' Biology 1 SATP scores for competency 1

a. Experimental: Mean= 4.64, Standard Deviation= 1.22, *N*= 91
b. Control: Mean = 4.59, Standard Deviation= 1.43, *N*= 93

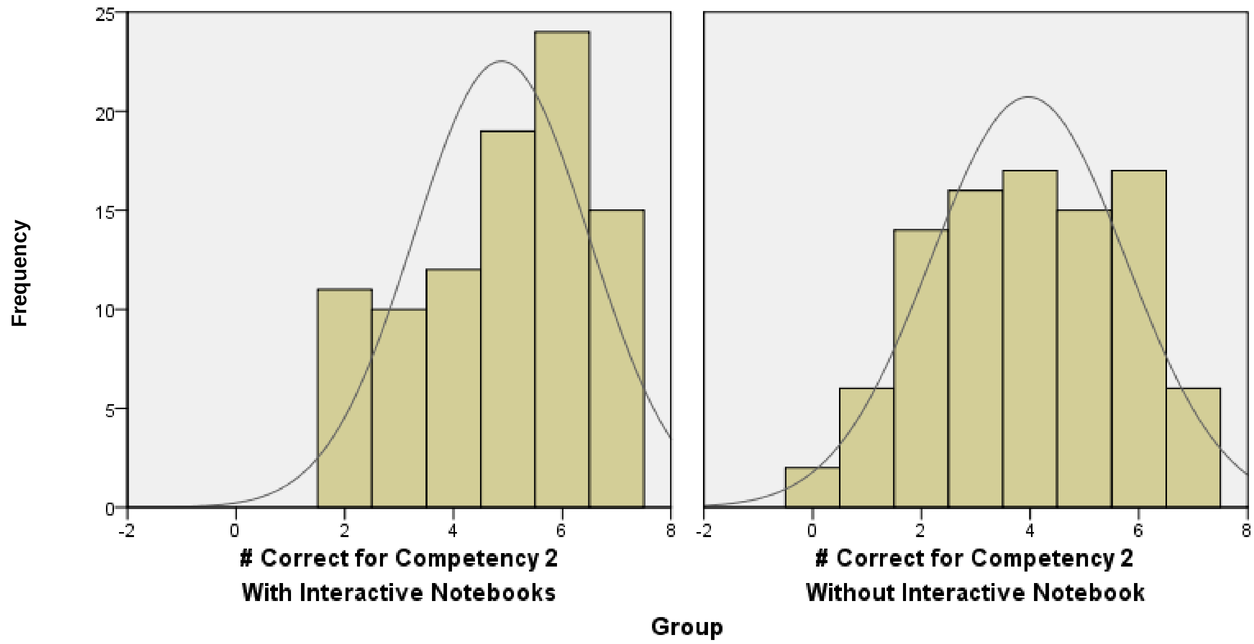

Figure A2. The experimental and control groups' Biology 1 SATP scores for competency 2

a. Experimental: Mean= 4.88, Standard Deviation= 1.61, *N*= 91
b. Control: Mean = 3.97, Standard Deviation= 1.79, *N*= 93

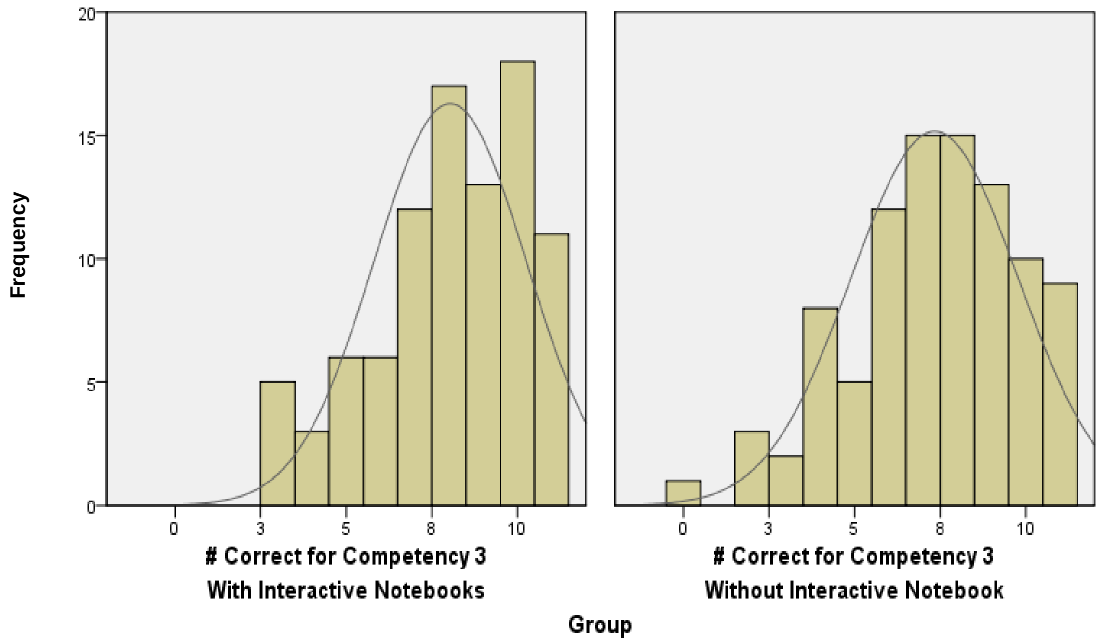

Figure A3. The experimental and control groups' Biology 1 SATP scores for competency 3

a. Experimental: Mean= 8.03, Standard Deviation= 2.23, *N*= 91
b. Control: Mean = 7.33, Standard Deviation= 2.45, *N*= 93

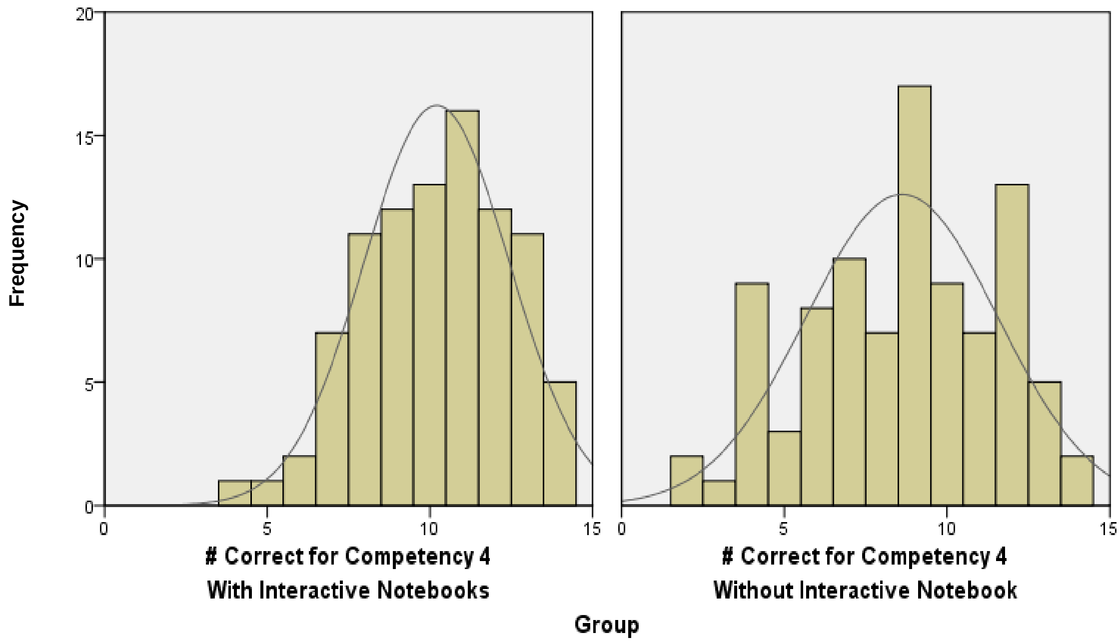

Figure A4. The experimental and control groups' Biology 1 SATP scores for competency 4

a. Experimental: Mean= 10.21, Standard Deviation= 2.24, *N*= 91
b. Control: Mean = 8.61, Standard Deviation= 2.94, *N*= 93

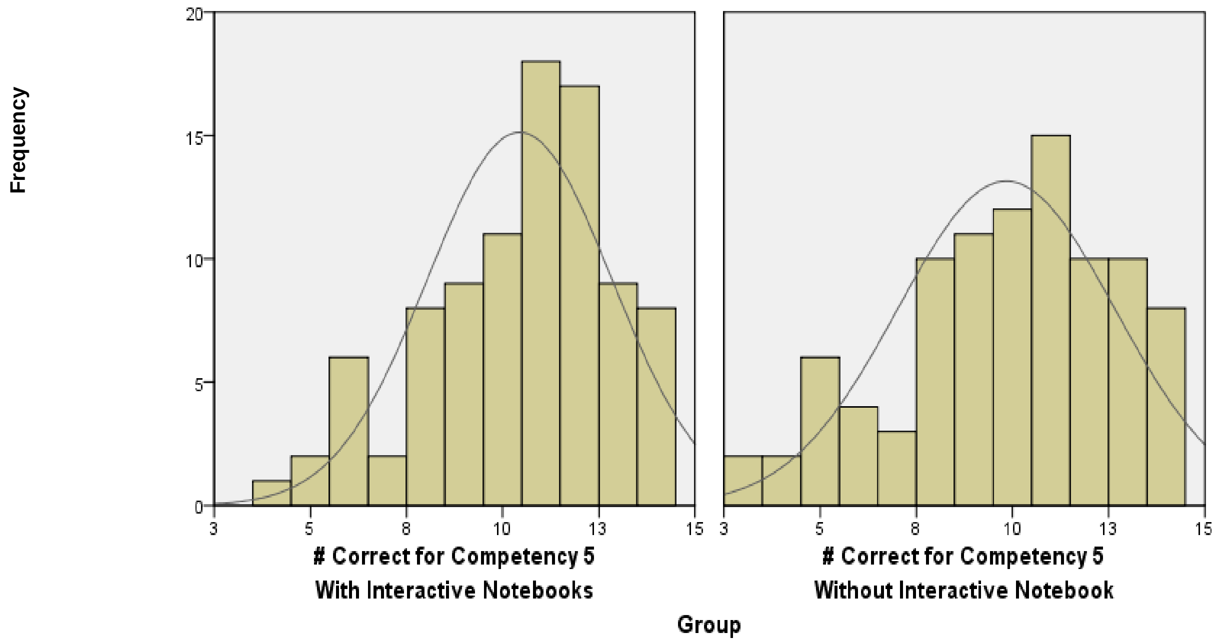

Figure A5. The experimental and control groups' Biology 1 SATP scores for competency 5

a. Experimental: Mean= 10.44, Standard Deviation= 2.40, *N*= 91
b. Control: Mean = 9.84, Standard Deviation= 2.82, *N*= 93

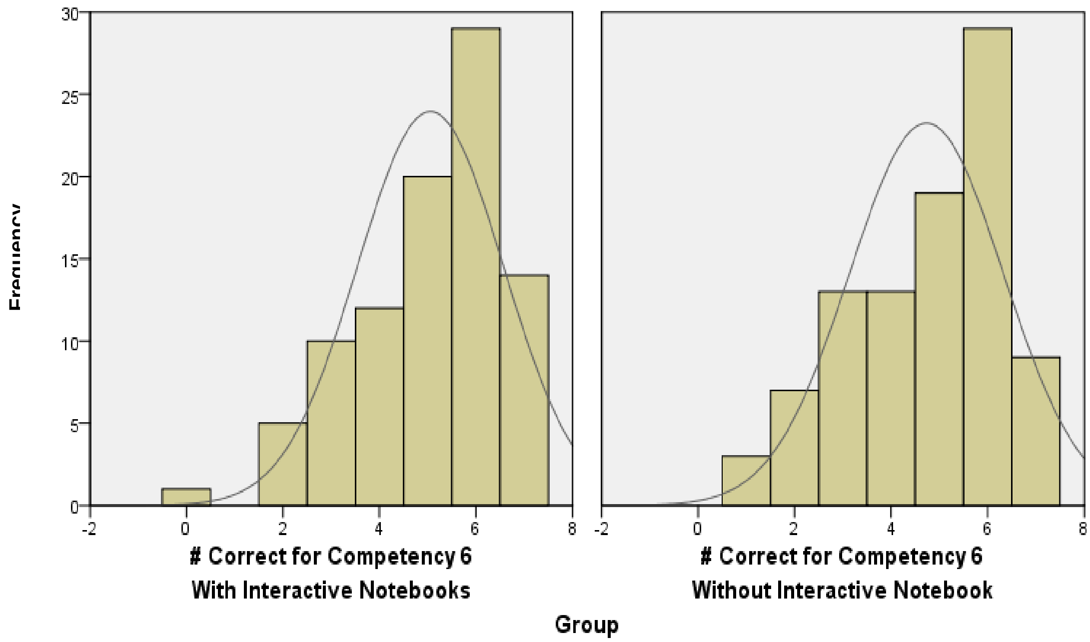

Figure A6. The experimental and control groups' Biology 1 SATP scores for competency 6

a. Experimental: Mean= 5.05, Standard Deviation= 1.52, *N*= 91
b. Control: Mean = 4.73, Standard Deviation= 1.60, *N*= 93

Conclusion and Recommendations

The foundation of this project study is constructed upon a triangulation of scholastic sources. Firstly, the quasi-experimental studies of Arop, Umanah, and Effiong (2015), Çıbık (2016), and Bektaş and Kızkapan (2017) exhibited measurable differences in students' achievement levels of scientific concepts when students utilize various instructional tools, such as the interactive notebook. Additionally, the MMECCA (MMECCA) Framework (2002) indicated that various instructional materials or tools, comparable to the interactive notebook, give students agencies of demonstration of concepts, numerous methods of participating in learning, and several processes of manifestation to demonstrate what they have learned. Lastly, the IDT (2010) suggested that instructional tools, similar to the interactive notebook, are purposely constructed to meet the needs of the students; therefore, creating a natural interaction between the learner and the instructional tool leading to amplified learning. Resting on these three bastions, this project study used an ex post facto quasi-experiment research design to examine the effect of the instructional tool, the interactive notebook, on the science proficiency of high school Biology 1 students when compared to traditional tools or methods of instruction.

Encompassed with quantitative evidence, this study supports the use of the interactive notebook as an instructional tool to proliferate science proficiency. It was discovered that the group that utilized interactive notebooks within the curriculum, had a higher level of science proficiency than the control group, the group that did not utilize interactive notebooks, as measured by the mean scores of the Biology 1 SATP assessment ($M_{experimental}$= 659.92, $M_{control}$ = 656.13; p=.006). However, it was determined there was no statistical significant difference between the two cohorts ($M_{experimental}$= 4.64, $M_{control}$= 4.59; p=.815) for competency 1, competency 5 ($M_{experimental}$= 10.44, $M_{control}$= 9.84; p=.122), and competency 6 ($M_{experimental}$= 5.05, $M_{control}$= 4.73; p=.160). Conversely, it was found that there was a statistical significant difference between the two cohorts for competency 2 ($M_{experimental}$= 4.88, $M_{control}$= 3.97; p=.000), competency 3 ($M_{experimental}$=

8.03, $M_{control}$= 7.33; p=.044), and competency 4 ($M_{experimental}$= 10.21, $M_{control}$= 8.61; p=.000). Given the findings of this study and the parallel findings of studies done by Arop, Umanah, and Effiong (2015), Çıbık (2016), and Bektaş and Kızkapan (2017), it is believed that the interactive notebook has the capacity to serve as an instructional solution to proliferate science proficiency and literacy at the Local High School and many similar schools across the nation.