THE EFFECTIVENESS OF INQUIRY AND COMPUTER BASED LEARNING IN

REMEDIATION OF SCIENCE STUDENTS

by

Kelli Leigh Caras

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2019

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Liberty University, Lynchburg, VA

2019

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ABSTRACT

The state of Virginia requires science Standards of Learning tests to be conducted as a graduation requirement as well as a measure of teacher performance. In an attempt to increase graduation rates, the state has adopted an expedited retake policy allowing certain students to retest if their scores were close to passing but fell short. No requirement, however, was given as to the means of remediation that the students must attend in order to retest. This quantitative study examined the effectiveness of three instructional strategies in improving student performance during the retest. A quasi-experimental nonequivalent control group design was used to examine two variables—inquiry-based instruction and computer-based instruction—and their effectiveness in raising SOL scores for students in the remediation program compared to the traditional method of direct instruction utilized in an urban southeastern Virginia public school district.

Keywords: *standards of learning*, *remediation*, *inquiry*, *direct instruction*, *computer*-based *instruction*, *quasi-experimental*

Acknowledgements

I would like to acknowledge the support of my family throughout this process. My husband, Frank, who pushed me to keep going every time I was faced with a challenge, I love you always. My children; Logan and Mackenzie, who were proud of each milestone accomplished, I love you to infinity. I hope watching this process reminds you that with dedication and hard work anything is possible. Thank you to my Mam-maw who has always been there for me. I share this success with you who always saw my inner strength, even when I have not.

Thank you to my wonderful committee. Your guidance has been instrumental in my process of becoming a Doctor of Education. You have inspired me to do great things for my current and future students and staff. Dr. Watson, you have pushed me to always find ways to improve, each time asking me to dig deeper. You helped me to find the fullest parts of my abilities and grow as a researcher. Dr. Flannagan, for 10 years you have inspired me to do better and great things for my students. I can never thank you enough for your support in making me a better teacher and person.

Finally, thank you to my friends and family who understood all the times that I was not available as I journeyed through this endeavor. I love you all.

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National Science Teachers Association (NSTA)

No Child Left Behind (NCLB)

Standards of Learning (SOL)

Virginia (VA)

CHAPTER ONE: INTRODUCTION

Background

Each year, nearly 1 million public school students take the Virginia Standards of Learning (SOL) assessment to measure their content knowledge at the end of the school year (Virginia Department of Education, 2016). The assessment both measures student content knowledge growth and is used for the accreditation of schools as well as an accountability measure in teacher evaluations. Scores on the SOL tests range from 0 to 600, with a passing score set at 400 or higher (Virginia Department of Education, 2014). While many students pass the test the first time, there is a growing number of students who will require a second testing opportunity. Students who score above 370 are now permitted an expedited retake following remediation in the content (Virginia Department of Education, 2009). While state testing is heavily regulated, little guidance is given as to exactly what the remediation component should look like to ensure student success.

When Virginia first began administering the standards of learning and end of course testing in the 1990s, the purpose was to ensure that students of all backgrounds were able to receive a quality education. The test gained in importance with the creation of the *No Child Left Behind Act*, which sought to establish higher academic achievement of all students while closing the educational gap between different student population bodies. To help bridge the gap between groups students, the concept of expedited retakes was introduced. In 2000, the state of Virginia began offering expedited test retakes for high school students in the hope of capturing higher passing rates and ensuring more on-time student graduations. In 2005, the state opened expedited retakes to middle school students as well. Finally, in 2011 elementary school students

gained access to expedited retakes with parental permission (Virginia Department of Education, 2014). While not all students will attain a passing status during the expedited retake, many will achieve a passing score, garnering further support for the initiative. The push for higher student passing rates is vested not only in school accreditation but in the community as a whole. Communities in which all schools are state-accredited tend to have higher residency numbers, which creates a larger tax base and, therefore, more income for the community. Higher student achievement and high school completion rates help to establish a larger educated workforce for the community. Recent studies have indicated the United States currently has a shortage of highly educated workers in the science, technology, engineering, and math career fields (Bureau of Labor Statistics, 2015). When students are able to complete remediation and successfully pass the expedited retake, they become better prepared to continue on these career paths and fill vacancies.

For a student to be eligible for the expedited retake, the state requires schools to provide remediation in the subject area for the student. As previously mentioned, however, the state has not established a set of guidelines for such remediation. The only specification for the structure of the remediation program is that it should be based upon research. Often, students are held after school or pulled from the normal classes to sit in an intensive recap lecture of the course, even though the National Science Teacher Association believes that the best practice in science instruction is the inquiry-based learning method (NSTA, 2018). In more recent years, the importance of technology integration in learning has been stressed throughout the country, as it seeks to compete with foreign education systems. This push for technology initiatives across the country has made it easier to use technology at a more affordable cost to schools.

The introduction of the *No Child Left Behind Act* led to teacher performance being based on high-stakes testing in many states. For teachers in the state of Virginia, the effects of NCLB are reflected in the Guidelines for Uniform Performance Standards and Evaluation Criteria for Teachers, which were originally set forth in 2011 and most recently revised in 2015. One of the standards on which teachers are rated is student test performance (Virginia Department of Education, 2015). The centrality of that standard has pushed teachers into research on the best instructional practices for their curricula. According to the National Research Council (1996), "Science teaching must involve students in inquiry-oriented investigations in which they interact with their teachers and peers" (p. 20). This is the guiding principle for best practices as set forth by the National Science Education Foundation. Inquiry-oriented instructional practice seeks to move instruction away from the teacher lecturing information to students toward actively involving students in the learning of the information through experience. It emphasizes students learning through asking questions and discovering answers with experiments and research instead of simply memorizing facts (Centre for Excellence in Enquiry-Based Learning, n.d.). Indeed, "A recent comprehensive meta-analysis indicates that inquiry instruction which infuses appropriate scaffolds and supports can significantly improve science achievement for students" (Villanueva, Taylor, Therrin, & Hand, 2012, p. 187).

Kamberi (2013) explored computer-assisted learning as the preferred method for directing classroom instruction in a follow-up study to her 2009 exploration of computer instruction in foreign languages in which no significant difference in results was found between the two instruction types. In 2013, she found significant differences in language learning classrooms where computer-based learning took place. Lee (2012), who also examined the effectiveness of computer-based learning in the math curriculum, found that computer-based

learning activities help to enhance student academic achievement in math. He stressed the importance of technology in achieving equal educational opportunity for students as well as the need for state and national funding to bring this technology to low income schools and communities. Kulik and Kulik (1991) were among the first researchers to explore the effect of computer-based instruction. In their findings, they were unable to find an individual outcome study that showed whether computer-based instruction was truly effective. They also examined the effects of more advanced technology being available since the studies of the 1960s and 70s. Their study of postsecondary students found that computer-based instruction raised student exam scores "from the 52nd to 62nd percentile" (Kulik & Kulick, 2013, p. 88).

The inquiry-based instructional method finds support in the Constructivism theoretical framework. The Constructivist approach stresses that knowledge must be constructed through active thinking and participation (Doolittle & Camp, 2003). It involves a process that builds upon prior student knowledge and the past experiences of the student. Constructivist lessons are "commonly classified under the moniker of inquiry-based and include hands-on activities as a way to motivate and engage students while concretizing science concepts" (Minner, Levy, & Century, 2009, p. 2). Doolittle and Camp (2003) established logical principles that apply in both inquiry-based instruction and Constructivist instructional theory. They stated that "the underlying philosophical tenants of Constructivism supports the pathological process of inquiry" (p. 70). The key components of the inquiry method put forth by Doolittle and Camp (2003) include that the problem investigated be related to students' needs and goals and lie within students' past experiences, that learning is enhanced by the use of real-world problems, and that students are encouraged to become self-aware and self-regulate their behaviors. Newcomb, McCraken, and Warmbrod (1993) established support for inquiry-based learning, underscoring

the concept that its main principle is "to maximize learning, student should 'inquire into' rather than 'be instructed in' the subject matter" and to use "problem oriented approaches to teaching and learning" (p. 37). Inquiry-based learning allows students to develop independent problem-solving skills as well as critical thinking skills, both of which are vital to a successful adult life.

Problem Statement

Kulik and Kulik (1991) examined the effectiveness of computer-based instruction in comparison to direct lecture instruction. While they found computer-based instruction to result in higher test scores for students than direct lectures, they did not examine inquiry-based instructional practices. As they found mixed results when examining different content areas in their research review, they suggested the need for further research on varying educational curricular content. Lee (2012) established support for computer-based instruction in the math content area. However, he did not examine science content or the use of inquiry-based instructional methods for comparison. Witt and Ulmer (2010) found a significant improvement in math scores when inquiry-based lessons were used. Kamberi (2013) offered support for computer-based instruction in the subject of the language arts. Again, the instructional content of science has been left unaddressed.

Some researchers have found that the use of inquiry-based lessons have no immediate effect on students' conceptual understanding; however, data later revealed the students exposed to this method scored higher than their peers who did not have inquiry-based lessons when tested on their retention of the science concepts. When tested on their science skills, the researchers found that students receiving inquiry-based lessons out-performed their peers in direct instruction courses (Villaneuva, Taylor, Therrien, & Hand, 2012). Minner, Levy, and Century (2010) found that "hands-on activities alone are not sufficient for conceptual change" (p. 18).

While both computer-based instruction and inquiry-based instruction have shown promising results in student content knowledge, this researcher could find no study comparing the two methods directly. No research to date has been found that examines these two instructional methods in terms of Standards of Learning remediation practices.

Purpose Statement

The purpose of this study was to determine the effectiveness of computer-based instruction compared to inquiry-based instruction in standards of learning science remediation programs. This knowledge could help to establish a best practice based in research for school administrators to create science remediation programs for those students taking the standards of learning assessments. To accomplish this goal, current research findings were examined supporting computer-based instruction as well studies supporting inquiry-based instruction by addressing the gap that currently exists through comparing the two methods directly to each other in science remediation programs. Middle school students placed in computer-based science Standards of Learning remediation as well as middle school students placed in inquiry-based instructional science remediation programs were examined. The programs examined took place in a heavily populated urban district within Virginia Public School system. Students enrolled at a high poverty middle school were assigned to remediation programs based on released 2015 Virginia Standards of Learning (SOL) test scores as a first phase. Those students eligible for a retake were also eligible to be placed in instructional remediation programs. After the completion of remediation, students took the 2015 Virginia SOL test.

Significance of the Study

This study sought to build on recommendations for future research proposed by Kamberi (2013), Lee (2012), Kulik and Kulik (1991) as well as to address current research gaps. By

addressing the current shortcomings in the research, this study can help the Virginia Department of Education to better assist school districts to establish client standards of learning programs that are in the best interest of the child and based on best practices research. Establishing best practices for science standards of learning remediation will allow more students to achieve passing test scores and, therefore, maintain the appropriate educational pace on the path to graduation.

On-time school completion along with student pass rates on the Standards of Learning tests are both key components of school accreditation (Virginia Department of Education, 2014). The results of this study will allow the state to assist schools to provide the best science Standards of Learning remediation, which, in turn, will assist them in reaching or maintaining full accreditation status. Not only will this allow schools to reach or maintain accreditation and assist students to graduate on time, it will also better prepare students to enter educational programs in the science, technology, and engineering fields. Such an increase in prepared students will result in an increase in prepared workers, allowing the United States to close the currently existing gap between trained workers and available positions.

Kulik and Kulik (1991) pointed out a potential added benefit to computer-based instruction. They suggested that, should it be found effective for the content areas, it can help to reduce educational costs while increasing educational effects. Kulik and Kulik (1991) even predicted "a day when computers will serve all children as personal tutors: a Socrates or Plato for every child of the 21st century" (p. 75). Should computer-based instruction be found effective, it can be tailored to address each individual students' needs, allowing every student to reach their full potential through individualized instruction with only one instructional supervisor required.

Research Question

RQ1: Which instructional practice (direct instruction or computer-based instruction) is best for the remediation of middle school science students?

RQ2: Which instructional practice (direct instruction or inquiry) is best for the remediation of middle school science students?

Definitions

Accreditation: A process used by the Virginia Department of Education to evaluate the educational performance of public schools in accordance with these regulations (Virginia Department of Education, 2014).

Constructivism: An educational theory stressing that knowledge must be constructive through active thinking and actions (Minner, Levy, & Century, 2009).

Computer-based instruction: Programs developed by educational technologists that are carried out on computers to drill, tutor, test, and manage educational programs of students (Kulik & Kulik, 1991).

Expedited retake: The ability to retake a failed SOL test with a score of at least 370 during the same testing administration window as the failed test after successful completion of remediation (Virginia Department of Education, 2014).

Inquiry-based learning: The educational practice of allowing students to learn through asking questions and finding answers through direct experience and research (Centre for Excellence in Enquiry-Based Learning, n.d.)

Remediation: Additional instruction provided to students who need more support and instruction time in core content areas to better grasp and master the concepts (Hemmons, n.d.).

***Standards of Learning* (SOL)**: "[T]he commonwealth's expectations for student learning and achievement in grades K-12 in English, mathematics, science, history/social science, technology, the fine arts, foreign language, health and physical education, and driver education" (Virginia Department of Education, n.d.).

CHAPTER TWO: LITERATURE REVIEW

Overview

The purpose of this study was to examine three instructional practices in the SOL remediation environment. Direct instruction is supported by the social cognitive framework as a best practice for the instruction of students. Inquiry-based instruction, rooted in the constructivism framework, is the currently accepted best instructional practice in science instruction. A newer instructional method is computer-based instruction, which is grounded in the tasked-based framework. With so many best practices supported by various educational frameworks, trying to pinpoint one as a best practice in science has been an ongoing area of educational research. Little research, however, has examined how effective these practices are when implemented in a remediation environment.

Theoretical Framework

Direct Instruction

Direct instruction—sometimes called explicit instruction—calls for teachers to present the concepts or material in small steps by modeling the process and having the students model the process in unison with the teacher and then alone as a means of checking for student understanding along the way. Teachers provide immediate feedback during these checks for understanding, which requires students to participate actively in the instructional process. Should a student not be able to complete the task alone, the process is repeated. Skinner's behaviorist theory is one of several theoretical frameworks applied in this mode of instruction. The operant conditioning aspect of behaviorist theory occurs as "teachers arrange special contingencies which expedite learning, hastening the appearance of behavior which would otherwise be acquired slowly" (Skinner, 1968, p. 65). Operant conditioning is a feedback system

of stimulus (question posed to students) and response (the acceptance of response or the reinstruction of the concept) that occurs in the direct instruction process.

Direct instruction is also supported by Bandura's social cognitive theory. Bandura underscored the importance of modeling learning skills to retention. Teachers implementing the direct instructional method are explicitly modeling the strategies to students along with how those skills are implemented to complete assigned tasks (Zimmerman, 2008). Teachers both explain and illustrate the concepts that students are to learn as the lesson is presented. These actions help to create the automatic recall of actions and concepts in students as they actively respond to teacher prompts during instruction. Bandura's social cognitive theory holds that learning is achieved through the observation of others' behaviors. Teachers build this modeling into their lessons by providing examples and displaying how to analyze information to obtain answers.

Vygotsky stressed that learning occurs through verbal interactions. As teachers present the material, classroom conversations unfold relating abstract ideas to everyday life. Scaffolding is a key component of direct instruction that allows teachers to build new concepts and knowledge upon students' current knowledge. Social cognitive theory also includes Vygotsky's zone of proximal development (McLeod, 2018), which refers to the point at which students cannot yet work through a problem without the assistance of the teacher. Direct instruction allows teachers to assist students through the zone of proximal development by assisting students in mastering concepts and problem solving as they model the actions needed to solve the problem.

Inquiry Based Instruction

Inquiry-based instruction is the method of instruction in the science curriculum preferred by the National Science Teachers Association (NSTA, 2004). Inquiry-based instruction is designed for learning to take place through the trial and error of students while examining problems. Inquiry is a method that poses a question or investigation that forms the center of the curriculum's lesson. Teachers serve as consultants and advisors while students use hands-on application and research to understand concepts.

> The role of the teacher in an inquiry-based classroom is quite different from that of a teacher in a conventional classroom. Instead of providing direct instruction to students, teachers help students generate their own content-related questions and guide the investigation that follows. (Center for Inspired Learning, 2008, p. 1)

This method is inspired by Dewey's theory of constructivism (Center for Inspired Learning, 2008).

Dewey believed that inquiry, a social activity, is the essence of successful education. According to the National Science Education Standards, "science teaching must involve students in inquiry-oriented investigations in which they interact with their teachers and peers" (National Research Council, 1996, p. 20). The practice of problem solving and communication involved in inquiry helps students to construct knowledge. Dewey placed a strong emphasis on the importance of social activity for true learning. He believed that the learner obtains knowledge by actively working through the problems proposed. According to Glassersfeld (1995), a student's knowledge is not passively received but, instead, is built up by the cognizing subject. In other words, we do not find knowledge; instead, we construct it. Knowing is not found in the imbibing of others' knowledge but, instead, results from becoming a part of their reality, which is what the

inquiry learning process encompasses. Dewey (1961) argued that the "contents of the child's experience" is more important than the "subject-matter of the curriculum" (p. 342). According to Dewey, active student participation, self-direction, and the learner's experience and worldview are all critical components of problem-solving based education.

Advocates of inquiry-based instruction also find support in Piaget (1970). Piaget supported constructivist learning theory and advocated for discovery learning as the best way to gain a deep and lasting understanding of scientific phenomena and procedures, particularly for children. "Each time one prematurely teaches a child something he could have discovered for himself," Piaget (1970) argued, "that child is kept from inventing it and consequently from understanding it completely" (p. 715). Thus, his ideas supported the constructivist concept that students should build their own knowledge based on previous knowledge and new experiences.

Task-Based Framework

Computer-based instruction became a new instructional strategy in the early 1960s. Since then, it has continued to grow in educational settings with many states moving to require that at least one online course be completed before high school graduation. Computer-based instruction can be tied to tasked-based instruction as students work individually to complete learning tasks on computers. One of the biggest benefits of this instructional strategy is the ability to base the tasks on students' prior understanding. Students are also able to move through tasks at their own pace, which enables them to spend more time on topics that that they do not easily grasp. This pedagogical approach is in direct contrast to a traditional classroom settings, where teachers must move through the material at a set pace, leaving some students bored and others unclear about the concepts. Since computer-based instruction requires students to be

actively engaged in the computer program, one can link Dewey's constructivism to it. As noted, Dewey felt that learning should be self-directed and self-paced.

Computer-based instruction allows a student to move rapidly through content that they are able to understand and move at a slower pace through material that proves to be more challenging. It often allows for multiple attempts to complete tasks, enabling the student to keep working on the task until success is acquired, which is unlike the classroom setting, where the task must be completed in the allotted time regardless of the result. Some computer-based learning programs allow students to interact with each other as they build knowledge, allowing them to be rooted in the social constructivist framework. The resulting "sociocognitive conflicts allow students to become conscious of the relativity and weaknesses of their conceptions as well as acquire techniques for communicating the knowledge they possess" (Barak, 2016, p. 285).

Related Literature

Direct Instruction

Klahr and Nigam (2004) examined the instructional influence on the application of science content among 3rd and 4th graders in inquiry and direct instruction classes. Citing Piaget in support of inquiry and its recent move to the forefront of science education practice, the researchers designed lessons in both methods involving ball movement with ramps. The inquiry-based course received no teacher intervention in the task beyond the statement of the objective to be met. The direct instruction group received a lesson on the concepts that modeled how the ramp could work along with the errors in the ramp; then, the students were directed on how to complete their own ramp build. Both groups had an active learning portion with the hands-on building of their own ramps. The assessment occurred immediately following the lesson. Students were to build upon the concept taught and examine how the surface off the ramp would

affect the ball. The experimenter provided no feedback at that point. The researchers found that the students in the direct instruction course increased their approach dramatically from exploration to assessment and increased their scores. The scores also increased for the inquiry students, but the increase was not as substantial.

Dean and Kuhn (2007) also examined the effect of direct instruction on the mastery of science concepts among elementary students. They sought to include a diverse grouping of students over a longer period of time (10 weeks) than Klahr and Nigam's (2004) study. One group received traditional direct instruction, a second group received inquiry-based instruction, and the third group received a hybrid of the two methods. Each group engaged in the same activity to reinforce the concepts. The direct instruction group showed significant gains immediately following instruction and application of the concepts. They found that no method proved to be superior to the others in short-term assessment results.

Direct instruction was once the preferred method of science instruction because it allowed for an emphasis on vocabulary building. Bhaskar and DeFranco (2008) explored this concept, seeking to prove that direct instruction was superior to inquiry-based instruction. They worked with 3rd grade students to measure short- and long-term vocabulary building. They found that those students who received direct instruction had a higher level of vocabulary gain and application on short-term assessments. Their long-term results revealed conflicting findings. The inquiry group had more significant long-term results, as the inquiry method connected the vocabulary lesson to their past experiences. The researchers proposed that experience in the construction of the lesson was not the reason that the vocabulary was retained longer but that the teacher took time to connect the concepts to students' everyday life experiences, which was not done in the direct instruction classroom. The researchers stated that this was a planned

occurrence since the direct instruction teacher used a nearly scripted lesson while the inquiry teacher used guidelines but could more loosely influence the lesson and the conversations.

Cobern et al. (2010) sought to establish the significance of direct instruction compared to inquiry instruction. They examined a middle school science classroom setting after defending both instructional practices as important and relevant to student development. Rising 8th graders attended a 2-week summer session for the lesson. No homework or reading at home was assigned, so all learning was conducted in the classroom environment. The researchers found no statistically significant difference between the two modes of instruction: Both modes of instruction yielded small gains in the concepts taught. Cobern et al. concluded that the claim that inquiry instruction is superior to direct instruction was an overstatement. They suggested that carefully planned lessons of any type can be successful.

Marin and Halpern (2010) conducted an experiment on the development of critical thinking skills among students attending direct instruction courses. They chose to examine high school students because a large amount of previous research had focused on post-secondary learners. They argued that their research was of particular importance because students are leaving high school lacking the critical thinking skills necessary for success in adulthood. They believed that "to learn critical thinking, both high and low achieving students benefit from explicit instruction and repeated practice" (p. 4). The design and delivery of a lesson requires deliberate effort on the part of the teacher for the lesson to be successful. Participants in a low-income California high school were sorted into the two contrasting instruction groups that covered psychological concepts, and they were then assessed on their ability to identify stereotypes as well as the long term-consequences of their choices. Their research found that students experiencing both explicit (direct) instruction and inquiry-based instruction showed

gains in content understanding. However, the "explicit instruction group showed much greater gains" (p. 7).

Therrien, Taylor, Watt, and Kaldenberg (2014) compared the effects of direct instruction to inquiry-based instruction for students with emotional and behavioral disorders (EBD). With the revision of the IDEA act, a follow-up to the Every Student Succeeds Act (ESSA) of 2015 that was completed in 2017 with the additions of parts B and C, there has been an increasing number of students with disabilities placed in the least restrictive learning environments. Such learning settings are called inclusive or collaborative classrooms. The researchers pointed out that students with EBD who have targeted academic outcomes can see non-academic behavioral improvements. They also brought attention to the lack of research in science education for EBD students. Their results about the best instructional method conflicted. They found that inquiry-based instruction could be beneficial as it would keep students engaged in the learning process, but it also had the drawback of being less structured, which could decrease the amount of time spent on a task, resulting in lower academic achievement. Their evidence suggested that direct instruction, particularly instruction using mnemonics, leads to improved achievement and the increased retention of science material.

Zepeda, Richey, Ronevich, and Nokes-Malach (2015) examined direct instruction in the science classroom, believing that "a student's ability to adapt his or her problem-solving behaviors to different types of academic tasks and feedback is critical for successful learning and academic achievement" (p. 954). To examine the effect that direct instruction has on the science comprehension of middle schoolers, the researchers implemented two lessons—one in physics and one in puzzle solving. From pre-test to post-test, the study took slightly over 30 weeks. Their results highlighted the importance of metacognitive skills in direct instruction. The more

skills that the students possessed, the more successful they were in the lesson. "Since the instructional materials focused on understanding," they noted, "we also expected students to be more likely to adopt a mastery goal over a performance goal" (p. 966). The results confirmed that expectation, as the students who had the intervention scored higher in mastery approach goals and retained more content knowledge from the science activity than the students who did not.

Aglarci, Sancayir, and Sahin (2016) examined direct instruction among chemistry teachers in Turkey. Only the nature of science concepts was addressed in their study. In 2007, Turkey launched an education reform with an underlining constructivist philosophy instead of the previously endorsed behaviorist approach. The researchers chose to focus on chemistry teachers for two reasons: first, to inspire teachers to integrate instructional practices in the classrooms favored by the results of the study; and, second, to help them overcome their misconceptions of the nature of science. They found that after direct instruction with a reflective element added, the teachers' misconceptions of the nature of science concepts were reduced and corrected. The researchers expressed the importance of the nature of science concept used and the instructional methods' differences. "The use of hands on inquiry-oriented activities or science process skills instruction will enhance students' NOS understandings," the researchers concluded. "However, this approach lacks direct reference to NOS" (p. 13).

Cadette, Wilson, Brady, and Dukes (2016) looked more deeply into the effectiveness of direct instruction in answering "Wh-" questions. They focused their research on students with autism, who tend to have social communication deficits that limit their ability to learn and express knowledge. These students are often found in mainstream classrooms, taking the same courses as average students. Cadette, Wilson, Brady, and Dukes examined the results of high

school students over 4 weeks of direct instruction. They found that students who received the direct instruction lessons showed stronger improvements than those not receiving the direct instruction at both a 2-week and a 4-week check.

Elementary school teachers were the subjects of a recent study by Adibelli-Sahin and Deniz (2017) of science instructional strategies for nature of science (NOS) units. The researchers pointed to previous studies of students in high school physics, elementary science, and 6th grade science having successful academic attainment with explicit instruction used for the nature of science units. "Expecting students to generate, on their own, accepted science and NOS ideas does an injustice to fields of study in which brilliant minds have struggled for decades, even centuries, to arrive at our current understandings" (p. 763). With little research into instructional practice available to inform either college students who intend to become teachers or current teachers, the researchers choose to focus on direct and inquiry-based instruction among members of this group since they would tend to have an understanding of the nature of science. They found that direct instruction, particularly with structured reflection included, was the best instructional method for the nature of science concepts.

Chase and Klahr (2017) examined direct instruction in invention learning. "The invention method encourages students to explore concepts by inventing a representation of a deep structure that underlies a set of contrasting cases" (p. 583). Their study involved 4th and 5th grade students from schools in Pennsylvania. The students worked to design a rocket with the goal of reaching the highest flight. They were divided into groups: One received the direct instruction and then built their rocket; the other group worked on their build only after invention learning. Invention learning closely resembles inquiry learning since students proceed on their own through trial and error to complete a task, learning from their successes and failures. Chase

and Klahr found that the direct instruction group scored higher on the worksheet portion of the lesson because they had instruction on the formulae needed to accurately complete the assignments. The results were not clear with respect to the design process and the rockets' success. The co-researchers suggested that this result could be due to the vast difference in the school environments used in the study.

Hughes, Morris, Therrien, and Benson (2017) sought to establish a more refined definition of direct instruction. They first focused on explicit instruction in early 1990s studies, as the terms are often interchangeable, and found that explicit instruction has been "identified as a key component of current education initiatives such as response to intervention and intensive instruction" (p. 140). They pointed out that since there are a limited number of studies examining the explicit instructional components used in an intervention, and that these components can vary across research, definitive results on the effectiveness of direct instruction are not currently available. They also found, however, that there is extensive support for the use of direct instruction in math, especially when teaching younger students.

Schuster et al. (2017) compared direct instruction and inquiry instruction in the science classrooms in a study examining middle school science students who attended an 8-week summer session over 4 years. Teachers taught these sessions in both instructional manners and knowledge gains were measured with pre and post assessments. The researchers emphasized that the facets of science vary and that comparisons of instructional approaches must take this into consideration. "One cannot assume that the same methods are necessarily best for teaching both content and process," the argued, "nor that both of these facets must always be learned together at the same time in the same lesson" (p. 391). For this study's classroom instructional portion, Newton's second law was taught. The established definition for their instruction

strategies were (a) inquiry as a process and (b) direct instruction as the didactic presentation of content by a teacher or textbook. Their results showed mixed findings, leading them to declare that "teachers need not be bound to one mode throughout and can flexibly decide on the pedagogical approach for each concept and situation" (p. 389).

Therrien, Benson, Hughes, and Morris (2017) examined direct instruction's impact on learning disabled students' content knowledge in science. These researchers argued that students with learning disabilities struggle in science because it requires the mastery of multiple skills that these students struggle with individually. They predicted that the use of direct instruction would allow learning disabled students to address each the needed skills individually, allowing for better mastery once these skills were combined. They suggested this based on the fact that direct instruction allows for the verbal communication of concept along with teacher demonstrations before the scaffolding and application of the concept for students. They found that the ability of students to have frequent opportunities to respond and receive feedback increases their engagement while allowing the teacher a glimpse of the students' understanding, helping them to adjust the lesson accordingly.

In a 2017 study, Adibelli-Sahin and Deniz examined the perceptions that teachers had of direct instruction and the impact on science instruction of these perceptions. They reflected on the Nature of Science unit taught to science students at all grade levels, noting that no single definition of what it is or how to teach it exists. Instead, there several beliefs held in varying communities. With this in mind, they set forth to research four teachers who were teaching the unit to their elementary students. They first provided each teacher with training in the direct instruction approach along with the nature of science unit. They found that the participants perceived effective nature of science instruction to provide the opportunity for the students to

reflect on the instruction before answering a series of questions and sharing the information with peers. With the inclusion of these steps in direct instruction, the students showed higher content knowledge. The researchers argued that these included components naturally fit with direct instruction as they allowed a longer time allotment for students to respond to questions asked by the teacher during the instruction. These participatory components are not as naturally implemented into computer-based or inquiry-based instruction since a teacher does not pose questions when those instructional methods are used.

Chen (2018) explored incorporating task-based learning in the direct instruction setting of a reading classroom. Reading is the foundation of education across cultures. Extensive reading improves reading ability as long as materials are within the students' linguistic levels. Extensive reading is also the primary way that learners receive educational input. Chen's research examined the tasked-based direct instruction of reading English in a Taiwan college. Before the task-based portion of the lesson, the teacher conducted a group reading of a teacher-selected text. The teacher then demonstrated how to complete each task before the students completed the tasks with the selected reading. "The tasks enabled students to express their ideas and develop thinking skills" (p. 6). At the conclusion of the study, the students reported positive experiences and successful learning.

Zendler and Klien (2018) compared the content knowledge of students in direct instruction learning environments with those in web quest learning environments. They attempted to address the current state of confusion over which instructional strategy is best suited for science classrooms. They defined direct instruction as encompassing five activities in the learning process: introduction, presentation/demonstration, joint exercises, individual exercises, and stocktaking. Emphasis was placed on the teacher in the instructional model. Web quest

instruction is computer-based learning in which the instructor loads a series of websites that students use for self-guided learning about a given topic. The steps used in the study were preparation, introduction, the assignment of tasks, material collection, research, evaluation, and presentation. In this model, teacher involvement is limited to the loading of websites. The researchers found that "in computer science education, direct instruction performs better than web quest with respect to learning outcomes" (Zendler & Klien, 2018, p. 14).

Also in 2018, Kruit, Oostdam, van den Berg, and Schuitema examined the effects of direct instruction on students' inquiry skills. For their study, 5th and 6th grade students' content knowledge of science inquiry skills were tested before and after direct instruction. They stressed the importance learning basic science skills in inquiry to students successfully understanding deeper science content. Their study confirmed their prediction that direct instruction would allow for better inquiry skills learning. Students receiving direct instruction "clearly outperform" (p. 436) those not in the direct instruction lessons. The authors pointed out that one limitation of their study was that the teacher assistants were using the lesson materials for the first time, but they suggested that further use of the materials could create further growth in student understanding. They concluded with the key finding that "students in primary school who have little experience with scientific inquiry and systematic, explicit instruction should be considered and incorporated as a starting course for developing skills" (p. 438).

Inquiry-Based Instruction

Smith, Sheppard, Johnson, and Johnson (2005) examined inquiry-based instruction in the college engineering setting. They used problem-based lessons for their inquiry as that approach was best aligned with the engineering course. Students were grouped into small informal cooperative learning groups and asked to discuss what they were learning every 10 to 15 minutes

within the group. The researchers found that this action helped students to better relay information and correct misunderstandings as they went through the problem that was tasked to the students. One added benefit of the program was that the students were better able to communicate with their peers and developed enhanced listening skills.

Kirschner, Sweller, and Clark (2006) scrutinized inquiry-based learning. They stressed that the method was only effective if the teacher was more actively engaged in the learning process with the student than some models on inquiry call for. Inquiry-based lessons often call for minimal guidance and instruction from teachers, but this was found to be successful only when students had adequate prior understanding of the content area. When this level of prior understanding exists, intermediate level inquiry sessions proved successful in enhancing a student's content knowledge.

Wilson, Taylor, Kowalski, and Carlson (2010) explored the effectiveness of inquiry-based instruction in increasing high school science students' knowledge and reasoning skills. Students in an inquiry-based group attained higher levels of achievement not only in the immediate assessment but also in an assessment of that same material 4 weeks later. These researchers also found that inquiry-based instruction leads to lower gaps in understanding among different races of students. This finding supports inquiry-based instruction as the preferred science instructional method. Since experiences are presented in the classroom, inquiry-based instruction eliminates the gap that can occur when knowledge acquisition is left to outside experiences that are not common to all students.

Lee, Linn, Varma, and Lui (2009) explored technology mixed with inquiry-based lessons. They incorporated a 2-year study of students in high school science courses. During the first year, students were exposed to traditional direct instruction. In the second year, they were

exposed to an online learning experience that rich in visualizations within the inquiry units. The finding of that study was that the students displayed higher content knowledge and increased ability to integrate and apply concepts following the online inquiry year compared with the previous year. The mix of instructional methods proved to be beneficial in creating deeper content understandings for the high school science students.

Minner, Levy, and Century (2009) completed a synthesis of research on inquiry-based instruction in which they stressed the importance of the constructivist learning application on which inquiry-based instruction is developed. They also expressed the sentiment that inquiry-based instruction tends to be focused to science instruction. Citing the National Science Education Standards, they offered support for a synthesis of research as a means to establish the best practice for science being inquiry-based lessons. "Fifty-one percent of the 138 studies in the synthesis showed positive impacts of some level of inquiry science instruction on student content learning and retention" (p. 20).

Blanchard et al. (2010) explored whether inquiry is possible in light of the accountability teachers are being held to in standardized testing scores. They used math and science students in Florida K-12 classrooms, paying particular attention to students considered at risk. The perceived growing gap between educational group categories has been an accountability area that teachers are often subjected to, with the most scrutiny as schools move to close the levels of content understanding gaps to create a more level playing field for students as they seek to start college and careers. Their research found that in the 12 middle and 12 high school science classes, students showed high post-test scores and deeper understanding after a week-long inquiry lab-based forensics unit. Long-term content understanding was also recorded. The results were stronger for students who had teachers with stronger inquiry implementation levels. This was the

case regardless of poverty level among the students, helping to establish this method of instruction as vital to closing the achievement gap.

Middle school students were the focus of Witt and Ulmer's 2010 research. Again, the researchers cited the National Science Education Standards and constructivism as support for inquiry as the preferred method of science instruction. Instead of applying the instructional method to science, however, they worked with student in math courses. They stressed that inquiry-based instruction "engages students at their own ability level. Due to the individualistic nature of inquiry learning, all students may not gain the same knowledge, but instead, students are able to discover the knowledge that they need and build upon it" (p. 272). They found that students, on average, experienced a 40% growth from pre-assessment to post assessment across all units taught in the inquiry format. They also cited studies done in the months before theirs that found conflicting results, and they push for further research, particularly in other academic content areas.

A twist on inquiry research, the delivery method instead of effectiveness was explored by Furtak, Seidel, Iverson, and Briggs (2012). Traditionally, content material is delivered by the teacher. Even in inquiry-based lessons, the teacher serves as the facilitator of the lesson. These researchers sought to examine the effect of teacher involvement in the inquiry lesson with content knowledge gained. Their study found that "teacher-led activities had a mean effect sizes about .40 larger than those with student-led conditions" (p. 1). They also found that when compared to research of the 1980s, the level of growth was stronger. They expressed the importance of student's involvement in generating, expressing, and justifying explanations as vital for a successful inquiry lesson.

Special education students are also a gap group widely studied by researchers in their attempts to create an instructional method that reaches each type of student equally. Villanueva, Taylor, Therrien, and Hand (2012) examined inquiry-based instruction as a way to lower the achievement gap of special needs students in science compared to their peers. Premade inquiry kits for elementary level science students were implemented in this study as "highly structured materials model authentic and instructional roadblocks to teaching science" (p. 191). They found that

> when students are immersed in the discourse practices of inquiry and argument, they test their own questions and determine what data they need to generate evidence. This process provides students with the opportunity to critically examine their work, critique their peers and discuss their explanations in a meaningful way. (p. 207)

The use of scaffolding on prior knowledge is key to the knowledge attainment levels found among special education students in inquiry-based science courses.

A 2014 study by Machtinger compared direct instruction to guided inquiry lessons. To do this comparison, she utilized a midlevel college science course. All students were presented a brief review of the scientific method before breaking into groups to complete a lab. Some had instruction before the lab while the others went straight to the lab without instruction. Machtinger found that students who completed the lab in the inquiry fashion with no direct instruction performed better as they were more committed to the scientific methodology of trial and error.

Marshall and Alston (2014) sought to review a five-year study of students in inquiry-based science classrooms. They pointed out the growing concern of little learning progress being made in gap groups for science. They argued that inquiry-based learning leads to higher-level

thinking while it acts as a vehicle for teachers to engage their students in experiences that go beyond lower levels of content understanding. They concluded that "when facilitated effectively, inquiry-based instruction may benefit all students, for all demographic groups measured" (Marshall & Alston, 2014, p. 807). One caveat of note put forth is the hesitance they found in urban school settings for teachers to use inquiry-based learning methods in their classrooms. They predicted that this could be a contributing factor to the low growth of content understanding in gap groups.

The positive trend in favor of inquiry-based learning in secondary schools led Aulls, Magon, and Shore (2015) to examine the instructional methods of education professors compared to those of other content at the undergraduate level. Their interest in creating this study was gained by the lack of empirical research comparing the inquiry-based setting to the more traditional classroom setting at the collegiate level. Previous research has shown that inquiry-based instruction in college level science courses resulted in better student achievement than the traditional classroom setting, but they did not locate research comparing education course to other courses. "Personal experiences with inquiry and learning to teach inquiry are both relevant to teachers', including higher education instructors', ability to create inquiry-based learning situations for their students" (p. 147). Through class observations, interviews, and syllabus collection, they determined that education course professors least often utilized lectures but instead relied on the collaborative learning, experiential learning, and self-directed learning often seen in the inquiry-based classroom.

Leak (2016) examined teacher beliefs, practices, and changes in inquiry-based instruction. She conducted a case study of one teacher and his inquiry practices in the classroom. She stressed the previous research supporting inquiry-based instruction as being effective in

motivating students and engaging them in lessons that lead to better concept understanding. As previously noted, urban schools tend to use less inquiry-based instruction even though research points to it as vital to group content knowledge growth. By using video recordings of his teaching, journaling, and initial coaching, Lebak found that teachers could raise expectations and, therefore, raise the abilities of students by increasing the use of inquiry instruction in science classes.

Special education students were the area of focus for Mulvey, Chiu, Ghosh, and Bell (2016). Their results suggested that the nature of science and the professional development of teachers in inquiry methods can lead to increased levels of expectations in special need students. Examining the level of teacher understanding in inquiry lessons is important because educators cannot fully implement inquiry lessons without a strong understanding of their design and practice. This study was one of few to examine that factor in inquiry-based lessons. After teachers underwent extensive training under Bell, they were better able to build lessons that tapped into student potential. This, in turn, raised teachers' expectations of students. Raised expectations led to increased levels of understanding of the concepts put forth by the teachers when special education students were tested on content.

Grabau and Ma (2017) explored how inquiry effects maintaining student engagement in science and their science achievement levels. The researchers were driven to this concept after U.S. science education levels fell below the PISA international average. They pointed out the current recommendations, reduced class size, improved resources, and enhanced science teaching methods in an attempt to reverse the current standings. Grabau and Ma argued that inquiry is best suited for science instruction as it allows for high levels of student engagement. Engagement, in turn, is tied to high student self-efficacy. "Science self-efficacy was positively

associated with science achievement in several countries" (p. 1047). Their study was large, encompassing 4,456 students from 132 different schools nationwide. They found that schools that incorporated inquiry-based instruction had high levels of self-efficacy within the school climate. Those schools also had high science achievement levels.

Ramirez and Rodriguez (2017) examined inquiry-based instruction in English among foreign language 4th grade readers completing a tasked-based assignment. Language instruction is conducted in a way that teachers and students are immersed in the class so deeply that they construct their own reality. This reality highlights the different reactions that teachers and students have to the instructional process. Communication is key in a successful classroom, but it must be done in a way that is free and reduces anxiety (Ramirez & Rodriguez, 2017). By using an inquiry-based instructional practice, the researchers stated, "learners have the opportunity to focus on a language learning target through real life situations in the classroom" (p. 97). Their main goal was to describe how language learning happens in an inquiry setting. The found that "the exchanges presented by teachers and learners in class let them analyze, through conversational analysis methodology, the interactions that emerged among the teacher and the student" (p. 106). The findings and patterns of interactions of the learners showed how they are social learners actively participating in the learning process. The learners became more participative toward the end of the study and took more responsibility in making decisions and developing tasks collaboratively to reflect real life scenarios. Their confidence in their usage of the language as well as the context was increased.

Henderson-Rosser and Sauers in (2017) examined inquiry-based instruction in science. The pointed out the growing gap in STEM knowledge between United States students and those in other countries. The gap is particularly large among women minorities taking STEM-related

subjects in school. Henderson-Rosser and Sauers suggested that when moving to an inquiry-based focus that incorporates some technology for more complex concepts that are typically not replicated or observable, students better understand science concepts and retain the information longer. They related this idea to the constructivist theory of building knowledge through action. They found that the technology allowed students to better share their results in lab reports, group discussions, and presentations. Students with technology available in the inquiry setting had an increased ability to explain concepts. A secondary finding was that the teacher's ability to use technology impacted students' ability to put forth their understanding of concepts with technology. They concluded that inquiry was still a best practice that could be enhanced with technology simulations if a teacher was fluent in the technology being used.

Computer-Based Instruction

Kulik and Kulik compared several studies relating to computer-based instruction and student content knowledge. Their 1991 study examined over 254 previous studies in an attempt to give academics an updated understanding of the success rates of educational methods. All of the studies they analyzed were in a post-secondary setting. In that study, they stressed that "no individual outcome study . . . can show whether CBI is generally effective" (p. 75). They argued for the cost effectiveness of this instructional method compared to the traditional methods while it also enhances educational effects. As computers have evolved and become more affordable, this argument has been upheld. Kulik and Kulik also stated that "CBI students gained mastery status in a shortened period of time" (p. 76). "CBI students required about two-thirds as much instructional time as did students who were taught conventionally" (Kulick & Kulick, 1991, p. 88). CBI was also found to raise students' final course test scores from the 50th to the 62nd percentile.

Serin (2011) conducted a study of students examining the earth, sun, and moon unit delivered as a computer-based course that meet several times for three weeks. Serin's study was needed as greater emphasis is placed on computer-based science labs as an addition to ordinary labs in the science curricula of developing countries. This change is due to the rapid development of information technology along with lowered costs, making it more readily available and, therefore, more frequently found in the schools. "The use of technology in education provides the students with a more suitable environment to learn, serves to create interest and a learning centered atmosphere, and helps increase the students' motivation" (p. 183). Computer-based instruction allows students to learn by self-evaluating and then reflecting on their learning. It also motivates students to learn better as it provides them with immediate feedback (in contrast to the longer time lapse required for feedback in a traditional classroom setting). Computer-based learning with games involved can also be exciting and interesting ways to keep students involved. Serin used this information to conduct a study of the computer-based learning environment on 4th grade students. Using pre- and posttests, Serin found that there was a statistically significant increase in the academic achievement and problem-solving skills of the students who utilized computer-based learning.

In 2012, Ahlam Lee published his study on computer-based learning in math courses. His study examined computer-based learning in the k-12 educational setting. His study compared students' previous math performance levels acquired in the direct instruction-based classroom to a post-math performance level after exposure to computer-based learning instruction. He found that "within school level, taking into account gender, student SES, and previous math performance, computer-based learning activities had a significant and positive effect on student math performance" (p. 67). Lee also pointed out that having school leaders

who are supportive of the initiative can be a contributing factor to such a program's success. He also pointed out the need for community funding as a successful computer-based learning environment would require a 1:1 computer-to-student ratio. Should all these components exist, Lee believed, computer-based education could help to "offer equal educational opportunities for all students" (p. 70).

Smetana and Bell (2012) were interested in the effects that computer simulations had on science instruction and learning. Technology in the classrooms is a new concept that the authors feel has been poorly integrated into classrooms and are often used in limited ways. Technology advocates claim that computer technology can help to transform learning as it increases access to information and allows for collaborative learning. Their research found that computer simulations are most effective when they are used as supplements, have quality support structures, encourage student reflection, and promote cognitive dissonance. "Used appropriately, computer simulations involve students in inquiry-based, authentic science explorations" (p. 1337). "Technologies that support content-based instruction which are student centered, inquiry based, and make scientific views more accessible have the most potential to make a positive difference in science teaching and learning" (p. 1338).

Campbell and Abd-Hamid (2013) examined the use of technology in science instruction. Seeking to establish the value of technology and how its capabilities can enhance student concept learning, the researchers studied 17 different classrooms. They referenced direct instruction as a historical manner of teaching science that conflicts with science based in a constructivism theory. They predicted that technology-based science learning allows student to learn by engaging the processes of science, thus cultivating awareness. They concluded that teachers should use technology to instruct students in science, especially if it can be done in an inquiry-based format.

Kamberi (2013) introduced computer-based learning into a language classroom setting. Kamberi examined the effectiveness of computer-based learning in studying idioms and idiomatic instruction. A simple 10 question test was administered after students were exposed to the lesson. The group consisted primarily of female students in the researcher's Master's degree level class. The test results indicated that there was a significant difference between computer-based learning and classroom instruction. Those who took computer-based instruction could recall more idioms than those who did not. Kamberi closed the research article with the statement that computer-based learning "gives students the opportunity to acquire knowledge and retrieve information in long-term memory storage" (p. 1694).

Voogt, Erstad, Dede, and Mishra (2013) supported computer-based instruction because it helps to bring instruction into the 21st century and address new learning competencies that have developed along with changing technology. These researchers stressed that such competencies are "essential for living in and contributing to our present societies" (p. 404). They compared the concept of embracing computer-based learning to better prepare students for a future level of implementation between several countries. Highlighting Denmark and China's higher level of STEM-prepared students compared to the United States' current level of STEM readiness, the use of computer-based instruction was evident. They found that many Asian and European countries had years more computer-based instruction that American schools. Their research stressed the importance of the computer-based learning in a manner outside of content itself but, instead, in life skills and future employability.

Chen's (2014) research examined the computer-based learning of college freshmen students enrolled in technology courses. Chen stressed that computer-based learning could be more successful than traditional classrooms because it incorporates animated demonstrations that

allow students to have the modeling of tasks available at all times during the learning process. Previous research found that users who had these demonstrations during corporate trainings were quicker and more accurate in task completion, which inspired Chen to examine the same concept in classroom settings. Chen found that using computer-based instruction with an animated demonstration was more effective in teaching an adobe lesson to students than those who did not receive the method.

Web-based science learning environments that allow for collaborative inquiry were examined by Sun, Looi, and Xie (2014) in a study related to how teachers utilize such software. The booming availability and ease of access to technology has shifted how technology is used in the science classroom and, in turn, the teacher's role. The information and communications technology software examined in this study facilitated classrooms that rely on teachers to coordinate activities and artifacts as well as handle the varying levels of social interactions taking place within the programs. Two science teachers and their secondary classes were examined during an osmosis and diffusion science unit. While one teacher spent time assigning reading selections, the other led peer discussions and explained tasks to students. The results showed that good technology education could not be achieved without the appropriate teacher facilitation. The "teacher responses to the key instructional events and their roles acted in the inquiry phases were key factors for inquiry-based instruction" (p. 393). They feel that teachers should play a wider range of roles when incorporating inquiry-based activities into a technology-based course: "CSI lessons are intended to create a learner centered inquiry based learning environment for students' individual and collaborative investigation of science phenomena and concepts" (p. 400). The resulting student test scores supported that supposition, yet a gap existed

that the researchers explained as the result of a deviation in teaching practice by one teacher in the study.

Erdogan and Dede (2015) examined computer assisted, project-based learning in science achievement. Project-based instruction allows students the chance to work independently to solve real world issues. It enables students to show problem solving skills as well as to develop deeper critical thinking skills. The introduction of technology into schools allows students a richer learning environment that helps to create interest and motivation through student-centered learning. This research combined the two approaches. It tested this theory with 7th grade students' studying living conditions. "The findings of the study indicated that the science achievement scores of the group that received computer assisted project-based instruction were significantly higher than that of the control group which received traditional project-based instruction" (p. 183).

Van der Kleij, Feskens, and Eggen (2015) examined computer-based learning environments in the hope of helping to better advise the designers of educational software. Their study focused on feedback being more immediate in computer-based learning environments and their effects on overall content understanding. Assessment and feedback are crucial components of the learning process. Three types of feedback and their success rates were examined: knowledge of correct response (KCR), knowledge of results (KR), and elaborated feedback (EF). The results showed that "EF was more effective than KR and KCR" (p. 501). This finding is important because it shows that computer-based learning provides elaborated feedback in a more rapid manner than in a traditional classroom setting.

Maenh (2016) sought to establish the effectiveness of technology in the high school science classroom because it serves as a tool of differentiation. Maenh worked with one teacher

to track the use of technology in her classroom of ecology students. Students were given websites to complete instructional research and assignments based on the concept being covered. The websites and assignments varied based on students' pre-assessments in the unit. Maenh found that this instructional method is successful, but they pointed out that a key component of it is student readiness for that type of learning environment. Maenh suggested having students practice with peers before diving into this method.

More recent research has focused on computer-based instruction as a supplement to classroom instruction. Shute and Rahimi (2016) examined this topic and stressed the concept of the feedback that computer programs can more rapidly provide to students. Vygotsky stressed feedback as an important component of developing an understanding in order to move out of the Zone of Proximal Development. They examined the use of these computer-based supplements in the elementary and secondary educational math classroom settings. The participants utilized computer-based learning each day, completing games that reinforced the concepts taught in class. The games gave immediate feedback to students, allowing them to better adjust their responses and seek additional help. Shute and Rahimi found that this action led to increased problem-solving skills in students.

Barak (2016) explored computer-based learning in science teacher education courses. More specifically, he examined the social constructivist side of computer-based learning. Students interacted with each other through the program to share information as they completed a course entitled "Methods of Teaching Science and Technology" (p. 288). Students used the instructional program along with cloud-based platforms such as Google Drive, blogs, YouTube, and social media. One factor that Barak's research identified was the teacher's ability to navigate the technology. Students with no previous technology experience struggled to complete

tasks and teach the material to others in turn. Barak argued for the importance of implementing computer-based instruction training to current teachers as well as starting current elementary level students in the process so that the technology will be easier to maneuver as its use grows. Barak found that the teachers in the program expressed positive feelings about the cloud learning environment and the ability to share information using it. This component of computer-based learning was reported to help the teachers feel more engaged in the learning process, allowing more ideas and concepts to be shared and acquired.

Yuan (2016) explored the inquiry-based learning setting of Chinese students who were English language learners. The first step was to describe a task-based method aiming to draw learners' attention to the meaning in the language. Keeping students engaged in learning is a key component to not only inquiry-based learning but also to student achievement. "Language learners could be engaged in the real communicative environment through classroom activities settings, such as group problem solving, simulations, and decision making" (p. 392). The task assigned to students is of great value because it provides opportunities for learners to experience real time, real life communication. "Task based language teaching, which focuses on the meaning-based learning and student-centered teaching approach, would make learners have a sense of accomplishment when they perform task successfully" (p. 393). The issue lies in the learners' ability to produce accurate language with grammatical features without task-based instruction in grammar rules. Yuan's research found that task-based learning is superior to the traditional instructional teaching approach because it actively engages learners in the communitive classroom.

Yuan, Wang, Kushniruk, and Peng (2016) explored the effectiveness of computer-based instruction to support diagnostic problem-solving expertise among medical students. Problem

solving is an everyday activity in life that must be mastered and completed rapidly in the medical profession. Having a best instruction practice for medical students to master this is, therefore, imperative. Problem-solving experience can also help to engage students, leading to better learning experiences. "Given the constrains of classroom settings in offering learning with real-world problems, computer-based environments have been increasingly explored" (Yuan, Wang, Kushniruk, & Peng, 2016, p. 541). Their research found that participants reported feelings of better preparedness to solve problems in the medical setting. They also reported higher understanding of the concepts covered in the computer-based lessons.

Zheng (2016) examined computer-based learning and academic performance in the social sciences. Zheng looked for computer based-learning that had built-in scaffolds for learning. While several types of scaffolds were discussed, Zheng chose to use conceptual scaffolds. These included concept mapping activities and guiding questions that were hard built so that students had to acknowledge them to move on in the course. When they were implemented in computer-based learning, students' conceptual knowledge showed a medium positive effect. Zheng stressed the need for further research in computer-based learning since it is an emerging learning environment with little research behind it compared to other teaching methods.

Computer-based instruction and technology integration into the 21st century classroom has become a dominant research area. Fang and Hsu (2017) examined the computer-based instruction of science teachers, particularly in an inquiry manner. They pointed out that the use of computer tools can help students to generate and test hypotheses, collect and display data, examine evidence, and create explanations or models. Their study sought to establish the factors for successful computer-based instruction in an inquiry manner. "Due to different knowledge, beliefs, values, and experience, the ways in which teachers enact computer-based inquiry

curricula can be very different and have consequences for student learning" (p. 70). To examine this phenomenon, they observed two secondary science teachers' utilization of the Collaborative Web-based Inquiry Science Environment software for the plate tectonics unit. Through classroom video observations and student assessment scores, the researchers established that the students of the teacher who "provided a highly-structured, step by step approach in contrast with the other teachers' more freely structured, segmented approach" (p. 78) achieved exceptional assessment results and exhibited better conceptual knowledge than the students of the more freely structured teacher.

Rusli and Negara (2017) examined the effect of adding animation to computer-based instruction, examining the effectiveness of computer-based learning for students enrolled in an online computer systems course. They compared a traditional classroom setting, computer-based setting, and a computer-based setting with animations added. The animations served to help better identify hints to concepts, such as pointers and highlighted boxes that linked to answers or questions. Rusli and Negara found that adding multimedia animations to the computer-based learning program had a positive effect on student learning outcomes. This was particularly the case when applying the concepts, procedures, and principals to JAVA programing. They found no interaction effect when they considered the student learning type as well.

More recently, Deekens, Greene, and Lobczowski (2018) examined the use of computer-based learning environments in science. They stated that the importance of their study comes from today's learners' constant use of the Internet as a source of information. "Despite the opportunities presented by the Internet, evidence indicates that students struggle to successfully locate, integrate, evaluate, and comprehend information they encounter online" (p. 63). This evidence pushed the researchers to examine how effective computer-based learning is in science

as a self-regulated learning setting. They utilized college students who were entering a circulatory unit in their college course. They found that students who were engaged in self-regulated learning environments showed enhanced learning in the circulatory unit.

Summary

Direct instruction was once the preferred method of science and math instruction, as it allowed for vocabulary building and retention through constant modeling and practice. This building of basic skills then carried over into reading and writing classes. Research in the early 2000s compared direct instruction method to inquiry-based instruction frequently, but little current day research on the topic has been published. This researcher has not found any recent comparison of direct instruction to computer-based instruction. Research could also not be found on the direct instruction method being utilized in a remediation setting at the secondary science level.

Inquiry-based instruction has been well document through the years. One area of study in which no research was found was its implementation in a remediation setting instead of a general classroom instruction setting. Varying student populations have been explored, along with varying content areas. Even among those varying categories, all of the studies found in the literature review were in the normal classroom timeline environment instead of the condensed and time-restrained SOL expedited retake remediation window. Inquiry-based instruction could be beneficial as a remediation method because it seeks to build on prior knowledge, which is the goal of remediation, building a fuller content understanding on content understanding deficits. Research was found comparing inquiry to direct instruction, but no research was found comparing it to a computer-based instructional plan.

The computer-based instruction research presented lacks implementation in a secondary high school setting. Current research has been focused on language acquisition and math skill building, but this researcher could not find computer-based secondary science instruction research.   The currently available research presented all supports the validity of computer-based instruction in student content growth for the topics explored in the literature thus far. No research could be found on computer-based instruction as a remediation instructional tool, however.

CHAPTER 3: METHODS

Overview

Chapter Three provides an examination of the research methodology for this study, which seeks to establish what remediation instructional technique proves to be best practice for middle school science students taking the Released 2015 Virginia SOL test. Previous research has not yet addressed this area and current SOL trends support the need for further information. This research examined the pre- and post-test scores for students grouped into direct instruction, computer-based instruction, and inquiry-based instruction remediation classes. Previous studies have revealed success in computer-based learning for math students; however, no research could be found on the success of science instruction delivered in this same manner. Inquiry-based instruction is the most commonly touted best practice in science instruction, but little has been studied regarding the effects of this method when it is used in remediation classes. The current practice of the district in this study is direct instruction, which has led to mixed results. This chapter seeks to establish the design method to address the research question and identify the null hypotheses. It will establish the procedures while identifying the participants, setting, and instrumentation of the study. Chapter Three concludes with a description of the data analysis method chosen for this study.

Design

A quasi-experimental nonequivalent control group design was used to examine the two variables—inquiry-based instruction and computer-based instruction—and their effectiveness in raising SOL scores for students in the remediation program. The rationale behind this research design selection was based on the manipulation of variables without the random assignment of participants in the study (Gall, Gall, & Borg, 2007).

Research Questions

The research questions for this study were the following:

RQ1: Which instructional practice (direct instruction or computer-based instruction) is best for the remediation of middle school science students?

RQ2: Which instructional practice (direct instruction or inquiry-based) is best for the remediation of middle school science students?

Hypotheses

The hypotheses for this study were as follows:

H1: There is no statistically significant difference in achievement scores for direct instruction compared to computer-based instruction as shown by student scores on the 2015 Virginia 8th grade science SOL test.

H2: There is no statistically significant difference in achievement scores for direct instruction compared to inquiry-based instruction as shown by the released 2015 Virginia 8th grade science SOL test.

Participants and Setting

This study consisted of a convenience sample of approximately 102 science remediation students from an urban Virginia public school system. The convenience sampling was used in the study as participants were easily accessible to the research due to their proximity to and enrollment in the research district. According to schoolequality.virginia.com, the 8th grade total student enrollment in the district was 375 as of November 2018. The student population was 51% female and 49% male. The ethnicity of the student body was 87% Black, 6% White, 3% Hispanic, 3% two or more races, <1% Asian, <1% American Indian, and <1% Native Hawaiian. Students with disabilities account for 11.5 % of the student population. The district is considered

an area of high poverty as 61% of students are economically disadvantaged. When sorted, the remediation group's student ethnicity (which is identified on the state tests) were taken into account. Groups were created to be as equal as possible in participant demographics. The school had a 72% Science SOL pass rate as of 2018. Passing Science SOL scores are a vital part of the school's accreditation and grade promotion process.

Participants are required to take the state's 2015 8th grade science SOL test during the allotted testing window based on course enrollment. Students who score 400 and above are considered competent and issued a passing score; they were not used in this study as no remediation was required. Participants who scored between 375-399 were selected to attend remediation and allowed an expedited retake of the 2015 8th grade science SOL test. A total of 102 participants were deemed to be within the desired study score range. They were used in this study, exceeding the required minimum for a medium effect size with a .7 statistical power at the 0.5 alpha (Gall, Gall, & Borg, 2007).

The sample groups came from each of the 8th grade science classes and were composed of students with science SOL scores qualifying them for remediation. The first overall sample group consisted of 20 females and 18 males. Of those, the racial breakdowns was 34 Black, 2 White, 0 Asian, 0 Hispanic, 0 Native American, 0 Native Hawaiian, and 2 of two or more races. Group 1 received six hours of computer-based instruction for remediation.

The second sample group consisted of 8 females and 8 males. Of those, 15 were Black, 0 were White, 0 were Asian, 0 were Hispanic, 0 were Native American, 0 were Native Hawaiian, and 1 was two or more races. Group 2 received 6 hours of inquiry-based instruction for remediation.

The third sample group consisted of 24 females and 24 males. Of those, 40 were black, 3 were white, 1 was Asian, 1 was Hispanic, 0 were Native American, 0 were Native Hawaiian, and 3 were of two or more races. Group 3 received 6 hours of direct instruction for remediation.

Instrumentation

The independent variable in this study was the method of instruction that the participants received for the science SOL remediation. The control method was direct instruction, which is typically used across the district. The first experimental group received computer-based instruction. The second experimental group received inquiry-based instruction with inquiry labs provided by the district and state. Upon completion of 6 hours in the remediation class, students then took the released 2015 Virginia Science SOL aligned with their science course.

In computer-based remediation, students log into to their individualized classes and complete the assigned modules at their own pace. Modules consist of information on the content and application of the information in various simulations. This remediation course was overseen by science instructors during the remediation sessions: two after school sessions of 1 hour each and 4 hours during the school day.

The district has compiled an inquiry lab guidebook for each of the science SOL contents that align with the curriculum. This book was used for the inquiry-based remediation group lesson. The inquiry lab booklet consisted of a content review section summary followed by varied inquiry level application labs. During each 1-hour session over the 2 days and the 4 hours of sessions offered during the school day, the students completed the inquiry labs, which were overseen by science instructors.

The control group method of direct instruction is the standard remediation practice of the district. Students attended the 2-day, 1 hour per day and 4 hours of in-school sessions in their

assigned building. Science instructors went over the 200-slide review PowerPoint with the students, completing fill-in-the blank notes as they went. Students were then asked a series of questions to ensure their knowledge of the content.

The Virginia SOL for middle school science was the test instrument used in this study. The test consists of 50 questions. The point value for each question varies based on its level of complexity. Since experimental questions are typically not released, all questions were scoreable. There is no time limit for the test, which is given on computers at the student's home school during official testing, but students were limited to one class session of 90 minutes to complete the test. No instructors reported issues with students not completing the test in the allotted time. Questions consisted of multiple choice, sorting, and matching, and there were no written answers.

The 2015 released tests for each science content area have been proven to be highly reliable: "The reliability of the SOL assessments is quite high, indicating reliable assessments" (Virginia Department of Education, 2014), with a coefficient alpha of 0.85 for non-written tests. The middle school science test has an alpha of .87 for black students and an alpha of .91 for white students, which are higher than the established 0.85 highly reliable alpha for non-writing tests.

> During the 2014-2015 academic year the SOL assessment results were not linked empirically to other assessments or scores that would provide validity evidence for the SOL scores. However, Virginia plans to carry out additional research in this area to support the validity of the SOL assessment program in the coming years. (Virginia Department of Education, 2014)

While the reliability is quite high, it is not perfect, which is why the state allows students within a close passing score margin to retake the test after remediation.

Procedures

Approval of the research was obtained through an IBR form submitted to Liberty University for approval. Once IBR approval was granted, school officials were contacted and made aware of the study. This information was then shared with the science teachers at the middle school. After the students completed the 2015 Virginia science SOL test, their SOL scores were examined and students eligible for the expedited retakes were identified. Each student eligible was assigned a tracking number and their score was recorded as a pretest score on the Excel spreadsheet. Each of these students received a copy of their score along with a letter of assent, for parents of students 17 years old or younger, explaining the remediation instruction groups for the study. Those students with completed forms were assigned to a remediation group based on demographic balancing. Those who did not return completed forms were given the traditional district direct instruction remediation and none of their data were collected. Traditionally, the school has offered remediation for the science SOL; however, students could not select between computer or inquiry instruction.

Groups were created to reflect, as closely as possible, demographic profiles that were equal to each other. This was done to help establish equal opportunity. This also helped to eliminate validity errors resulting from groups that were unequal in student composition. The groups of students in existing remediation classes were divided into closely equal demographic groups. Students were assigned to remediation based on the 2015 released science SOL scores to help alleviate the "main threat to the internal validity of a nonequivalent control croup experiment, "which is the possibility that group differences on the posttest are due to preexisting

group differences rather than to a treatment effect" (Gall, Gall, & Borg, 2007, p. 417). By mixing the groups with students of varying backgrounds, the data are less likely to be skewed by factors such as special education status, poverty level, or ethnicity.

Each group was assigned an instructor who oversaw the instructional practice in the classroom. Participants were assigned a testing identification number to maintain confidentiality. These groups then attended the remediation classes for the 6 assigned hours before retaking the released 2015 science SOL test, which served as the post-treatment test. The control group data were established by examining remediation through direct instruction scores, which is the tradition of the district. This group consisted of students who were eligible for the retake but had not turned in assent or consent forms. The student data were given with student identifying information removed. According to Gall, Gall, and Borg (2007), using a control group design assists in controlling for internal validity threats that are inherent to the design. This practice aligns with pre-test and post-test comparison practices identified by Gall, Gall, and Borg (2007). It allows for the identification of differences between groups by establishing a pre-exposure score and allowing for the collected post-exposure data. The selection threat was controlled by statistically holding the pretest scores for each group as a constant while examining the difference in post-test scores. Figure 1 shows the order in which the pre-test and post-test were administered.
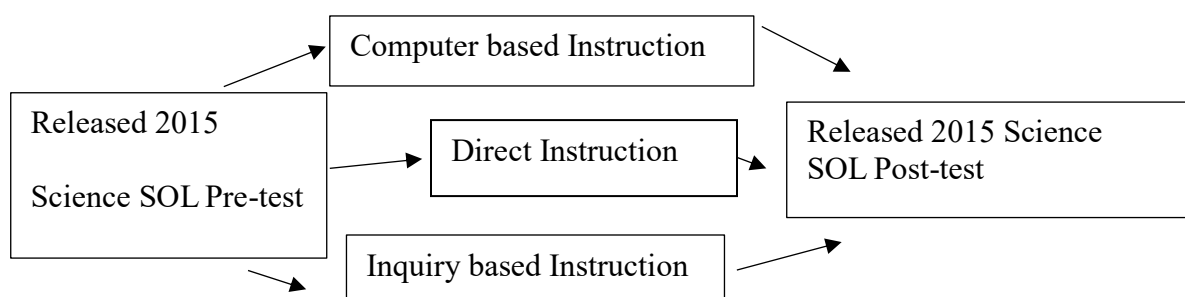

Figure 1. Pre-test and post-test design.

Once groups were established, students were informed of their dates, times, and locations for remediation. Instructors were given the inquiry handbook provided by the district or the computer program information provided by the district, depending on the group that they would oversee. Those in the direct instruction group continued to use the PowerPoint presentations and note sheet previously used by the district. The inquiry-based instruction manuals and supplies were given to instructors the week before remediation began at an hour-long meeting to discuss the procedures of each lab and the role of the instructors. In a separate meeting, the expectations of those instructors assigned to the computer-based remediation courses were established. Instructors were given NASA E-Clips, Gizmo access, Phet website links, and Legends of Learning Access along with links to You Tube video lesson to utilize in their computer-based remediation.

 All students attended 6 hours of remediation over 4 days before retesting in the course to which they were assigned at their school. Remediation took place during the school day. Students who missed a school day session were offered a makeup session after school to maintain eligibility to retest. Once remediation was complete, the 2015 Virginia Science SOL test aligning with each students' course was administered. New test scores were then added to the student's information on the Excel spread sheet for data analysis.

Data Analysis

Analysis of pre- and posttest scores was completed for each of the three groups. The following null hypothesis was conducted:

H1: There is no statistically significant difference in science SOL scores for students who attend inquiry-based remediation or computer-based remediation instruction compared to those students who attend direct instruction-based remediation.

To test this hypothesis, the pretest (initial Virginia science SOL) was first conducted. The students attended the remediation sessions over a one-week window, and then the posttest (expedited retake Virginia science SOL) was conducted as established by the pretest/posttest control group design. Seeking to control for pretest effects, an analysis of covariance (ANCOVA) was used to compare posttest groups. An "ANCOVA is used to control for the initial differences between groups before a comparison of within-groups variance and between groups variance is made" (Gall, Gall, & Borg, 2007, p. 320). A pretest was necessary in this study to establish the eligibility of participants as well as to examine the control and experimental groups for equality, as the groups are not randomly created and could include preexisting differences (Campbell & Stanley, 1963). Results from the ANCOVA indicated no statistical difference between the groups on the pretest. An ANCOVA was then conducted on the post test results. To test the null hypothesis, an alpha level of $p < 0.5$ was used to either reject or fail to reject the null hypothesis (McLean & Ernest, 1998). These tests were conducted for each science content test in each remedial instruction grouping as a whole, not by individual school, to establish district-wide data.

Assumption testing was conducted before the analysis. Tests were conducted to establish normality and homogeneity of variance and to identify to any extreme outliers. Normality was assessed using the Sharpiro-Wil test. Box plots were used to identify any extreme outliers and Levene's test of homogeneity was conducted for equal population variance (Assumptions for Covariance, n.d.).

CHAPTER FOUR: FINDINGS

Overview

Chapter Four provides an analyzes the data collected during the research. The examination of distinct content areas shows that while some subjects perform better with specific instruction approaches, others exhibit poor outcomes. This study sought to determine the efficacy of computer-based compared with inquiry-based instruction. The research question addressed in the study was aimed at investigate the most effective instruction-based standard of learning in remedial science programs. The dependent variable was the posttest score gain from the released 2015 Virginia 8th grade science SOL. The independent variable was the remediation instructional strategy: direct instruction, inquiry-based instruction, or computer-based instruction.

Research Questions

The research question for this study were the following:

RQ1: Which instructional practice (direct instruction or computer-based instruction) is best for the remediation of middle school science students?

RQ2: Which instructional practice (direct instruction or inquiry-based) is best for the remediation of middle school science students?

The null hypotheses for this study were as follows:

H01: There is no statistically significant difference in achievement scores for direct instruction compared to computer-based instruction as shown by student scores on the 2015 Virginia 8th grade science SOL test.

HO2: There is no statistically significant difference in achievement scores for direct instruction compared to inquiry-based instruction as shown by the released 2015 Virginia 8th grade science SOL test.

Descriptive Statistics

To conduct this research, a central Virginia middle school was utilized to administer a pretest using the released 2015 Virginia 8th grade science SOL, remediate students in the varying instructional strategy, and then give the students the posttest, which was also the 2015 released Virginia SOL. Per district policy, all 8th grade students completed the pretest. Only those with scores comparable to the state remediation scores were eligible to complete the remediation and participate in the study. Once pretesting was complete, 102 students were found to be eligible for the remediation. The females comprised of 50.98% of the student participants while males comprised the remaining 49.02%. Of those students, 87.25% were black, .03% were white, .009% were Asian, .009% were Hispanic, and .059% were of two or more races. Students were placed in remediation courses with their teacher for 6 hours. The posttest was then administered and the scores were compared for point value change.

The direct instruction group had a mean score increase of 17.705 (SD =26.562) points between the pre- and posttest. The inquiry-based group had a mean score increase of 16.675 (SD= 23.354) points between the pre and posttest. The computer-based remediation group had a mean score increase of 7.111 (SD= 21.779) between the pre and posttest. These descriptive statistics are found in Table 1 and Table 2.

Table 1

Between Subjects Factors

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Group	90	1.000	3.000	2.222	.731
Pretests	90	333.000	399.000	383.422	12.229
Posttest	90	342.000	452.000	395.900	25.763
Valid N (listwise)	90				

Table 2

Descriptive Statistics

Statistics

		Pretests Inquiry	Posttest Inquiry	Pretests Direct	Posttests Direct	Pretests Computer	Posttest Computer
N	Valid	16	16	38	38	36	36
	Missing	16	16	38	38	36	36
Mean		387.060	403.750	381.450	397.90	383.89	390.31
Median		390.000	408.000	384.000	397.000	387.000	385.000
Mode		390.000	406.000	392.000	395.000	392.000	383.000
Std. Deviation		9.788	25.091	13.699	25.435	11.419	25.872
Sum		6193.000	6460.000	14495.000	15120.000	13820.000	14051.000

Tables 1 and 2 compare the pre- and posttests in terms of the means, median, mode, standard deviation, and sum of the two tests. The outcomes indicate a rise in the test scores. After breaking down the means into individual groups, the scores for the posttest seem higher than the pretests. The shows that the inquiry instruction method exhibited a higher level of effectiveness than the rest of the methods. Comparing the above scores, the inquiry method reveals the highest level of improvement in the performance of the students. Figure 2 shows the means scores.
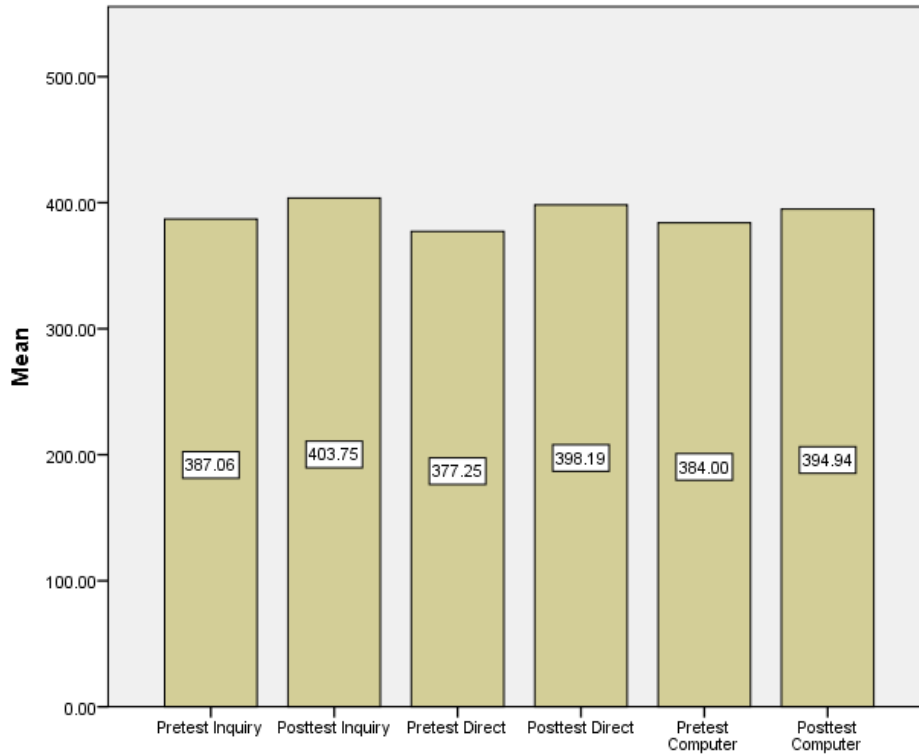
Figure 2. Mean scores between pre- and post-tests.

Results

Data Screening

Data screening was performed to identify any outliers or inconsistent elements that could influence the overall outcome. Outliers refer to extreme values that are considered distant from the rest of the observations. The difference between the pretests and the posttests could show potential outliers that affect the overall calculation of the ANCOVA. The Box and Whisker plot (Figure 3) shows the differences and the presence of outliers in each case.
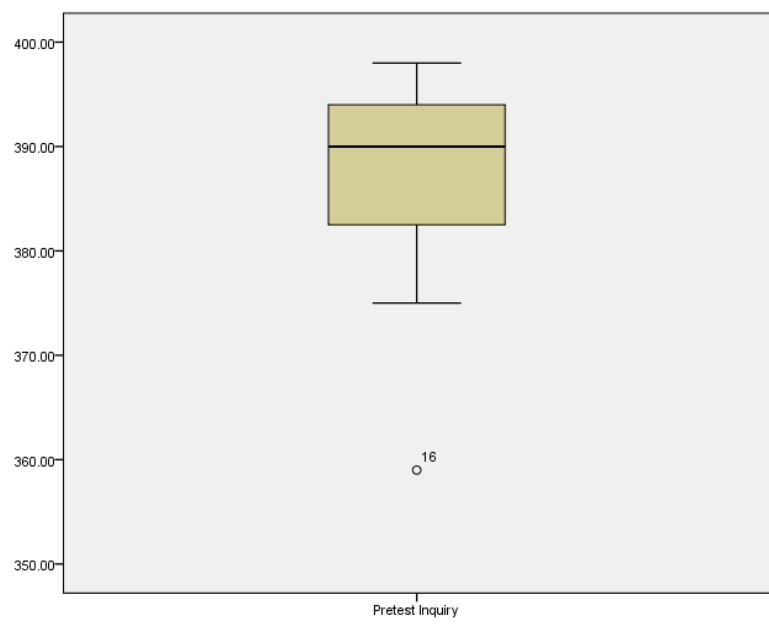
Figure 3. Pre-test scores inquiry instruction.

The Box and Whisker plot presents the difference between pretests and posttests. Accordingly, no outlier exists and the values are within the recommended range.
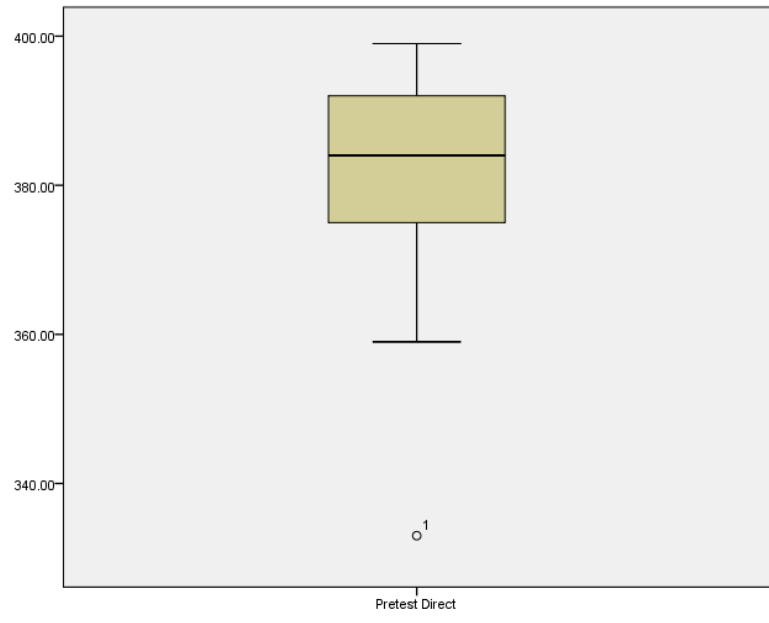

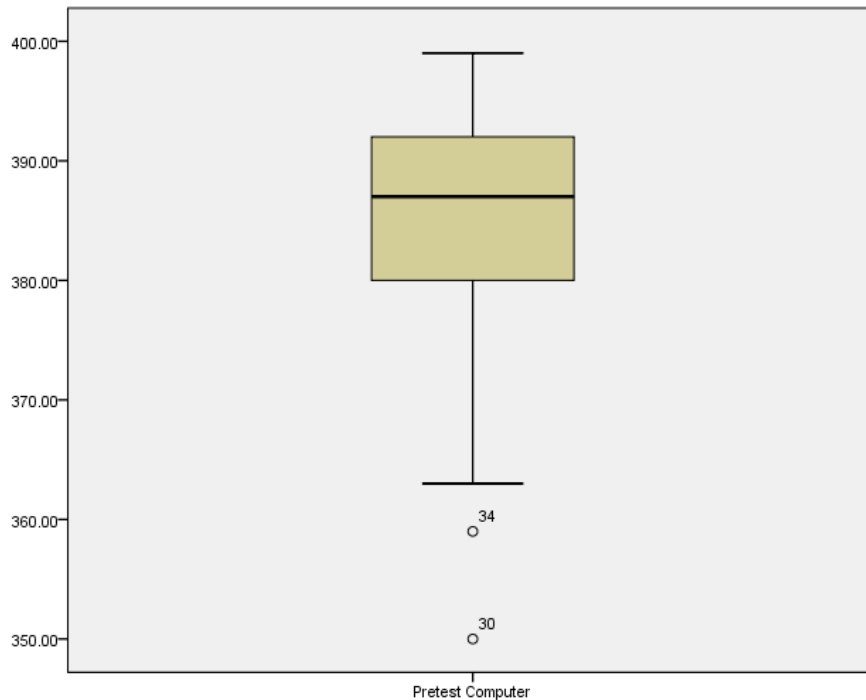*Figure 4*. Pre-test scores for instruction.

Figure 5. Pre-test for computer instructions.

The above Box and Whisker plots illustrate the pretest scores. In Figure 3, the pretest for inquiry instruction revealed an outlier on the 16th value; in Figure 4, the outlier exists on the first value, and in Figure 5 outliers exist on the 30th and 34th values. The outliers were eliminated from the values to limit their interference with the calculations.

Post-test Scores

The post-test results, show in Figures 6, 7, and 8 illustrates no presence of outliers. The pretests scores for inquiries, direct instruction, and computer instruction do not show any outlier. This implies that the values are distributed appropriately.
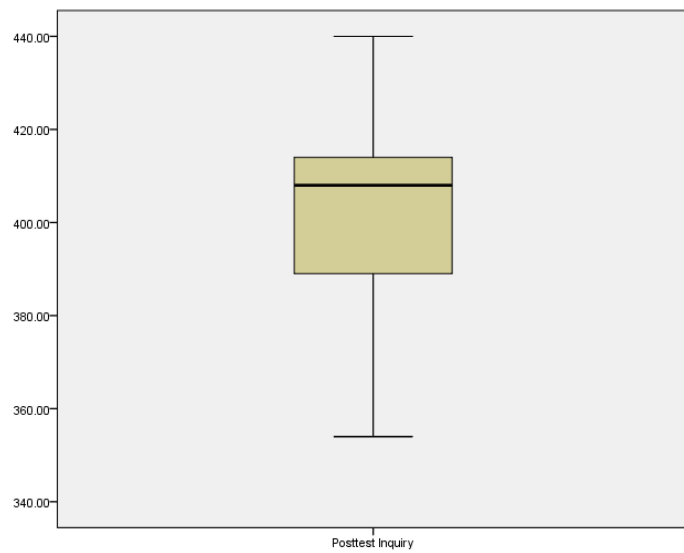
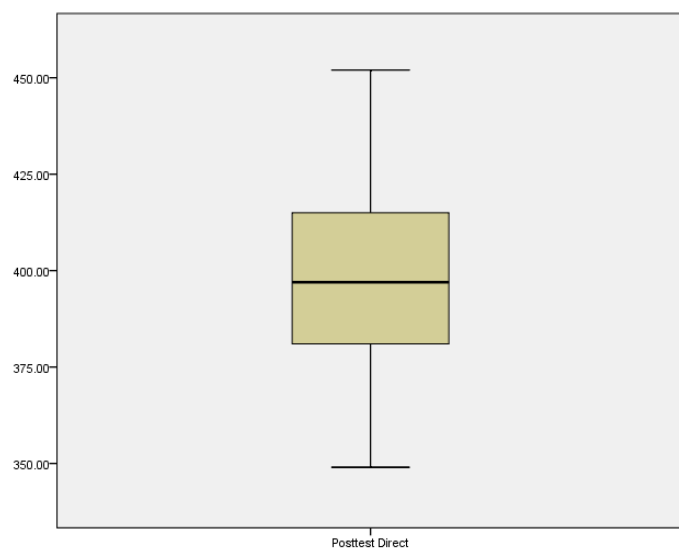*Figure 6*. Pre-test scores inquiry instruction.

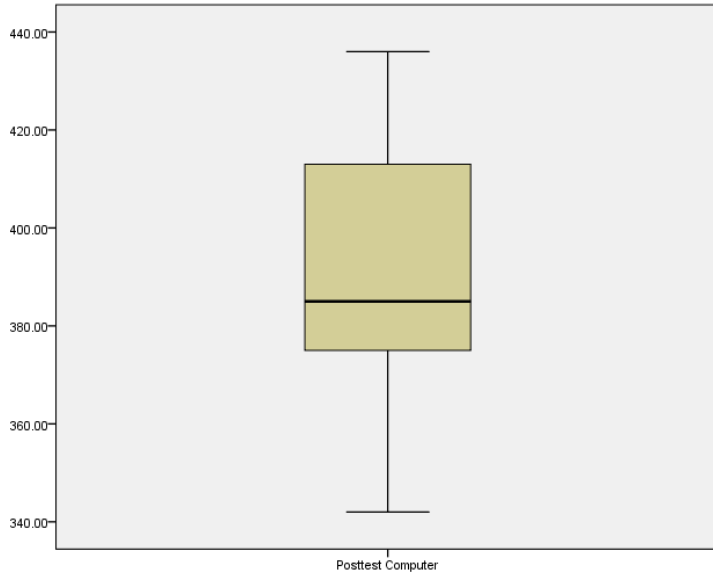*Figure 7*. Post-test for direct instructions.

Figure 8. Post-test for computer.

Assumptions

Numerous assumptions underlie an Analysis of Covariance. The assumptions tested in this case included normality through the Kolmogorov-Smirnov test, the Assumption of Linearity using a series of scatter plots for pre- and posttests, and an assumption of equal variance using Levene's Test of equality of error variance.

Kolmogorov-Smirnov Test

A test of normality was utilized to determine if the depression levels of the individuals in the test groups were distributed on a standard curve. The Kolmogorov-Smirnov test was used due to the sample size being greater than 50. The assumption of normality for all groups was met because the significance for each is greater than .05. The results of the Kolmogorov-Smirnov tests are depicted in Table 3.

Table 3

One-Sample Kolmogorov-Smirnov Test

|		Pretest Inquiry	Posttest Inquiry	Pretest Direct	Posttest Direct	Pretest Computer	Posttest Computer
N		16	16	38	38	36	36
Normal Parameters[a,b]	Mean	387.0625	403.7500	381.4474	397.8947	383.8889	390.3056
	Std. Deviation	9.78753	25.09050	13.69888	25.43544	11.41873	25.87201
Most Extreme Differences	Absolute	.243	.207	.126	.097	.145	.111
	Positive	.132	.154	.118	.078	.100	.111
	Negative	-.243	-.207	-.126	-.097	-.145	-.080
Kolmogorov-Smirnov Z		.972	.829	.774	.598	.870	.667
Asymp. Sig. (2-tailed)		.301	.497	.586	.867	.435	.765

a. Test distribution is Normal.

b. Calculated from data.

The One-Sample Kolmogorov-Smirnov Test shows the normal distribution of the data. A data sample is not normally distributed if the *p* value is <0.05. Considering the results shown in Table 3, the scores for pretests and posttests for inquiry, direct, and computer are greater than the alpha value threshold. This illustrates that the data are normally distributed.

Assumption of Linearity

The assumption for linearity, which predict the linearity of the relationship, can be measured using scatter plots. The current study compares computer-based instruction and inquiry-based instruction when direct instructions are controlled. The scatter charts in Figures 9 and 10 represent the association between the variables between the pre-test and posttests.
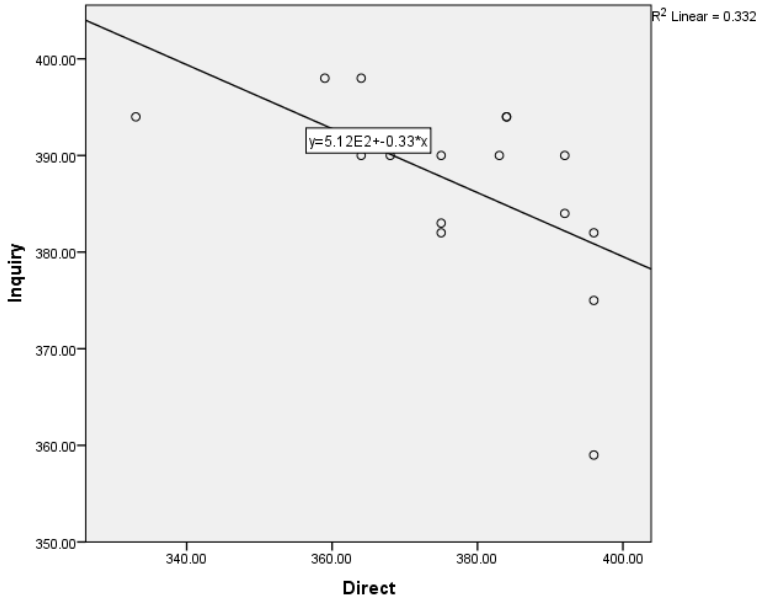
Association between inquiry and direct instructions during the pretest.
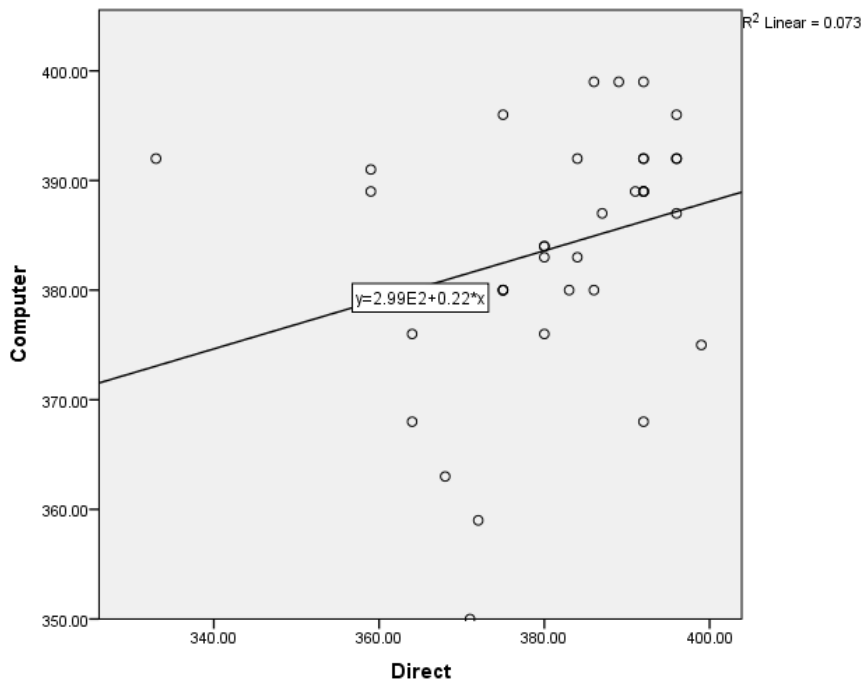
Association between computer and direct instructions during the pretest.
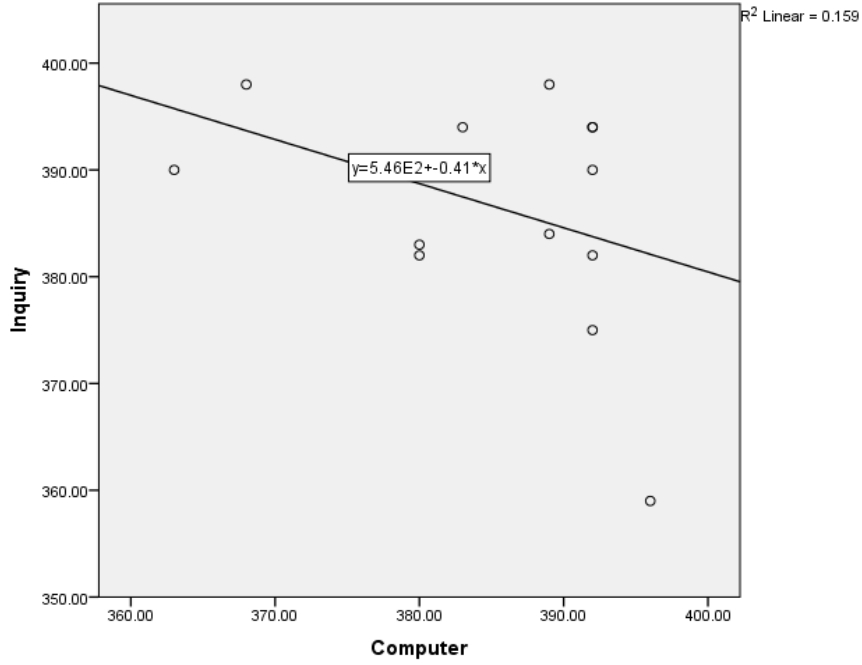
Association between Inquiry and Computer instructions

Figure 9. Scatter plots for pre-tests.

Posttest

Association between inquiry and direct instructions during posttest.
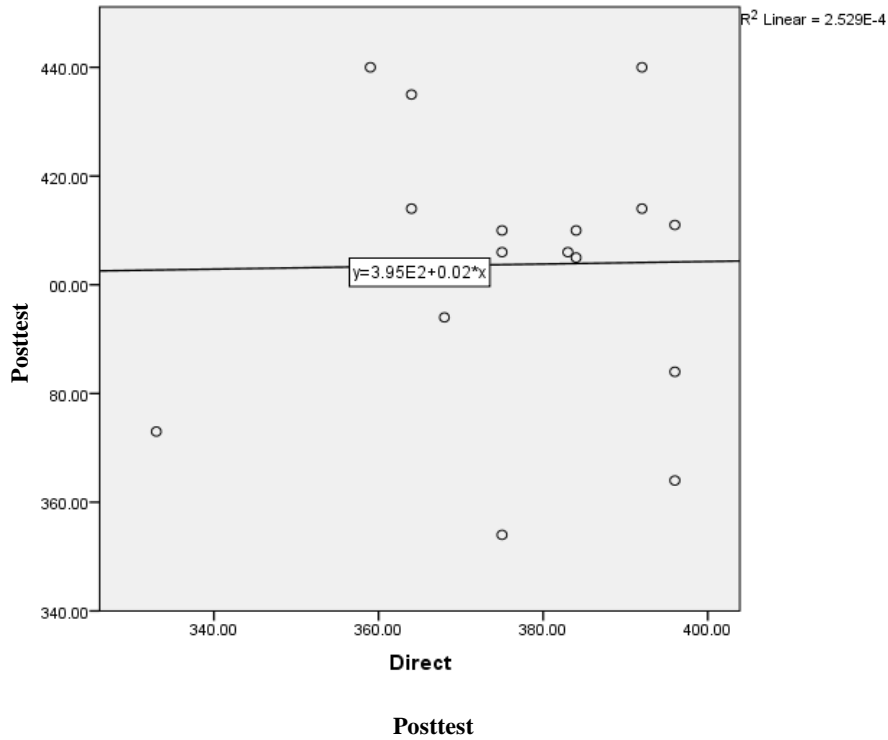

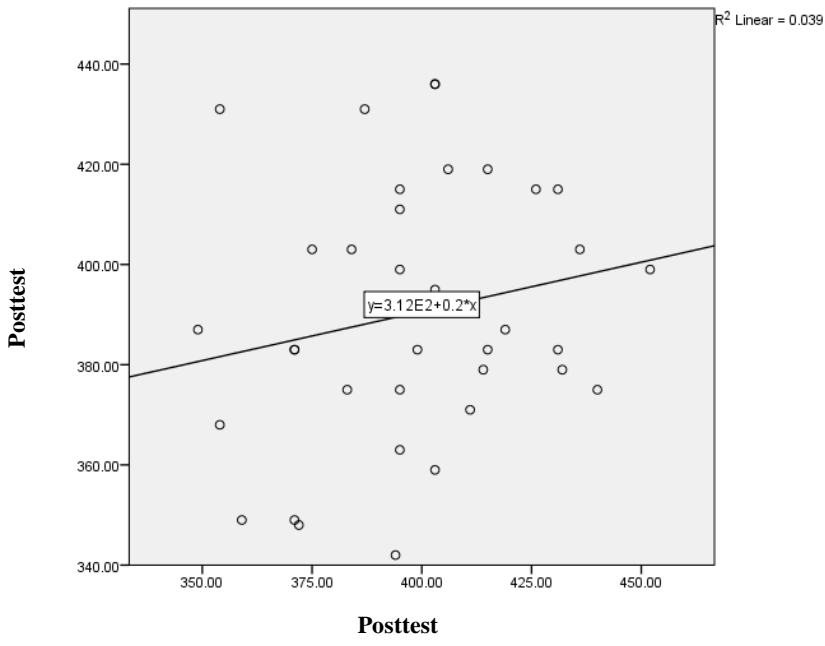Association between computer and direct instructions during post-tests.
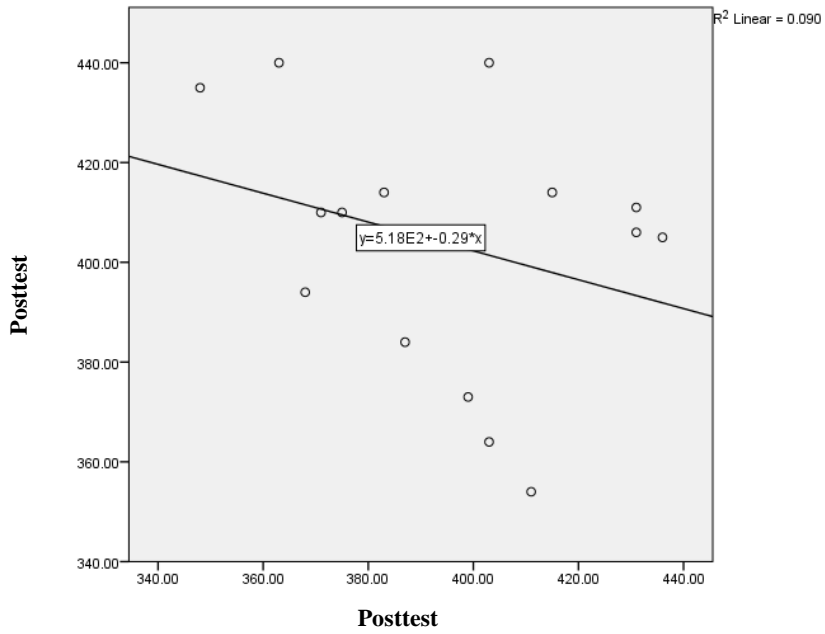

Association between inquiry and computer instructions post-test.

Figure 10. *Scatter plots for post-tests*.

These scatter charts show the association between the variables during the pretests. Direct instruction is considered the covariate factor and, therefore, its influence is measured relative to the two variables. In the first scatterplots, the association between the inquiry method and direct method is negatively correlated, where direct instructions do not strongly influence inquiry instructions. The second scatter plot reveals the association between computer instruction and direct instruction. The outcome predicts a strong positive correlation, where one factor increases with the other. This suggests a positive association between the variables. The final part reveals the correlation between the computer-based instruction model and inquiry-based model. The outcome predicts a negative association between the independent variables.

Assumption of Equal Variance: Use Levene's Test of Equality of Error Variance

The homogeneity assumption emphasizes the notion that population variances tend to remain equal for all groups. To test this assumption, a Levene's test of equality of error variance was run on the data. Thus, the null hypothesis would be affirmed if the groups compared had equal variances.

Table 4

Levene's Test

		Sum of Squares	df	Mean Square	F	Sig.
Diff.Inquiry	Between Groups	7669.438	14	547.817	1.070	.650
	Within Groups	512.000	1	512.000		
	Total	8181.438	15			
Diff.Compute	Between Groups	12054.033	25	482.161	1.113	.452
	Within Groups	4332.717	10	433.272		
	Total	16386.750	35			

The significance levels shown on the table reveal figures above the recommended alpha value of 0.05. The assumption of equal variance is, therefore, fulfilled. The variance between the variables is, therefore, the same.

Analysis of Covariance (ANCOVA)

The study null hypotheses stated the following:

H1: There is no statistically significant difference in achievement scores for direct instruction compared to computer-based instruction as shown by student scores on the 2015 Virginia 8th grade science SOL test.

H2: There is no statistically significant difference in achievement scores for direct instruction compared to inquiry-based instruction as shown by the released 2015 Virginia 8th grade science SOL test.

Testing for Covariate

The ANCOVA test requires a comparison between the means when the covariate variable is controlled. Thus, the current study included an analysis of the ANCOVA where the pretests comprised the covariate factor, the dependent variable was the posttest, and the group was the fixed factor. Table 6 shows the outcome of the ANCOVA test.

A one-way ANCOVA test was performed to compare the inquiry-based method and the computer-based method with direct instruction. A normality check and Levene's tests were conducted, and the underlying assumption was met. The plot of regression standardized residual proved linearity, while the scatter plots exhibited a strong positive correlation between the inquiry-based instruction method and the computer-based instruction method. The outcome in Figure 6 reveals a *p*-value of .170, a figure that is higher than the threshold alpha value. The first hypothesis stated that there was no statistically significant difference in achievement scores for

direct instruction compared to computer-based instruction. The *p*-value for the association

between the group variables exceed the threshold Alpha value, leading to the conclusion that

there was no statistically significant difference in the achievement scores for direct instruction

compared to computer-based instruction. The second hypothesis stated that there was no

statistically significant difference in the achievement scores for direct instruction compared to

the inquiry-based instructions. The *p*-value, in this case, also exceeded the alpha value threshold,

an indication that there was no statistically significant relationship. The results, therefore, failed

to reject the null hypotheses in both cases.

Table 5

ANCOVA Test Outcome

Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8198.133[a]	3	2732.711	4.620	.005
Intercept	1649.886	1	1649.886	2.789	.099
Pretest	5934.251	1	5934.251	10.032	.002
Group	2143.359	2	1071.679	1.812	.170
Error	50873.967	86	591.558		
Total	14165385.000	90			
Corrected Total	59072.100	89			

a. *R* Squared = .139 (Adjusted *R* Squared = .109)

CHAPTER FIVE: CONCLUSIONS

Overview

Chapter Five begins with a discussion relating the literature review to the theoretical framework and data analysis. The purpose of this chapter is to establish the implications and limitations of this study's results. The chapter concludes with recommendations for future research based on these results.

Discussion

The purpose of this research was to determine if a best instructional practice exists for middle school science remediation. Direct instruction, inquiry-based instruction, and computer-based instruction were all utilized in the study. To examine this, students from a southeastern Virginia Middle school participated in a 6-hour remediation of science. The statistical analysis failed to reject the null hypotheses that neither inquiry-based nor computer-based instruction would be more effective than direct instruction in the science remediation of middle school students.

In the context of the literature review, the proposal set forth by the National Science Teacher Association (NSTA, 2014) regarding the preference for inquiry-based instruction in the science curricula dwelt on the ability to integrate direct instruction with inquiry instruction. These findings seem to be align with the research by Hughes et al. (2017) showing that the direct instruction method is an important part of the education process. Direct instruction allows teachers to repair student misconceptions more immediately through discussion and feedback. This ability of teachers to make the information clear and applicable to real world experiences is a vital part of learning that can play a major role in the outcome of education.

Schuster et al. (2017) also compared the effectiveness of inquiry and direct instruction. Their findings were mixed, which could explain the non-statistical significance in the present study when the covariate was introduced. Their findings demonstrated an uncertainty in the relationship between instructional types that was supported by the data collected in the present study.

The direct instruction strategy explores students' abilities and enables teachers to understand fully the students' abilities within the classroom setting. The reviewed literature demonstrated increased confidence when the direct instruction methods were used compared to either the computer or inquiry methods. The effects of direct instruction also occurs in cases where the emphasis is placed on learning basic skills. This takes place in the early stages of learning. Indeed, direct instruction at that point is inevitable, and children between grades 5 and 6 require direct instruction to improve their grasp of presented content. Lopez-Agudo and Gutierrez (2017) also supported the use of direct instruction, finding that monitoring student's work and providing feedback allowed teachers to make the clarifications that were necessary. Considering such outcomes, the use of direct instruction remains a major component of student learning.

The literature review showed that the inquiry-based approach was only effective if the teacher was more actively engaged in the learning process with the student than some models on inquiry call for. Inquiry-based lessons involve varying stages of guidance and instruction from teachers, but they only proved successful when students had adequate levels of prior understanding of the content area. When this prior understanding exists, intermediate-level inquiry sessions proved successful in enhancing content knowledge. That level of understanding could be best established with direct instruction followed by inquiry as a capstone. Van Uum,

Verfoeff, and Peeters (2017) found that the scaffolding approach offered in inquiry-based instruction best promoted student learning when teachers offered middle-level guidance during the inquiry process. A student's scientific knowledge was promoted through the implementation scaffolds during the inquiry sessions, allowing the students to learn from failures and seek answers on their own, leading to self-gained knowledge. This can present challenges if the student does not properly understand the information gained, which leads to misconceptions. Proper debriefing after inquiry labs are key to ensuring that misconceptions are not derived from the lesson.

The literature indicated that the computer-based instruction model proved to have a major positive effect on the learning of the sciences. The effectiveness of the computer-based instruction hinged on a number of factors spanning the quick mastery of the approach. The studies reviewed revealed that students gain access to a large amount of information through computer learning, which results in their ability to capture more of the taught content. The use of computer instruction has equally been inspired by the affordability of the technology. Unlike in past decades, recent times have witnessed major improvements in technology and the increased use of computers at home and in the classroom. Technology has not only become more affordable but also more easily accessible to students. Many high schools offer online courses and some states even offer online high schools. Many higher learning institutions have improved student access by introducing long-distance learning that has improved both instruction and the results of students.

Research by Holmes et al. (2013) has offered support for the utilization of scaffolding in education, as it leads to improved learning outcomes. They found that learning improves because students who invent become more likely to notice deeper concepts, particularly after a

failure and an attempt to overcome it. Computer-based lessons, especially the Gizmos, Phet, and Legends of Learning sites, allow students to adjust the lessons' difficulty levels and manipulate the labs as a means of scaffolding the materials learned. As Henderson-Posser and Sauer (2017) noted, meanwhile, the integration of both inquiry and computer learning paves the way for improved outcomes. It also supports a constructivist theory of building knowledge through actions. The technology component allows students to facilitate collaboration during the inquiry process and to model actions that a traditional lab would not facilitate.

These findings on the relationship between computer-based instruction and direct instruction reveal that a combination of the two approaches led to significant improvements in learning. The outcome of the analysis seems to justify the observation, made by Serin (2011), that technology has ushered in a learning environment that can be used to boost learning and further increase the student's levels of motivation. One of the major benefits of technology is the ability to access a pool of information from various databases instantly. The traditional classroom setting presented immense difficulties gaining access to information. In most cases, students engaged in research by manually locating books and journal articles; this process proved tiresome and lengthy. Access to information seems to provide useful study materials to the students that could account for the difference in correlations between direct, inquiry-based models and direct, and computer-based instructions. The association between direct instruction and computer-based learning seems to be more statistically significant than the association between direct the instruction and the inquiry model.

The correlation outcomes support the finding of Serin (2011) that students who utilized the computer learning processes exhibited significant improvements compared to those that utilized only direct instruction. Improved problem-solving skills stemmed from increased access

to information from multiple sources. As articulated in the reviewed literature, computer-based instruction provides the opportunity for self-evaluation and further reflection on learning outcomes. The student also has the option to compare information from various sources regarding the viability of the outcomes. Computer-based learning approaches also enable collaborative learning in group discussions. During the process of information sharing, students tend to gain increased mastery of subjects in various fields. The integration of that information enables comparison and critical analysis, which causes a deeper understanding of the learning concepts used. Learning through computers also allows students to engage practically in the learning processes. Computers provide the chance for practical simulations during learning; hence, scientific subjects can be clearly demonstrated to them and the outcomes observed through simulations, which enables students to develop a strong mastery of the subjects and put into practice the theoretical models taught in the classroom. The outcome of the analysis, therefore, shows that an augmentation of the computer-based approach by the direct instruction approach could result in highly effective instructions for science students.

Lopez-Aguido and Gutierrez (2017) underscored the importance of teachers having the materials that they need to be effective teachers. In their study, they provided teachers with the materials needed to implement remediation. Teachers of each instructional strategy were given access to materials several days before the remediation to allow them time during the school break to review them and address utilization concerns. This left them better prepared to carry out the instruction, leading the students to make gains regardless of the instructional strategy employed. Jones and Stapleton (2017) noted the importance of hands-on learning tools. Their research supported the use of computer-based labs (which were provided through the Phet and Gizmos websites) to expand student learning and help them master complex science concepts.

They, too, expressed the need for teachers to have access to materials to be efficient in instruction.

Considering the outcomes of the analysis, there is strong evidence that the three instructions methods (direct, inquiry, and computer-based) have a considerable level of influence on learning. While using both inquiry- and computer-based approaches resulted in an increased significance in the strength of the association, the covariate factor seems to have a significant influence on that association.

Implications

The results of this study demonstrate the need for direct instruction in science subjects. Direct instruction is necessary for students to connect past experiences with content knowledge. Through it, teachers are able to give more immediate feedback in the classroom, helping the to correct students' misconceptions early. Courses that rely on only direct instruction can lead to lower student engagement, however. Inquiry-based lessons have been shown to be those in which students are more engaged since they feed the innate desire of students to learn.

When the components of computer-based instruction are deeply examined, research has shown that both direct instruction and inquiry-based instruction can be delivered in one lesson through the use of technology. A better designed computer-based program could be of benefit to students seeking to gain content knowledge, particularly when they are unable to attend school at the campus. Computer-based instruction can aid students in growing their knowledge when it is properly designed to give the student lessons with feedback is simultaneously rooted in inquiry methods to cement the concepts. For those students with medical issues, those who must work to support family, and those with athletics or after school responsibilities, meanwhile, having a technology-based option available to them anywhere at any time is invaluable. Previously, these

students were left out of learning opportunities, but the mass production of today's technology, paired with mindful educators, helps to correct that.

The findings of this study support the need for schools to have better access to technology. While this researcher is not supporting the move to total technology-based education in the science classroom, this study does underline the importance of its utilization. Technology companies should also note the importance of technology in learning. The invention of the Cloud, for instance, allows for the worldwide sharing of ideas and technology. Technology that can be shared via the Cloud could allow more teachers and students to utilize virtual labs in the classroom. Further, by making licensing agreements more accessible to schools, developers can help students gain better access to virtual labs, increasing their understanding of more abstract concepts that are not typically demonstrated in the traditional classroom setting.

Levin and Schrum (2013) expressed the importance of funding partnerships to integrate educational technology with schools. This researcher agrees and encourages schools to seek grants and major corporate partnerships to obtain better access to resources for teachers. Community partnerships can establish funding for technology as well as increase awareness of the need for that funding. Jefferson Labs, for example, was approached by districts in its area and it now offers teacher training programs in the evenings to ensure that teachers are comfortable with the content while supplying them with materials needed to conduct inquiry-based labs. Many areas in the country could form partnerships with community businesses that work in a similar content area to better prepare teachers, allowing them to be more comfortable presenting the material. Such efforts could help to address the misconceptions that can happen

during direct instruction when teachers are not comfortable with and fluent in the concepts taught.

This study indicated that there is no best instructional strategy for the remediation of middle school students in regard to science content. Remediation did help the students overall to gain deeper understanding of the science content. It is important, however, to remember that no two students learn the same way. Teachers must be able to determine the needs of each student and work to create lessons that address their particular learning needs. This research opens the door for teachers to use multiple strategies that help to ensure that each student can gain additional science knowledge. For those districts that put forth only one mode of instruction for remediating students, this research supports the push to incorporate additional instructional strategies. Multiple teaching strategies allow for higher student engagement and learning. This is of particular concern to students of color. Greer, Clark-Louque, and Balogun (2018) found, for example, that providing enriching activities with lessons increased African American male engagement in the classroom, with the result that students retained more information and content understanding. Overall, each instructional strategy leads to higher content knowledge, which supports the findings of the previous research reviewed and the need for varying instructional strategies in the remediation of students.

Limitations

This research has several limitations. Methodologically, the sample size was smaller than originally anticipated. Many schools are hesitant to participate in studies related to standards of learning scores. Additionally, the groups did not all have equal teacher interest. Unfortunately, only one teacher was willing to offer remediation in an inquiry-based format. This seemed to support the finding in earlier research that teachers in urban schools will often not utilize the

strategy. Several teachers were interested in utilizing computer-based remediation as it allowed them to customize the learning based on student knowledge. It was also utilized for those students not able to attend after school sessions. The school also offered a limited number of hours to remediate the students as the official testing window was upcoming, and other content areas needed to be addressed.

External limitations also exist that are typical of most research involving participants. Neither the researcher nor the teachers could control for student attitudes during testing. Being an urban and high poverty school, many students are coming to school unable to focus or disengaged from learning. Students could put forth little effort on the tests because they knew they were not being graded. These conditions could not be controlled for, but they should have had only a small impact on the data.

Recommendations for Future Research

Based on the previous research the present findings, the following recommendations for future research are offered:

1. Combined instructional strategies. Students who are exposed to multiple instructional strategies could benefit from the mixed approach as it relates to each student's learning style.

2. High School SOL remediation practice effectiveness. As children grow, their learning abilities shift. Older students might respond differently to varying instructional strategies during remediation.

3. Long-term remediation programs throughout the school year. Often, remediation is left to take place just before SOL testing. The results could be impacted if the remediation took place over the entire school year based on student weaknesses as units are taught.

4. Comparisons of various computer-based learning programs. A multitude of computer-based learning programs are available to districts. Comparing varying programs and the components of each could help to establish the best design for future computer-based remediation tools.

5. Additional education content remediations. As other educational subjects also require a passing SOL score for credits to be earned, these subject matters could show similar results when varying instructional strategies are used.

6. Gap group point gains based on instructional strategy. Gap groups are a secondary school improvement plan component. By examining gap groups results based on instructional strategies, schools may be able to find a best practice to increase gap group passing rates.

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APPENDX A

IRB EXEMPTION

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

April 3, 2019

Kelli Leigh Caras
IRB Exemption 3568.040319: The Effectiveness of Inquiry and Computer-Based Learning in the
Remediation of Science Students

Dear Kelli Leigh Caras,

The Liberty University Institutional Review Board has reviewed your application in accordance
with the Office for Human Research Protections (OHRP) and Food and Drug Administration
(FDA) regulations and finds your study to be exempt from further IRB review. This means you
may begin your research with the data safeguarding methods mentioned in your approved
application, and no further IRB oversight is required.

Your study falls under exemption category 46.101(b)(1), which identifies specific situations in
which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):

> (1) Research, conducted in established or commonly accepted educational settings, that specifically
> involves normal educational practices that are not likely to adversely impact students' opportunity to learn
> required educational content or the assessment of educators who provide instruction. This includes most
> research on regular and special education instructional strategies, and research on the effectiveness of or the
> comparison among instructional techniques, curricula, or classroom management methods.

Please note that this exemption only applies to your current research application, and any
changes to your protocol must be reported to the Liberty IRB for verification of continued
exemption status. You may report these changes by submitting a change in protocol form or a
new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption or need assistance in determining whether
possible changes to your protocol would change your exemption status, please email us at
irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

LIBERTY
UNIVERSITY.
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APPENDIX B

PARENTAL CONSENT

PARENT/GUARDIAN CONSENT/STUDENT ASSENT FORM
The Effectiveness of Inquiry and Computer Based Learning in Remediation of Science
Instruction

This research study is being conducted by Kelli Caras, a doctoral candidate in the School of Education at Liberty University. Your child was selected as a possible participant because he or she is eligible for the science standards of learning (SOL) expedited retake. Please read this form and ask any questions you may have before agreeing to allow him or her to be in the study.

Why is this study being done?
The purpose of this study is to establish the most effective remediation instructional method to better assist students in passing the SOL retake. The two instructional methods being researched are inquiry based instruction and computer based instruction. If you choose to allow your child to participate, your child will be randomly assigned to one of these two groups. Both instructional methods are considered best practice in education currently but have not be researched in the remediation setting.

What will my child/student be asked to do?
If you agree to allow your child to be in this study, he or she will be asked to do the following things:
1. Attend the science SOL remediation based on random assignment. The date, time, and duration of SOL remediation sessions are based on your school. Typically they are held after school but please see your teacher for the exact schedule.
2. SOL data will be gathered by the student's school district and will be stripped of identifying information before being released to the researcher. The researcher will then be able to compare pre-test and post-test scores to determine which remediation method was most effective.

What are the risks and benefits of this study?
Risks: The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

Benefits: The direct benefit participants may receive from taking part in this study is an increase in science SOL scores. Benefits to society include the potential for higher on-time graduation rates, which could lead to a better educated work force.

Will my child be compensated for participating?
Your child will not be compensated for participating in this study.

How will my child's personal information be protected?
The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely and only the researcher will have access to the records
- SOL data will be gathered by the student's school district and stripped of identifying information before being released to the researcher.

- Data will be stored on a password locked computer and may be used in future presentations. After three years, all electronic records will be deleted.
- I cannot assure participants that identifying information will be secure if the . Public Schools System becomes compromised.

Is study participation voluntary?
Participation in this study is voluntary. Your decision whether or not to allow your child to participate will r · affect his or her current or future relations with Liberty University or ... nlic Schools. If you decide to allow your child to participate, he or she is free to withdraw at any time without affecting those relationships.

What should I or my child do if I decide to withdraw him or her or if he or she decides to withdraw from the study?
If you choose to withdraw your child or if your child chooses to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should your child choose to withdraw, any data collected from or about him or her will be destroyed immediately and will not be included in this study.

Whom do I contact if my child or I have questions or problems?
The researcher conducting this study is Kelli Caras. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at kcaras@liberty.edu. You may also contact the researcher's faculty advisor, Dr. Scott Watson, at swatson@liberty.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd, Green Hall 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

_____

Signature of Minor   Date

_____

Signature of Parent   Date

_____

Signature of Investigator   Date