A Virtual Learning System’s Impact on Student Achievement in a Secondary Biology College Preparatory Course; An Action Research Study

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A Virtual Learning System’s Impact on Student Achievement in a Secondary Biology College Preparatory Course; An Action Research Study

by

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DEDICATION

I dedicate my dissertation work to my loving husband and two beautiful children, whose support, patience, encouragement, and understanding were instrumental in the completion of this thesis. Without the three of them, this accomplishment would not be complete. They have never shown such love and grace, and for that I thank God every day.

I also dedicate this dissertation to my family and many friends who have supported me through this process. I will always appreciate their love and understanding for the missed outings, the extra carpools, and the countless words of encouragement. It takes a village to help those accomplish their dreams, and my village is irreplaceable. I will forever be grateful for each and every one of them.
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ABSTRACT

The purpose of this action research study was to describe the effectiveness of a virtual learning system (VLS) on college preparatory biology students’ pre- and posttest scores. Data were gathered from observations of students using the VLS for video lectures, practice tests, reviewing, and other online simulations in the spring of 2017. Data were also collected using a pretest and a posttest designed by the participant-researcher before and after the implementation of the VLS. A $t$ test was used to analyze the pre- and posttest quantitative data, and the constant comparative method was used to analyze the qualitative data from the formative assessments. Findings included the following themes: cultivating habits of student self-monitoring, developing student decision making, and improved equity and access to higher level science courses. The results of the present action research study were used to develop an action plan to enable other science educators at White Hall High School to make informed decisions regarding the implementation of a VLS in their classrooms to enhance student learning.

*Keywords*: virtual learning system (VLS), technology integration, blended learning
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iv</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
<tr>
<td><strong>CHAPTER ONE: INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td>PROBLEM OF PRACTICE</td>
<td>6</td>
</tr>
<tr>
<td>RESEARCH QUESTION</td>
<td>7</td>
</tr>
<tr>
<td>STATEMENT OF PURPOSE</td>
<td>7</td>
</tr>
<tr>
<td>THEORETICAL BASE</td>
<td>7</td>
</tr>
<tr>
<td>KEY CONCEPTS/DEFINITIONS OF TERMS</td>
<td>9</td>
</tr>
<tr>
<td>POTENTIAL WEAKNESSES</td>
<td>11</td>
</tr>
<tr>
<td>SIGNIFICANCE OF THE STUDY</td>
<td>12</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>13</td>
</tr>
<tr>
<td><strong>CHAPTER TWO: LITERATURE REVIEW</strong></td>
<td>14</td>
</tr>
<tr>
<td>OVERVIEW</td>
<td>14</td>
</tr>
<tr>
<td>CURRICULUM THEORY</td>
<td>17</td>
</tr>
<tr>
<td>IMPORTANCE OF LITERATURE</td>
<td>21</td>
</tr>
<tr>
<td>TECHNOLOGY INTEGRATION AND METACOGNITIVE STRATEGIES</td>
<td>23</td>
</tr>
<tr>
<td>ACTION RESEARCH METHODOLOGY</td>
<td>35</td>
</tr>
</tbody>
</table>
CONCLUSION ..................................................................................................................36

CHAPTER THREE: METHODOLOGY ...........................................................................38

BACKGROUND OF THE PROBLEM OF PRACTICE .....................................................39

POSITIONALITY ........................................................................................................41

RESEARCH DESIGN .................................................................................................42

STUDY PARTICIPANTS ...............................................................................................43

DATA COLLECTION ....................................................................................................44

DATA ANALYSIS .........................................................................................................45

ETHICAL CONSIDERATIONS ....................................................................................46

REFLECTING WITH PARTICIPANTS .........................................................................47

DEVISING AN ACTION PLAN .....................................................................................48

CONCLUSION .............................................................................................................49

CHAPTER FOUR: FINDINGS AND IMPLICATIONS .......................................................50

FOCUS OF THE STUDY ...............................................................................................51

DATA COLLECTION STRATEGY ..................................................................................52

ONGOING ANALYSIS AND REFLECTION .................................................................53

REFLECTIVE STANCE .................................................................................................55

FIELD NOTES ............................................................................................................57

DATA ANALYSIS AND INTERPRETATION .................................................................58

ANSWERING THE RESEARCH QUESTION .................................................................67

ACCESSIBILITY ..........................................................................................................68

METACOGNITION .......................................................................................................69

CONCLUSION .............................................................................................................70
### TABLE OF CONTENTS

**Chapter Five: Conclusion and Action Plan** .................................................................72

**Major Issues to Address Prior to Implementation** ..................................................74

**Key Questions Related to Findings and Implications** .............................................75

**Action Researcher** ....................................................................................................76

**Developing an Action Plan** .......................................................................................78

**Action Plan for the Classroom** ................................................................................82

**Action Plan for the School** ......................................................................................83

**Action Plan for the District** .....................................................................................84

**Facilitating Educational Change** .............................................................................85

**Summary of Research Findings** ..............................................................................87

**Suggestions for Future Research** .............................................................................88

**Conclusion** ................................................................................................................89

**References** ................................................................................................................91

**Appendix A: Field Notes Page** ...............................................................................102

**Appendix B: Participant Scores** .............................................................................103

**Appendix C: Parent Consent Form** .........................................................................104

**Appendix D: Student Consent Form** ......................................................................106

**Appendix E: Evolution Unit Test** ...........................................................................108

**Appendix F: Ecology Unit Test** ..............................................................................113
LIST OF TABLES

Table 4.1 Class Average Scores........................................................................................................54
Table 4.2 Results of 95% Confidence Intervals.................................................................................61
Table 4.3 Average Scores by Gender .................................................................................................61
Table 4.4 Average Scores by Race .....................................................................................................62
Table 4.5 Sample $t$ Test on Gain Scores for Students of Color ......................................................63
Table 4.6 Sample $t$ Test on Gain Scores for Students of Low-SES Backgrounds .................64
Table 4.7 Average Scores by SES ....................................................................................................64
LIST OF FIGURES

Figure 4.1 Difference in gain scores between the ecology and the evolution units of study ........................................60

Figure 4.2 Difference in gain scores for female students between the ecology and evolution units ........................................62

Figure 4.3 Difference in gain scores for students of color between the ecology and evolution units ........................................63

Figure 4.4 Difference in gain scores for students of low-SES backgrounds between the ecology and evolution units .......................65
CHAPTER ONE

INTRODUCTION

The purpose of Chapter One is to describe the action research study that focused on the effect of a virtual learning system (VLS) on 19 ninth- and 10th-grade college preparatory (CP) students’ summative unit exam in an upstate, urban high school in South Carolina. Technology integration is very important to the district; however, knowing how VLS technology is implemented is vital to whether it aids or detracts from the learning process with this local and particular group of CP biology students. These students are comfortable with technology and, at times, require the participant-researcher to provide both remediation and extension for the same course content.

Today’s science students have never known life without computers and daily use of technology. Therefore, it is essential that today’s educators meet their students where they are in terms of technology; however, the focus for public school students remains learning the science content to pass the state standardized test.

The literature shows that incorporating technology as a teaching strategy can provide science students with the opportunity to learn personal responsibility and how to gauge their own learning (Lee, Irving, Pape, & Owens, 2015; Zepeda, Richey, Ronevich, & Nokes-Malach, 2015). For example, Buoncristiani and Buoncristiani (2012) argued that “metacognition is the conscious application of an individual’s thinking to their own thought processes with the specific intention of understanding, monitoring, evaluating, and regulation of those processes” (p. 14). In other words, individuals are conscious of
their own thinking while being active participants in the process of what they are learning or doing. Most universities and businesses today say that students lack the ability to think on their own. For example, in a YouTube video posted by TEDx Talks (2011), Dr. Derek Cabrera argued that the education system produces students who are “very good at doing school, but not good at life because those skills were not transferable” (1:18). He implied that today’s students do not understand how to take personal responsibility or engage in the process of learning. Technology integration into the classroom, which is further discussed in Chapter Two, can be used as a tool to hold students accountable for their own learning.

By providing students with access to online video tutorials, practice tests, guided notes, and online simulations, the extension of the classroom gives today’s science students the opportunity to interact with the material as much as they need to reach mastery. According to Chapman and King (2012), “Self-assessment gives students a sense of ownership and emphasizes immediate feedback” (p. 65). Chapman and King further argued, “When learners are self-assessing they can monitor their own thinking” (p. 59). In return, the technology benefits teachers in knowing exactly where to focus time for remediation.

The present study was an action research study in a science classroom that utilized a VLS, where the participant-researcher explored the impact and effectiveness that these technology tools had in promoting her students’ achievement on summative tests in a CP biology class. The participant-researcher observed that many of her biology students took several days to process the curricular content when she delivered the content in an essentialist pedagogical form of lecture and note taking. For example, her
students were assigned a graphic organizer to demonstrate comprehension of macromolecules 2 days after the lecture. The participant-researcher observed that the majority of her students were not able to remember the lecture in order to complete the organizer without guidance. For many of her students, it took several lectures over several days to understand content information that they were expected to learn for a summative test. Therefore, the participant-researcher worked to prepare a remedial study guide for students to use during class and at home. However, some students need more guidance than what is provided at school. Some students may not have support or someone monitoring their progress at home. Other students may have responsibilities like caring for siblings or working to help provide food and clothing for family members. There are many reasons why students may need more time or flexibility in processing information learned in class.

Several courses, including Biology 1, throughout public schooling in South Carolina have an end-of-course test, and the pacing guide for curricular content delivery requires students to complete the required course content at a particular time. Because of this lack of flexibility with pacing and the amount of content, the participant-researcher has observed that many high school teachers often struggle with finding effective tools that provide students with opportunities, away from the teacher and the classroom, to absorb and interact with content that fits their specific needs. This has led to the exploration of incorporating technology more into the learning process because it gives all students access to a tool for remediation in class along with accessibility outside of the classroom to fit their very busy schedules. The participant-researcher wanted to leverage
technology to provide a more constructivist approach to learning and give her students the opportunity to cultivate habits of self-monitoring and develop decision making.

In today’s classrooms, there are several ways in which the participant-researcher has seen technology integrated into teaching. Some teachers use it for inquiry during class time as an online review, for virtual labs, or for research projects. They combine the use of technology with their current classroom instruction strategies and pedagogical practices. This is known as blended learning. Additionally, some educators have changed their teaching altogether, providing online lectures for students to watch at home in place of the teacher lecturing during the day and then using the face-to-face time in class for collaborative activities or inquiry. This is known as the “flipped” classroom. Tom Driscoll, a social studies teacher, said, “When you leverage technology and take the direct instruction out of the group learning space, the opportunities are limitless” (as cited in Hennick, 2014, para. 15).

The present action research explored a VLS that included video lectures, practice tests, online simulations, the biology Techbook, and review tools as a teaching strategy and extension of the classroom. This research incorporated these tools into a VLS to which the participant-researcher’s students had 24-hour access and that served as an extension of the actual classroom and class content. The VLS did not take the place of instruction in the classroom but was used as a classroom instructional strategy as well as a tool for students to access outside of class during the ecology unit of the action research study. By doing this at White Hall High School, biology student-participants had the opportunity to engage in and work on self-monitoring skills through personal decision making. They revisited material as often as needed, tested themselves, and received
instant feedback. This type of technology integration has been shown to improve understanding and attitudes toward course content (Gedera, 2014; Gulek & Demirtas, 2005; Vickers & Field, 2015; S. Wang, Hsu, Campbell, Coster, & Longhurst, 2014), which is further discussed in Chapter Two.

This study examined the effect of the blended learning environment created by the participant-researcher with the application of a VLS on student achievement on a unit test in a CP biology course. Technology integration is becoming an essential aspect of teaching and learning for students. Incorporating a blended learning model offers both synchronous and asynchronous teaching methods and fosters an environment that extends well beyond the traditional boundaries of the brick-and-mortar classroom setting while enhancing the learning experiences of students. The student-participants at White Hall High School attended class for 90-minute blocks with the participant-researcher every day. The students were provided instruction during that time that included some direct instruction, activities, and use of the VLS for simulations, formative assessments, and online guided notes for the ecology unit of study. The VLS was also used for homework, extra practice, and extension of learning. The VLS was supplemental to classroom instruction and learning and was available for student-participants to revisit complex content by watching videos, accessing notes, or doing extra practice if needed.

To prepare student-participants for the use of the VLS, access was provided to the participants to use the system for units prior to the one tested (ecology) in the study. The student-participants were familiar with the tool and what the VLS had to offer them as far as practice, remediation, and extension of learning. The participant-researcher observed in this CP biology class that the students were motivated to use the technology instead of
traditional means of review, homework, and extension. For example, when the participant-researcher gave student-participants the option to choose a traditional review where they were able to ask questions to the participant-researcher and have direct instruction or to choose the VLS to take an online practice test and then pick a review tool on the VLS when they were through, all the student-participants chose to use the VLS. The participant-researcher was able to monitor their review and offer suggestions regarding their choice of review tool based on their weak areas of content knowledge. The VLS offered a gaming component for students, and it was also accessible on their mobile devices. Student-participants were able to continue their review outside of the classroom with the VLS whereas that was not the case with the first option of review. The blended learning environment gave students a more personalized learning experience to aid in their content mastery and provided a more constructivist approach to teaching and learning.

**Problem of Practice**

The problem of practice identified for the present action research study involved incorporating more progressive strategies for teaching science in one CP biology class. By implementing a VLS at one upstate, urban South Carolina high school, the participant-researcher enabled her students who struggled with understanding complex content for her biology course to have a more personalized learning experience by focusing remediation and practice on areas of weak content knowledge. This identified problem of practice involved exploring VLS technology in a secondary science classroom and its impact on student achievement in one unit of study, ecology, and on the unit summative test. The VLS was implemented by White Hall High School; however,
the VLS had not been formally evaluated in an educational research study in a ninth-grade science classroom.

**Research Question**

What is the effect of the VLS on 19 ninth- and 10th-grade CP students’ achievement on a summative unit test?

**Statement of Purpose**

The primary purpose of this action research study was to explore the relationship between the use of a VLS and student achievement on a unit test in one CP biology class as related to the student achievement on a unit test where the VLS was not utilized in the same CP biology class. The secondary purpose was to explore the VLS as a model to improve the participant-researcher’s own pedagogical practices from a more traditional, essentialist lecture and note-taking approach to a more technology-based constructivist approach.

**Theoretical Base**

Dewey (2004) believed there was interconnectedness between individuals’ education and their own experiences. For many students, the interaction of experiences with certain content only happens at school. It is important for educators to provide students with learning experiences that they can use to help connect with content. Educators must focus on what students already know not as a fixed possession but as an instrument to open new fields of learning that capitalize on the use of memory. Linking new experiences to those that students have already had is crucial in development of concepts and overall learning (Dewey, 2004). Technology integration provides avenues for students to explore content inside and outside of the classroom. Using technology
engages student learning and enhances instructional strategies for the teacher. Furthermore, in the Vygotskian approach, instructional strategies used to scaffold could be prompts, cues, or tools to assist in learning (Vygotsky, 1934/1962).

Technology integration provided in a useful format can be a tool that can be gradually transformed from being teacher guided to become more student guided. This allows the students to begin guiding their own learning and develop habits of self-monitoring. As mentioned previously, students who self-assess monitor their own learning. According to Chapman and King (2012), “Teachers must continually monitor the classroom to find ways to optimize the assessment environment to meet each student’s cognitive and affective needs. The general climate has a direct impact on the learner’s success” (p. 37). By offering formative assessments throughout learning and using the VLS to engage students while at home in practice, teachers enable students to understand their own learning processes. By extending the classroom to include the VLS, teachers enable students to interact with the learning environment at school with guidance from the teachers and then at home with the VLS on their own. These tools can be used to gain more knowledge, building on each content area learned to aid in the mastery of the next skill or topic (Piaget, 1962).

Using action research for this study and providing students with scaffolding through a VLS embraced the theoretical foundations of Dewey (2004), Piaget (1962), and Vygotsky (1934/1962). Students were able to engage in varying activities and extend their own learning while working toward mastering more advanced concepts and skills. The students were able to use the VLS as assistance throughout the learning process. The VLS provided a platform for both the students and the teacher to gauge and reflect on
learning and analyze different strategies for effectiveness. These reflective practices built metacognitive strategies within students and increased motivation for student learning (Aydin, 2016; Zepeda et al., 2015).

**Key Concepts/Definitions of Terms**

*Blended learning:* The use of both classroom teaching and online learning in education.

*Classroom connectivity technology:* A wide-ranging set of technological devices that allow teachers and students to wirelessly communicate using handheld devices.

*Constructivist-learning model:* Theory by Jean Piaget regarding how students learn by interacting with the environment around them and solving complex problems. The students internalizing the process actively construct this learning (Educational Broadcasting Corporation, 2004).

*Digital immigrants:* Individuals born before the rise of digital technologies.

*Digital natives/wisdom:* Individuals born after 1980 whose way of thinking and learning has been changed by technology. Programs that use computers, videos, video games, and social media are all of interest.

*Flipped classroom:* An instructional strategy and a type of blended learning that reverses the traditional educational arrangement by delivering instructional content, often online, outside of the classroom and moves activities, including those that may have traditionally been considered homework, into the classroom. In a flipped classroom model, students watch online lectures, collaborate in online discussions, or carry out research at home and engage in concepts in the classroom with the guidance of the instructor.
**Formative assessment:** A wide variety of methods that teachers use to conduct in-process evaluations of student comprehension, learning needs, and academic progress during a lesson, unit, or course.

**Knowledge society:** The result of information and communication technology (ICT) that has increased the world’s capacity to generate, process, share, and access information for all.

**Learning management system:** A software application used to organize and distribute e-learning materials, assignments, and assessments; track and calculate grades; and facilitate communication among students and teachers.

**Online learning:** A virtual learning environment through a web-based platform for the digital aspects of courses of study, usually within educational institutions.

**Online simulation:** An educational simulation involving the conveying of an online experience in which a learner goes through a sequential or nonsequential experience that models or emulates a real-world experience.

**Scaffolding:** A variety of instructional techniques used to move students progressively toward stronger understanding and, ultimately, greater independence in the learning process.

**Self-regulated learning:** Learning that is guided by metacognition (planning, monitoring, and evaluating personal progress against a standard) and motivation to learn.

**Summative assessment:** Used to evaluate student learning, skill acquisition, and academic achievement at the conclusion of a defined instructional period—typically at the end of a project, unit, course, semester, program, or school year.
Technology integration: The use of technology tools in general content areas in education in order to allow students to apply computer and technology skills to learning and problem solving.

Twenty-first (21st) century skills: As defined in The Glossary of Education Reform,

A broad set of knowledge, skills, work habits, and character traits that are believed—by educators, school reformers, college professors, employers, and others—to be critically important to success in today’s world, particularly in collegiate programs and contemporary careers and workplaces. Generally speaking, 21st century skills can be applied in all academic subject areas, and in all educational, career, and civic settings throughout a student’s life. (“21st Century Skills,” 2016, para. 1)

Virtual learning systems (VLSs): Information-technology-based environments “in which the learner’s interactions with learning materials (e.g., assignments, exercises, etc.), peers, and/or instructors are mediated through” technology (Alavi & Leidner, 2001, as cited in Brookshire, Lybarger, & Keane, 2014, p. 332).

Web-based learning tools (WBLTs): Interactive web-based tools that support and enhance specific content concepts during the learning process.

Potential Weaknesses

The participant-researcher was the main instructor out of four who conceptualized and developed the VLS as a technology solution and tool to be used for student learning. Personal bias and beliefs about the influence of the VLS on student learning and the creative ways of integrating the tool throughout instruction could have impacted the
emphasis that was placed on the instructional tool. However, judgments were set aside throughout the analysis of quantitative and qualitative data from the student-participants.

Another potential weakness in the study was that the participant-researcher had no way of monitoring use of the VLS outside of the classroom. The student-participants communicated use and amount of time spent outside of class utilizing the VLS. Student self-regulation was optional, and reporting may not have been precise.

The following limitations were present in this study: (a) the use of only biology materials in development of the VLS, (b) possible inaccurate reporting by students of use of VLS, and (c) student absences that limited in-class use and instructor modeling of VLS.

**Significance of the Study**

The district the participant-researcher works in is planning to add technology integration strategies into curriculum guides that are provided as instructional tools for all educators. This action research could serve as a model for instructional tools that can be used and developed in other content courses. By using technology to address specific needs of students in content-area courses, educators and schools will be able to provide a more individualized learning experience.

This VLS can also be used to cultivate habits of student self-monitoring while developing decision-making skills for improvement of learning and understanding. Additionally, the VLS has the potential to provide improved equity and access to higher level science courses by targeting achievement gaps in student populations and providing students with experiences to develop the skills and content understanding to be successful. Female students, students of color, and students with low-socioeconomic-
status (SES) backgrounds all improved their summative test scores within the unit that utilized the VLS. Therefore, this potentially can help these subgroups close achievement gaps and enable schools to provide more equity in the technology experiences students have as well.

**Conclusion**

As a result of using technology to leverage student learning, student-participants had positive effects in their achievement and were also able to work on important life skills. The VLS increased student success on a summative test while helping to develop self-monitoring and decision-making skills. Hence, the VLS improved equity and access to the biology course.

The remainder of the study is organized in four additional chapters. Chapter Two contains the literature review. The review examines technology integration and pedagogy that incorporates metacognitive strategies for students as well as curriculum theory. A detailed report describing the setting and the methods used in the present action research study follows in Chapter Three, along with the process for data analysis and reflection on the data in the study. Chapter Four describes the findings of the study and the interpretation of the results. The dissertation concludes with Chapter Five, which includes a plan emphasizing the implications of the study and suggestions for future research.
CHAPTER TWO
LITERATURE REVIEW

Overview

The purpose of Chapter Two is to describe the scholarly literature on the VLS technology. The literature review focuses on two areas. Curriculum theory is explored to provide support for the theoretical framework that informed this study and the use of technology integration as a pedagogical practice. Additionally, the technology is examined as a tool that incorporates metacognitive strategies for student learning. The identified problem of practice for the present action research study was to explore VLS technology in a CP biology classroom with a unit on ecology.

Wisniewski (2010) observed two major learning theories in today’s schools: behaviorist and constructivist. Advocates for the behaviorist learning theory believe that the purpose of educators is to transfer knowledge to students in the form of direct instruction and memorization and then to assess their effectiveness with a summative assessment. The transfer of knowledge is normally done through lectures. In contrast, advocates of the constructivist learning theory believe in a very different approach. Constructivists believe that knowledge is built on prior knowledge and experiences. They also believe real-world connections increase engagement and make learning applicable. The core belief of this form of education is that students play an active role in constructing new knowledge (Wisniewski, 2010). The learning is student-centered.
The VLS took on the constructivist approach to learning by engaging the student-participants to take an active role in the learning of concepts in this biology course. By incorporating a more constructivist approach to teaching, the participant-researcher’s purpose was to explore the relationship between the use of a VLS and student achievement on a summative unit test after experiencing the VLS in one unit of study in a CP biology course.

Technology and innovation are becoming goals for districts while professional development opportunities push teachers to use more innovative technology. The technology use is expected to increase student engagement and help develop college- and career-readiness skills of communication, collaboration, and computer literacy. A recent initiative by Green County School District in the study area has increased the focus of technology integration into the classroom. The initiative pilots one-to-one technology in select schools with the intention of moving to a districtwide policy. The skills needed for existing globalization are rapidly changing, so pedagogy and curriculum must change to ensure equal access to technology and to prepare students to be communication-technology literate.

In the technologically advanced society of today, educational instructors need to incorporate a better variety of ICTs in their daily lessons along with the overall learning experiences students have in their classrooms. The backgrounds and experiences of educators mold and impact the way in which they teach and interact with students. The students are no different. As Chan (2013) explained, “Teachers come to teaching with strong views about some aspects of teaching. These strong views may also be interpreted as ‘biases’ in some situations” (p. 309). The experiences teachers have had in their own
schooling and in their teaching shape what they focus on in their curriculum. Technology was not a part of the learning process for many current educators, so incorporating it into their students’ learning has been difficult. On the contrary, the students do not know life without technology. Technology is and will be a part of their day-to-day lives and careers. The real-world experiences technology can bring to the classroom provide students with opportunities in problem solving and better prepare them for their future careers.

With the vast array of technology options for teachers and the recent focus on technology for professional development by many districts, students are beginning to be exposed to multiple types of technology integration throughout their learning experiences. Teachers are starting to use virtual tours, online simulations, videos, animations, and web-based testing sites, and in combination with all these tools, schools have created VLSs for their students. These interactive courses use many tools to aid in student learning. In an initiative in Canada to improve high school completion rates, innovative technological strategies were encouraged to focus student-centered learning (Daniels, Jacobsen, Varnhagen, & Friesen, 2013). Throughout this initiative, there were barriers that impeded the development of the program. According to Daniels et al. (2013), “Based on the one-size-fits-all perspective, it should not be surprising that some teachers and leaders see the technology as an add-on to their existing workload, rather than an opportunity to rethink practices and learning designs” (p. 6). The teaching and practices must support and leverage technology in a way that learning is the focus of the technology integration. The research on this initiative concluded that the technology integration was not as widespread as the developers had hoped and has not resulted in
systemic change for the students in Alberta, Canada (Daniels et al., 2013). Although the integration was not sustainable for all, there were some very positive changes and pockets of innovation. From this, one can conclude that technology itself is not going to change classrooms, but the innovative strategies teachers implement within their own teaching and learning practices have the potential to engage students as well as transform and enrich their learning experiences. By using both traditional and more innovative practices, educators can find a balance between their own teaching practices and the needs of their students who are a part of this knowledge society.

**Curriculum Theory**

The use of technology can help promote collaboration and provide experiences for students to build critical thinking and problem-solving skills. According to the Partnership for 21st Century Skills (2011), “Students must also learn the essential skills for success in today’s world, such as critical thinking, problem solving, communication and collaboration” (p. 1). Being computer literate is a skill that is vital to many careers in society today. One study conducted in Turkey looked at how science teachers use instructional technologies in their classrooms (Savasci Açikalin, 2014). According to Savasci Açikalin (2014), “Based on the analysis of 63 teachers that had just completed an alternative teaching certificate program, PowerPoint was the most widely used instructional technology in their lesson plans” (p. 197). Students are accustomed to more interactive technology than just looking at presentations, and this cannot be the only form of technology integration in classrooms today. The VLS incorporates more types of technologically advanced strategies like gaming tools and simulations. It also provides
equity and access to all students in helping them build skills that will help them become computer literate.

Technology is also a tool that can help students become more accountable for their own learning by actively participating in the process of learning. In today’s classrooms, technology should be used as a learning tool. Piaget (1962) explained the value of learning by interacting with the environment. According to K. C. Powell and Kalina (2009), “Piaget’s theories celebrate the individual and his or her own personal process to gain knowledge building on experience” (p. 246). These interactions in today’s classrooms are seen as “hands-on” learning experiences “that emphasize the use of physical and, more recently, virtual objects to represent target information and concepts” (Marley & Carbonneau, 2014, p. 1). Dewey (2004) suggested that students should discover for themselves and learn best when lessons are connected to their interests. He believed there was interconnectedness between individuals’ education and their own experiences (Dewey, 2004). For many students, experiences interacting with certain content concepts only happen at school. It is important for educators to provide students with learning experiences that they can use to help connect with content.

Technology integration provides avenues for students to explore content during the school day as well as outside of the classroom. Using technology engages student learning and enhances instructional strategies for the teacher. Furthermore, in the Vygotskian approach, instructional strategies used to scaffold could be prompts, cues, or tools to assist in learning (Vygotsky, 1934/1962). Technology integration provided in a useful format can be a tool that can be gradually removed from being teacher guided to become more student guided. This allows the students to begin guiding their own
learning. As mentioned in Chapter One, students who are self-assessing are monitoring their own learning. According to Chapman and King (2012), “Teachers must continually monitor the classroom to find ways to optimize the assessment environment to meet each student’s cognitive and affective needs. The general climate has a direct impact on the learner’s success” (p. 37). By offering formative assessments throughout learning and using the VLS to engage students while at home in practice, students are able to understand their own learning processes. By extending the classroom to include the VLS, students are able to interact with the learning environment at school with guidance from the teacher and then at home with the VLS. These tools can be used to gain more knowledge, building on each content area learned to aid in the mastery of the next skill or topic (Piaget, 1962).

One of the common threads of constructivism is the idea that development of understanding requires the learner to actively engage in meaning making (Ultanir, 2012). The common core of constructivist theory is that learners do not find knowledge; they construct it (Boghossian, 2006). The VLS created for this research study provided a tool for students to actively engage in their own learning, and the teacher became a facilitator. From this point of view, the task of the educator is not to deliver knowledge directly to students but to provide students with opportunities and incentives to build it up for themselves (von Glasersfeld, 2005).

John Dewey was a major force for progressive education in the United States. His belief that education was to develop the natural ability and potential of each child influenced both Piaget and Vygotsky (Ultanir, 2012). Dewey felt it important for students to be able to model self-directed learning. Piaget built much of his theory by
observing his own children as they learned and played. Piaget’s main focus of constructivism had to do with the individual and how the individual constructs knowledge (Ultanir, 2012). His theory on assimilation and accommodation had to do with the children’s ability to construct cognitively or individually their new knowledge within their stages of development (Piaget, 1973). Recognizing that this process occurs within each individual student at a different rate helps the teacher facilitate constructivist learning. Piaget’s theory of cognitive constructivism incorporates the importance of understanding what each individual does to gain knowledge and learn at his or her own pace (K. C. Powell & Kalina, 2009). By meeting each student where he or she currently is in the learning process and guiding him or her, the students are able to progress to mastery at individual rates. This allows for a more personalized learning experience instead of assuming one size fits all. The VLS provides a platform for an educator in today’s climate to make learning more individualized while teaching in a classroom of 30 students. The VLS also engages the students in their own learning to help develop metacognitive skills.

However, Vygotsky’s (1934/1962) approach was not that individuals learn in stages but rather that social experience shapes the ways of thinking and interpreting the world. Therefore, these social relationships are vital to the learning process because peers and adults construct and transfer knowledge through language to each other by internalizing concepts through self-discovery (Jaramillo, 1996). The interaction between the teacher and the students, the formative assessment feedback provided by the VLS, and use of the technology’s gaming tools all provide social interaction with peers and the teacher to help construct knowledge and content mastery.
Using action research for this study and providing students with scaffolding through a VLS embraced the theoretical foundations of Dewey (2004), Piaget (1962), and Vygotsky (1934/1962). Students are able to engage in varying activities and extend their own learning while assisting themselves in mastering more advanced concepts and skills. The students are able to use the VLS for assistance throughout the learning process. The VLS provides a platform for both students and teachers to gauge and reflect on learning and analyze different strategies for effectiveness. This VLS created by the participant-researcher can be used to cultivate habits of student self-monitoring while developing decision-making skills for improvement of learning and understanding. Students are able to actively participate in the construction of their own knowledge and experiences with course content.

**Importance of Literature**

Today’s students are interested in technology. Technology was being explored as a learning tool as early as the 1960s. PLATO was a computer-based educational system developed at the University of Illinois (Cherian, 2009). It was designed for use with conventional and multimedia learning aids. Individuals or groups of students had access to instructional materials ranging from drill and tutorials to presentations, dialogues, simulations, and games (Cherian, 2009). In 1996, the National Association for the Education of Young Children (NAEYC) released a position statement regarding the use of computers in the early childhood years. NAEYC (1996) did this as a response to the recognition that “technology plays a significant role in all aspects of American life today, and this role will only increase in the future” (p. 1). According to Yelland (2005), “Studies overwhelmingly suggest that computer-based technology is only one element in
what must be a coordinated approach to improving curriculum, pedagogy, assessment and teacher development, and other aspects of school structure” (p. 207). By integrating technology in the classroom, students are able to gain experience collaborating, problem solving, and using critical thinking skills. Yelland noted, “Further, there is an increasing recognition that curriculum decision-making needs to take note of children’s out-of-school experiences and build upon them. Meeting this challenge involves teaching new skills, not simply teaching old skills better” (p. 207).

In the present action research, the importance of this literature review was to establish the need to incorporate technology as a form of blended learning into curriculum as well as explore the effectiveness of technology-based instructional strategies on student achievement. Throughout the present research, the qualitative data were overwhelming in their indication of the improvement of attitudes toward the courses students were taking when technology was integrated. However, the quantitative data were not studied or results were mixed. By reviewing and focusing on the methodologies of others, it was determined that there are gaps in research examining the effectiveness of technology on student achievement using quantitative data. After much research that has centered on how to incorporate different technology strategies into classrooms, the focus of this inquiry was on the blended learning environment. The importance of using technology to aid in learning and how blended learning can extend the classroom outside of the brick-and-mortar buildings seems clear.

In a collaborative action research study on technology integration for science learning, students were asked to complete a research project and present their projects using PowerPoint (C. Wang, Ke, Wu, & Hsu, 2012). Students had to use the Internet to
do their research and could ask questions during class or were able to post on the teacher-researchers’ blogs if they were at home or apprehensive about asking questions in class. C. Wang et al. (2012) concluded, “Their [the students’] engagement in the project revealed their level of enthusiasm for learning” (p. 129). Students who were too shy to ask questions in class were able to ask the professors on their blogs. Other students shared new information collected on the blogs as well. According to C. Wang et al. (2012), “The blog became a space for further discussion in and beyond the class” (p. 129). Leveraging the technology not only engaged the students in and out of class, but it also provided a place for students to get the feedback they needed as well as take part in communicating and collaborating with classmates (C. Wang et al., 2012).

Using technology can allow teachers to reach students outside of the classroom. According to Dwyer (2007), “Information and communication technologies promote a motivating student-centered learning environment for young students, increasing their desire to take part in and experiment in their own learning” (p. 90). Technology also allows the flexibility for students to access materials at times that suit their schedules and responsibilities outside of the school day. Many students in the participant-researcher’s class have jobs, take care of siblings or family members, or are active in extracurricular activities outside of school. Providing flexibility to interact with content provides equity and access.

**Technology Integration and Metacognitive Strategies**

According to N. W. Powell, Cleveland, Thompson, and Forde’s (2012) study on using technology-supported learning strategies, “The prevalence of technology use by students outside of the classroom makes a compelling case for schools to use the latest
ICTs to create technology-supported active learning instructional environments” (p. 46). Today’s students spend more time using technology than they do interacting with each other on a daily basis. According to a national survey conducted by Rideout, Foehr, and Roberts (2010), “8- to 18-year-olds devote approximately seven hours a day to using multimedia technologies outside of the classroom” (p. 4). Students today, from a very early age, immerse themselves in social online networks to gather and share information, collaborate with others across the Internet, and create multimedia-rich content using YouTube and Snapchat. These technology tools can be used in a classroom to engage students in an active learning environment.

Observations and interviews were conducted over a 5-year longitudinal study by Bang and Luft (2013) that investigated the use of technology in secondary science teachers’ classrooms. Ninety-five teachers were studied, and PowerPoint was overwhelmingly the technology of choice. The researchers found that teachers used PowerPoint most frequently compared to lecture and labs. They concluded that technology in science classrooms should be used to enhance inquiry-based teaching and learning (Bang & Luft, 2013). The importance of this study was to increase awareness and show science educators how to incorporate new technologies into the classroom in order to enhance students’ learning experiences.

In 2014, S. Wang et al. conducted a study that compared technology experiences between the students (“digital natives”) and their teachers (“digital immigrants”) in middle school science classes. “This study used a mixed-methods approach to survey and compare” 24 teachers’ and 1,060 students’ inside- and outside-school technology experiences (S. Wang et al., 2014, p. 637). The researchers “conducted focus group
interviews to investigate any barriers that prevented [the use of] technology in school” (S. Wang et al., 2014, p. 637). The results of the study showed that “the concept of digital natives may be misleading and that . . . the lack of sufficient teacher training [in regard to] technology integration strategies” could be the reason for the lack of in-school technology experiences students are having in middle school science (S. Wang et al., 2014, p. 637). This study, along with the previous study, indicates how important teacher training is to implementing the use of technology in the classroom. Educators must know strategies to integrate technology into the learning process.

Chien (2013) studied 12 teachers from the state of Mississippi. All of these educators were pursuing their master’s or specialist degree in educational leadership. The purpose of this study was to review teachers’ resources, knowledge, and skills, and further examine teacher attitudes and beliefs as related to technology and some of the challenges that face teachers. The researcher concluded that technology integration is evident in every aspect of everyday life, and it needs to be integrated in every aspect of the teaching-learning process (Chien, 2013). Teachers have to overcome the challenges and barriers of integrating technology into classroom instruction in order to ensure quality teaching and learning.

There is substantial evidence that incorporating technology of any kind in the classroom as an instructional tool enhances student learning and educational outcomes. Gulek and Demirtas (2005) provided students with laptops and observed an increase in collaborative work, better research skills, greater quantity and quality of writing, and more time spent doing homework. These students were also shown to direct their own learning, readily engage in problem solving and critical thinking, and use technology with
greater ease. Students engaged in decision making and were able to guide their own learning. These two aspects of the technology use in this study are common with the themes discovered in the action research study conducted by the participant-researcher. According to Zepeda et al. (2015), “Improving students’ ability to monitor their task performance might also make them more aware of their own control of learning” (p. 955). By engaging in decision making and guiding their own learning, student-participants were able to practice metacognitive skills for learning. The students using laptops showed significantly higher achievement in nearly all measures after 1 year (Gulek & Demirtas, 2005).

In 2014, Gedera’s study examined students’ experiences of learning in a virtual classroom. Interviews and observations of online activities were done at the beginning and end of the semester with university students who were using Adobe Connect as part of their course assignments (Gedera, 2014). Students felt that having online virtual experiences early in the class was beneficial because it made them feel like they were a part of the class. Relying solely on a distance learning format during this study, students felt frustrated when there were technological problems that disconnected them from the group. They also felt that the online format presented did not allow for enough flexibility for access to content. The structured nature of the course required students to be online at specific times. The students felt that the videos and collaboration were important to the learning of the content, but they wanted more flexibility and unlimited access to the content. Students wanted to be able to access information at convenient times as well as have the opportunity to dialogue with classmates (Gedera, 2014). These studies have shown that integration of technology enhances learning and that having face-to-face
interactions can increase learning outcomes more than just having access to the technology alone. However, flexibility in accessing material is important. Blended learning incorporates all of these factors and was the focus of the current action research study.

A blended learning classroom environment incorporates both traditional methods of learning and online learning. Dikmenli and Unaldi (2013) studied the effect of the blended learning environment on achievement and attitude in a geography course. Results revealed that the blended learning/virtual environment contributed to higher student achievement. The researchers used pretest/posttest data, and students in the blended learning environment scored higher on the posttest than those in the traditional classroom environment. However, the blended learning environment did not affect or change the attitudes of students toward the course. By using both traditional instruction and technology, the researchers were able to leverage the technology to benefit individual student needs (Dikmenli & Unaldi, 2013).

Five universities in Europe undertook an innovative project called Media Culture 2020, and the aim of this project was to break down classroom and campus walls by creating a virtual learning environment. Vickers and Field (2015) concluded that Media Culture 2020 offered an innovative solution to learning and teaching in a collaborative manner. The project was considered a great success among all the partners and especially among the students who took part. The blend of synchronous and asynchronous teaching methods fostered an environment that extended well beyond the traditional boundaries of the classroom setting (Vickers & Field, 2015).
Suprabha and Subramonian (2015) studied how blended learning enhances students’ learning experiences. The purpose of their study was to gain a deeper understanding of the characteristics and methodological perspectives of a blended learning environment in an Indian context. They concluded that blended learning is the most logical and natural evolution of the learning agenda. It maximizes the total impact on students’ learning experiences even though the student achievement is not always higher. The learning experiences the students have are positive (Suprabha & Subramonian, 2015).

Along with scaffolding, technology integration can give teachers assistance in explaining very difficult and abstract concepts to students. According to Kay (2011), “One particular feature of Web-Based learning tools (WBLT) is the use of visual supports to help make abstract concepts more easily understood, often by reducing working memory and cognitive load” (p. 360). For students, learning abstract concepts can be the most difficult. These concepts are harder for students to make connections to, and providing hands-on learning experiences for students can be more difficult for teachers when the topic is something students cannot see for themselves. The WBLTs provide a format to bring to life some very difficult concepts. For example, photosynthesis is an abstract concept in biology that students cannot actually see happening right in front of them. One cannot see oxygen leaving the leaves as a byproduct or carbon dioxide being absorbed by plants. Technology integration can allow students the opportunities to see this process through video, animation, or a guided simulation. Another important feature of WBLTs is the immediate feedback given to students, which can often lead to increased motivation. These two features of WBLTs
were highlighted in the study by Kay in which she examined the effectiveness of WBLTs in middle and secondary school science classrooms. The study found that significant increases in student performance were observed when WBLTs were used. Also, the students even felt that the tools helped them learn. It is important to note that a small group of students felt overwhelmed by the technology (Kay, 2011). As part of the implementation of new technologies into a classroom, it is imperative to the learning process that students know and understand how to use the tools. This allows students to focus on the learning of the content and not on how to maneuver through the WBLTs.

Technology can aid with the learning of abstract concepts, and it can also help to increase the amount of formative assessment in classrooms. Formative assessments can take the form of activating strategies, games students play, or self-guided practice tests. Formative assessments allow both the teacher and the students to gauge learning and look for reteaching opportunities. A study by Shirley and Irving (2015) examined the use of connected classroom technologies (CCTs) as part of the formative assessment process. Four teachers from an initial cohort were identified as demonstrating ongoing use of the TI-Navigator system (the CCT of choice for this study). Perspectives from teachers, students, and outside observers were used to develop “clusters of meaning” related to the formative assessment process (Shirley & Irving, 2015, p. 59). The CCT was found to support the collection and interpretation of student learning evidence, therefore giving the teachers the opportunity to engage in formative assessments. The findings led to the implementation of instructional tasks such as lab activities, led to more informal assessment, and aided in learning before the formal assessment. The CCT helped both the teachers and the students understand student learning, and finally, teachers were able
to make pedagogical decisions on the student needs that were to be addressed (Shirley & Irving, 2015). By incorporating formative assessments into technology use in classrooms, students are engaged and teachers can scaffold and meet student needs. The data collected from formative assessments are critical for both students and teachers in understanding where the students are in the learning process. This helps the students develop metacognitive and decision-making skills.

Technology can offer teachers the flexibility for more formative assessments in classrooms as well as teach them important skills for living in a society engrossed in the use of technology. Florian and Zimmerman (2015) described in their case study how a secondary school integrated skills that are necessary to succeed in a knowledge (21st century) society. Teachers were to focus on using understanding by design, Moodle, and blended learning as models to provide students with the skill development necessary to compete globally. Their conclusion was that students are better served if they are introduced to skills like collaboration, critical thinking, and communication at the secondary level. For students to be competitive in a global marketplace, educators cannot wait until postsecondary school to expose students to these skills (Florian & Zimmerman, 2015).

As previously mentioned, accessibility has been a prevalent issue with integrating technology into academics and curricula. In a study conducted by Greenhow, Walker, and Kim (2010), Internet use among low-income students was examined. The study participants were 852 students from 13 urban high schools in the upper Midwest (56.0% female), who came from families whose incomes were at or below the county median income ($25,000) and participated in Admission Possible, an after-school program that
aims to improve college access for low-income youth. They were administered paper surveys. The response rate was 99.5% (848 of the 852 possible participants). The study showed that 94.0% of students surveyed used the Internet. Far more students used desktop computers (82.9%) than their own laptops (35.5%), cell phones (63.9%), or personal digital devices (7.9%) to go online. Of those surveyed, most students accessed the Internet from home (59.0%) or from school (31.0%). The authors suggested that most low-income students have computers or a device that can access the Internet, but many share those devices with others and therefore are limited in their ability to use the devices for frequent online activities and assignments. Another aspect that can limit frequency of use is the ongoing expense for low-income families to pay for Internet connectivity. Another significant finding was the difference in Internet use between students of different genders. Female students accessed the Internet more from the library (67.7%) than did males (57.7%). Male students used the Internet for playing online games (79.9%) more than females did (62.4%). These findings help teachers understand their student population and their broad experience with Internet-based technologies. Students will not be apprehensive about technology that is introduced into their educational environment and view this integration as essential to their schooling and their learning (Greenhow et al., 2010). The study also indicated that even though low-income students favor technology integration within educational environments, support for less familiar programs should be considered. Teachers may need to provide extra support for students in learning new programs, but these approaches will build on students’ out-of-school experiences with 21st-century skills. The study showed fewer gaps than expected between high-income students and low-income students; however,
teachers must take into consideration that low-income students may have to use public facilities, such as school and libraries, for access to the Internet (Greenhow et al., 2010). Teachers should design activities that take into account programs being used (student familiarity) and duration of technology use to minimize gaps for the low-income students.

Another study done with 5,990 middle school students from 13 school districts across Florida examined differences in student ICT literacy based on SES, ethnicity, and gender (Ritzhaupt, Liu, Dawson, & Barron, 2013). Ritzhaupt et al. (2013) found that students from high-SES backgrounds, female students, and students who identified as White outperformed their counterparts in each of the subsets tested. The study found that females appeared to be more proficient than their male counterparts in ICTs. The researchers did not measure whether males were more advanced than females in playing online computer games. This study also found that students of low-SES backgrounds were less proficient than students of high-SES backgrounds, which was assumed to be because of consistency of use and accessibility (Ritzhaupt et al., 2013). More opportunities are needed for students of low-SES backgrounds to improve their ICT skills because these are vital for future opportunities.

In a study done by Jackson et al. (2008), “a sample of 515 children . . . , average age 12 years old, completed surveys as part of . . . the Children and Technology Project” (p. 437). Of the total sample, “about half [of the children] were male (50.3% and 46.2% respectively)” (Jackson et al., 2008, p. 439). The “children were recruited from 20 middle schools geographically distributed throughout the southern lower peninsula of Michigan [and a]n additional 100 children were recruited from an afterschool center in
According to the researchers, “Findings indicated race and gender differences in the intensity of [information technology] use” (Jackson et al., 2008, p. 437). The study found that Black males used computers far less than any other group. In contrast, Black females led the way in intensity of Internet use, using the Internet more often than did any other group. Children whose parents had more education used computers and the Internet more often. Males played video games more than females did. When it came to cell phone use, “females used cell phones more than did males” (Jackson et al., 2008, p. 440). Black females used cell phones the most, and White males used cell phones the least (Jackson et al., 2008).

In an article by Tawfik, Reeves, and Stich (2016), the researchers examined “persistent inequality issues related to (a) educational access and (b) educational opportunity in the U.S. education system” (p. 598). The article discussed the “intended and unintended consequences of educational technology on social equality” and “how educational technology researchers and practitioners should consider the broader social context in which their work is conducted and the intended and unintended consequences it might have on social inequality” (Tawfik et al., 2016, p. 598). Technology is being leveraged in classrooms to try to help close gaps; however, these interventions may have differential effects favoring already advantaged groups. Literature shows where learning gaps have been addressed and compounded with technology. Therefore, there must be a focus on unequal access to professional development and technology-supported instructional strategies, and accessibility for students must also be explored. Advances in online formats and mobile technology provide new ways to reach a more diverse set of learners (Tawfik et al., 2016).
The technology research is important because the VLS that the participant-researcher created had to be accessible to students in order for them to be able to participate in the formative assessments the VLS provided. When technology is accessible through mobile devices, it lowers the accessibility issue and provides all students with an equal opportunity to use the learning tools. The access to the material also needed to be modeled so that all students were given the same opportunity to interact with the material. The VLS created by the participant-researcher was accessible through any device, computer, or tablet and could be accessed at any time. Students were taught how to use the VLS, and the participant-researcher modeled in class uses of the VLS to prevent disadvantages for the student-participants who may not have had the computer literacy competencies of students with more experience using these tools.

The studies reviewed showed that accessibility and computer use relates to SES, gender, and race. If teachers can leverage the devices available to students (phones, tablets, and personal computers [PCs]) and the use of these devices with curriculum strategies, then they can scaffold for all students. Accessibility for all becomes easier, closing the gap between high-income students and low-income students. Hence, teachers can provide all students with more experience using information technology, improving their learning while targeting their use with programs of interest. Teachers can also provide all students with experience communicating, collaborating, and working with technology, which will be expected for future educational and career opportunities. Providing a VLS that is accessible by any device will allow all students the ability to engage in course materials regardless of SES, race, or gender. The technology tool will
also allow students to practice making decisions about their own learning and developing their metacognitive skills to gauge their own learning.

**Action Research Methodology**

While planning for this action research study, a quantitative research design was determined to be the most appropriate. As stated previously, the study group was one CP biology class in an urban high school in South Carolina that was taught by the participant-researcher. The participant-researcher gathered pretest and posttest data for the unit in which the VLS was implemented and related these data to the data from the pretest and posttest for the previous unit for which the VLS was not utilized as an instructional strategy. The participant-researcher formatively assessed students throughout both units of study and recorded observations on student mastery of content. After reflecting on the formative assessment data, the participant-researcher provided remediation to students who had low content mastery. In the unit for which the VLS was utilized, remediation was provided by the participant-researcher and the VLS. Conversely, in the unit for which the VLS was not utilized, only teacher remediation was provided. Reflecting on the data, the participant-researcher examined the effectiveness of this type of instructional strategy on student achievement.

In this action research study, the study group was given both types of instruction to minimize participant-researcher bias. A simple $t$ test was conducted to analyze the pretest and posttest data, and the results were polyangulated with formative assessment data and teacher observations to explore the impact and effectiveness of the VLS.

This action research study was conducted from November 2016 through January 2017 in one CP biology class. The high school where the research took place is
comprised of ninth through 12th grades; however, ninth graders and one 10th grader made up the enrollment for the biology course studied. The school district is very large and has urban and rural schools. White Hall High School is one of 18 high schools within Green County School District in an urban setting in upstate South Carolina. White Hall High School, where the participant-researcher is a science teacher, has received many awards like Excellent Absolute Rating on the South Carolina Report Card for the past 6 years and more recently received the honor of being named a National Blue Ribbon School. At the time of the study, the size of the student population was approximately 1,642 and included 65% White, 22% Black, 9% Hispanic, and 4% Asian students. Almost 10% of the students qualified for special education services, and 123 students had an English proficiency level less than 5. In addition, 49.76% of students met the school poverty index.

**Conclusion**

By using technology as an innovative strategy to enrich learning, the extension of the classroom should aid in the learning process. The research also indicates that technology used in this manner can offer differentiation to students to allow them to pace individually to reach mastery. Further, the self-guided assessments and multiple strategies of formative assessments encourage students to take ownership of their overall learning experience, make decisions about their learning paths, and increase practice of metacognitive thinking. The integration of a VLS combines aspects of traditional instruction with more innovative experiences for students of the knowledge society of today. The differentiation and hands-on learning experiences provide an avenue for all levels of students to be successful and reach mastery. By incorporating technology into
the learning process instead of using it to replace aspects of the teaching, teachers enable students to extend their own learning beyond what the teachers can do alone. The technology is being leveraged as a learning strategy and not the ultimate answer to curriculum change. Today’s students need experience using technology as a positive and effective tool that aids in the overall learning process and provides experience to develop computer literacies.
CHAPTER THREE

METHODOLOGY

The purpose of Chapter Three is to describe the quantitative action research design used to investigate if the VLS technology impacted ninth- and 10th-grade students’ achievement in one unit of study, ecology, in one CP biology class. Using innovative technology in classrooms is becoming a way to incorporate these strategies into learning (Edwards, 2007; Gulek & Demirtas, 2005; Spires, Lee, Turner, & Johnson, 2008). Research that examined both technology in the classroom and actual strategies for technology was vital in the planning of this action research. The identified problem of practice was to explore if the VLS technology could aid in student achievement in one unit of study by improving test scores as related to a unit of study in which students did not utilize the VLS. The participant-researcher focused on the following research question: What is the effect of the VLS on 19 ninth- and 10th-grade CP students’ achievement on a summative unit test? The primary purpose of this action research study was to explore the relationship between the use of a VLS and student achievement on a unit test in one CP biology class related to the student achievement on a unit test where the VLS was not utilized in the same CP biology class. The secondary purpose was to explore the VLS as a model to improve the participant-researcher’s own pedagogical practices from a more traditional, essentialist lecture and note-taking approach to a more technology-based constructivist approach.
The VLS was a technology-based learning management tool that offered students access to guided notes, video lectures, practice tests, online simulations, flashcards, and their online Techbook. Students could leverage tools of interest outside of class while the participant-researcher further engaged students in the VLS as one of many teaching strategies in the classroom.

**Background of the Problem of Practice**

Integrating technology into curriculum and the learning process is essential for students today. Dwyer (2007) believed, “Information and communication technologies promote a motivating student-centered learning environment for young students, increasing their desire to take part in and experiment in their own learning” (p. 90). Student-centered learning environments are successful in promoting academic success and teaching accountability for student learning (Carlson, 2005). By engaging in the VLS, students received appropriate and immediate feedback throughout the learning process. The students showed personal responsibility for their learning and could focus on the areas of content in which they needed more understanding in order to reach mastery.

Studies by N. W. Powell et al. (2012) and Rideout et al. (2010) both showed the immense amount of time students spend using technology outside of the classroom. This indicates the need to engage students in learning by leveraging their interests in technology use. S. Wang et al. (2014) and Chien (2013) discussed in their studies how important it is for teachers to be properly trained on technology integration. Educators must be able to use the most effective strategies for their students in order to improve student achievement. Using laptops and virtual classrooms is becoming more prevalent;
however, face-to-face interactions can increase learning outcomes more than just having access to the technology alone. By incorporating both into the learning environment, teachers are able to push students beyond what can be done in the classroom alone. Blended learning incorporates both of these teaching strategies. Several studies (Dikmenli & Unaldi, 2013; Suprabha & Subramonian, 2015; Vickers & Field, 2015) researched blended learning, and all showed positive outcomes. The technology offers students scaffolding, visual support, and aid in learning abstract concepts (Kay, 2011). The VLS used in this study connected students to the content outside of the classroom and provided an avenue for self-assessment. The VLS also provided equity and access to the biology course. By providing formative assessments for both teachers and students, the learning process is more tailored to each student’s individual needs.

As previously discussed, this action research study was a quantitative study. A pretest and a posttest were conducted for the two units explored, evolution and ecology. The participant-researcher first gathered the pretest and posttest data from the unit of evolution for which the instruction did not utilize the VLS. The participant-researcher then gave students a pretest for the ecology unit. The participant-researcher incorporated the VLS into classroom instruction and encouraged students to access the VLS outside of school through homework, remediation, and extension. At the end of the ecology unit, the participant-researcher gave students the posttest and analyzed the scores. A simple repeated-measures $t$ test was performed to analyze the data. The simple $t$ test compared the two instructional strategies to determine whether a difference existed between the means of the two summative tests. The differences between the results of the evolution unit test and the ecology unit test along with the formative assessment data and teacher
observations were explored to describe the impact and effectiveness of the VLS in promoting student achievement.

**Positionality**

Prior to conducting the present action research study, the participant-researcher received approval from the Department of Accountability and Quality Assurance in Green County School District. The participant-researcher also was granted an approval/exemption letter for this action research from the University of South Carolina Institutional Review Board upon its review of the rationale for the study, data collection and analysis methodology, and draft copies of documents and letters that were provided to participants and their parents/guardians. Additionally, approval to conduct the research was granted by the participant-researcher’s principal at White Hall High School.

The participant-researcher believes awareness of one’s own personal experiences and bias must be explored in order to understand and teach others. Franco, Gutierrez Ott, and Robles (2013) argued that a leader who values diversity “seeks, respects, and values multiple diverse ideas, opinions, cultural perspectives, experiences and styles to inform decisions for the good of the organization and the community” (p. 98). For schools to address all inequities and give all students the same opportunity for success, there must be a shift toward curriculum containing more diversity and multiculturalism as well as leaders understanding the needs of the diverse populations in their schools. Starratt (2013) argued, “The school is not a social club where people gather for companionship and recreation. The school, instead, is a public institution serving the community, with a mission of educating all children to the best that their ability allows” (p. 62). A school
culture that allows for all students to grow and develop while meeting individual academic needs is important to overall student success.

**Research Design**

The design of the study was guided by Mertler’s (2014) cyclical action research process, which is comprised of four stages: planning, acting, developing, and reflecting. The first part of this process was to identify and limit the topic. In the CP biology course, the participant-researcher has observed that some students struggle with the more traditional teaching strategies of direct instruction and classroom activities alone. The students have had trouble keeping up with the pace of the course and have asked for more time to master the content. In an effort to reach all learning styles, the participant-researcher wanted to explore the impact of technology integration into the learning process. This action research study examined one CP biology class at White Hall High School in the southern United States where the use of technology innovation is in the forefront of the district’s plan for instructional improvement. Strategies for innovative technology integration are a focus for all teachers in the district.

While developing the plan, the first objective of the participant-researcher was to relate the use of the VLS to student achievement measured by performance on summative unit tests, formative assessments, and teacher observations. The second objective was to improve the participant-researcher’s own pedagogical practices by moving from a more essentialist, lecture and note-taking format to more progressive, technology-based instruction.
**Study Participants**

As discussed in Chapter Two, this action research study was conducted from November 2016 through January 2017 in one CP biology class. The high school where the research took place is comprised of ninth through 12th grades; however, ninth graders and one 10th grader made up the enrollment for the biology course studied. The school district is very large and has urban and rural schools. White Hall High School is one of 14 high schools within Green County School District in an urban setting in upstate South Carolina. White Hall High School, where the participant-researcher is a science teacher, has received many awards like Excellent Absolute Rating on the South Carolina Report Card for the past 6 years and won the honor of being name a National Blue Ribbon School.

The study group consisted of 19 students, 11 of whom were male and eight of whom were female. Of the students in the class, four were Black, nine were White, four were Hispanic, and two were biracial. This study group had a higher percentage of Hispanic students than was reflected in the county demographics. Across the county in 2016, 56.5% of children under the age of 18 were White, 32.5% were Black, 8.8% were Hispanic, and 2.2% were biracial (Children’s Trust of South Carolina, 2016). In the study group, on the other hand, 21% of the students were Hispanic and 10% were biracial. In 2016, the county reported 21.5% of students living in poverty (Children’s Trust of South Carolina, 2016). In comparison, in this study group, nine of the 19 students qualified for free and reduced lunch, which signifies the poverty index in schools. In the school and this study group, 47% of students met the poverty index requirement.
Data Collection

A quantitative research design was determined to be the most appropriate for this action research study. As stated previously, the study group consisted of one biology class in an urban high school in South Carolina that was taught by the participant-researcher. The participant-researcher gathered pretest and posttest data for the unit in which the VLS was utilized and related those data to the results of the pretest and posttest for the previous unit for which the VLS was not utilized as an instructional strategy. The participant-researcher also recorded observations in a field-notes journal using formative assessments throughout both units of study. The constant comparative method was used to determine the qualitative data from the formative assessments. The data indicated if there was a relationship between implementing the VLS as a type of teaching strategy and the student achievement on the summative assessments, on the formative assessments, and as identified in teacher observations.

The study group was given both forms of instruction, limiting participant-researcher bias. One unit of study utilized the VLS as an instructional strategy while the previous unit of study did not incorporate the VLS. The pretest and posttest data were polyangulated with formative assessments and the participant-researcher’s observations to describe the impact of the VLS on promoting student achievement. The formative assessments throughout the unit determined where students needed remediation. The field notes taken by the participant-researcher included a list of skills or content that should be mastered for each day (see Appendix A). The observations conducted and the data from the formative assessments aided in remediation by helping the participant-researcher determine the areas of content in which students needed more assistance and
practice in order to reach mastery. For the unit that utilized the VLS, the participant-researcher implemented reteaching opportunities utilizing this instructional strategy. Conversely, for the unit that did not incorporate the VLS, the participant-researcher provided remediation.

**Data Analysis**

The descriptive statistics used were measures of central tendency. The means were calculated for the pretest and posttest that students took during each of the two content areas of the study. As referred to earlier in the discussion on the methodology, one CP biology class was the study group, and the class enrollment was 19 students.

In action research, the goal of inferential statistics is to draw conclusions about the particular study being conducted. In the present study, these statistics allowed the participant-researcher to make judgments that the observed differences between groups were dependable (Trochim, 2006). A simple repeated-measures $t$ test was conducted to compare the pretest and posttest data for each unit of study (Mertler, 2014). Data were disaggregated by race and gender to explore if any significant increases were found in either of these subgroups. The pretest and posttest scores were used to determine if there was a difference between the two instructional strategies used during the action research. The differences in scores between the pretest and the posttest could not prove that the use of the VLS was the only cause for the differences because there are many factors that lead to student achievement, such as time spent in study and use of tutoring. One can only say that the use of the VLS aided in promoting increased student achievement. The analysis of the data allowed the participant-researcher to reflect on the integration of
technology as an instructional strategy and whether the VLS was able to promote student achievement on unit tests and engage students in their own learning.

The student-participants reflected on the data as well. The means of each unit summative test allowed students to examine their averages compared to the other students in the class as well as from unit to unit. Students reflected on the two types of teaching strategies and how they aided in their overall learning. Additionally, they were able to reflect on the use of the VLS as a tool. The participant-researcher and the students discussed the differences in mean scores on an individual level and the differences in mean scores between the two instructional strategies. Student-participants were able to examine their own experiences of how they interacted with the course content on the VLS and engaged in the learning process.

**Ethical Considerations**

The action research study included informal observations, formative assessments, and summative pretests and posttests. Student-participants and parents were given a brief description of the research plan and were asked to give permission to participate. The utilization of the VLS was not a requirement of the course, and the participant-researcher communicated to student-participants that they could not be penalized for not using the online tools. Participants’ identities were protected using a coding method, and data were stored on a password-protected database. Mertler (2014) argued, “An action researcher’s ability to ensure anonymity and confidentiality of participants and their data is a vitally important component of the action research process and of any action research project” (p. 151).
Classroom sets of laptops (Chromebooks) were utilized during class throughout the study period to ensure students had access to the VLS during the school day. However, the VLS was also available for students any time during the day when outside of class or at home. No participants indicated a lack of Internet accessibility outside of the classroom.

**Reflecting With Participants**

As part of the action research study, the students reflected on their individual scores for the evolution unit and related them to their scores for the ecology unit, which utilized the VLS. The reflection on the two summative test scores gave the students the opportunity to analyze their scores and the differences in learning strategies between the two units. Students explored if the VLS aided in their own learning and self-assessment. Students also explored if the VLS engaged them in the content and material along with promoting mastery of concepts. With each student in the study group, the participant-researcher discussed the student’s mean score on each summative test compared to the class mean score and reflected on what the student did for each unit to reach mastery. By reflecting with student-participants on classroom instructional strategies and their personal study strategies, the participant-researcher was able to analyze skills used throughout the learning process. According to Dana and Yendol-Hoppey (2014), “By participating in teacher inquiry, the teacher develops a sense of ownership in the knowledge constructed, and this sense of ownership heavily contributes to the possibilities for real change to take place in the classroom” (p.13). Additionally, through reflection, the student-participants were able to analyze the skills used to aid in their own content mastery.
Devising an Action Plan

All findings will be communicated with other educators at White Hall High School where the research was conducted as well as with personnel in Green County School District, as detailed in Chapter Five. Additionally, this topic can be further explored by providing a survey to students about their attitudes toward the course after the implementation of the VLS. The participant-researcher should interview the students who participated in the study to have them describe what they learned during their reflection on the use of the VLS and how they used it throughout the learning process.

After the completion of this study, one aspect of the action plan is to try to implement similar action research studies in other classes to explore if the technology integration lends itself better to certain content areas. The reflection on the current study allows for the opportunity to change and improve on the methodology and examine areas that were limited by this action research study. Some limitations are that the study was only conducted in biology and that there may be added materials that can be included in the VLS depending on the content areas. Also, the district is planning to add technology integration strategies into curriculum guides that are provided as instructional tools for all educators. This action research study can be presented to Green County School District as one model of technology integration. Dana and Yendol-Hoppey (2014) stated, “As a teacher researcher engages in the process of inquiry, their thinking and reflection are made public for discussion, sharing, debate and purposeful educative conversation” (p. 23). These strategies can be helpful for other classroom teachers and students, especially if more content areas are studied using a VLS created for their particular courses.
Conclusion

By sharing the results of the integration of the VLS, what was learned, and reflection on student outcomes, the action research becomes an example of practice for others to learn and innovate. The problem of practice develops the tool for students to use while they are learning and provides a model for a more progressive, technology-based instructional strategy. By having flexibility to engage in their own learning, all students have access to tools to improve and be successful.
CHAPTER FOUR

FINDINGS AND IMPLICATIONS

The action research study explored if the VLS technology could aid in student achievement by improving test scores in one unit of study as related to a unit of study in which students did not utilize the VLS. According to Mills (2010, as cited in Devlin, Feldhaus, & Bentrem, 2013), “Action research is any systematic inquiry conducted by teacher researchers, principals, school counselors or other stakeholders in the teaching/learning environment to gather information about how their schools operate, how they teach and how well their students learn” (p. 40). The participant-researcher focused the present systemic inquiry on the effect of the VLS on 19 ninth- and 10th-grade CP students’ achievement on ecology unit summative examinations. The primary purpose of this action research study was to explore the relationship between the use of a VLS and student achievement on a unit test in one CP biology class as related to the student achievement on a unit test where the VLS was not utilized in the same CP biology class. The secondary purpose was to explore the VLS as a model to improve the participant-researcher’s own pedagogical practices from a more traditional, essentialist lecture and note-taking approach to a more technology-based constructivist approach.

Implications of the findings suggest that student-participants increased their summative test scores with higher gains when the VLS was utilized as an instructional strategy. Some themes that emerged once the data were analyzed were that females,
students of color, and students with low-SES backgrounds had significantly different gains whereas White, male, and middle-class participants’ scores were not significantly different. Field notes indicated that the pattern of results from formative assessments created more of a bell-shaped curve with averages in the unit with the VLS instead of being more polarized as seen in the evolution unit in which the VLS was not utilized. This indicated to the participant-researcher that students progressed at different rates with the utilization of the VLS. However, all student-participants were able to discuss their learning with the participant-researcher and analyze how the VLS aided in their content mastery. They were also able to reflect on whether they self-assessed throughout the unit by utilizing the VLS in contrast to the evolution unit, which did not incorporate the VLS into instruction.

Focus of the Study

The focus of this study was to explore and describe the relationship between the use of a VLS and student achievement on a unit test in one CP biology course as related to student achievement on a unit test for which the VLS was not utilized. The participant-researcher also explored the VLS as a model for these students to engage in their learning and to improve the participant-researcher’s pedagogical practices. The VLS took the constructivist approach to learning inspired by Piaget (1962) and Vygotsky (1934/1962) by engaging these students to take an active role in the learning of concepts in the biology course. Teachers who incorporate technology in classrooms generally have a constructivist approach to teaching (Gulek & Demirtas, 2005).

Students who are given assignments that provide them with the opportunity to observe, evaluate, communicate, model, research/investigate, and document success/
failure are often self-directed and engaged (Koch & Sanders, 2011; Williams, 2000). The VLS technology gave students the opportunity to explore these skills throughout their learning. For example, students were assigned a simulation in which they were required to observe and evaluate data on how different levels of greenhouse gases affected the temperature within a given environment. Students were able to manipulate the data and were required to make predictions based on their current knowledge of greenhouse gases and their effect on temperature.

Once students completed both units of study and were able to reflect on their own learning as well as discuss the mean scores of their summative tests with the participant-researcher, they were able to explore how they engaged in the technology throughout the learning process and how it aided in their content proficiency.

**Data Collection Strategy**

A quantitative research design was implemented for this action research study. As stated previously, the study group consisted of one biology class in an urban high school in South Carolina that was taught by the participant-researcher. The study group consisted of 19 ninth- and 10th-grade students who were tested during the months of November 2016 through January 2017. This class met daily from 10:20 a.m. to 11:55 a.m., and all data were collected during class meeting times. The participant-researcher gathered pretest and posttest data from teacher-made tests for the unit in which the VLS was utilized and related those data to the results of the pretest and posttest for the previous unit for which the VLS was not utilized as an instructional strategy. The participant-researcher also recorded observations in a field-notes journal using formative
assessments throughout both units of study. The field notes taken were used to “polyangulate” (Mertler, 2014, p. 42) the quantitative data set.

**Ongoing Analysis and Reflection**

The study group started with 19 students; however, two dropped out during the study. One student in the study group was absent for 2 weeks of class and was not able to take the pretest for ecology. Another student was absent for 5 days and was not able to make up the posttest for ecology. Therefore, the study group consisted of 17 participants after two dropped out due to absences. Despite their absences, those two students continued to utilize the VLS during instruction; however, because the data collected were incomplete, they had to be removed during analysis. The data indicated if there was a relationship between the use of the VLS as a type of teaching strategy and the student achievement on the summative assessments, on the formative assessments, and as identified in teacher observations.

For the evolution unit, the pretest was given on the first day of the unit. The class mean was failing (9/20, or 45%; see Table 4.1), which was to be expected given that the majority of students in the class had not been taught evolution in previous science courses. However, three of the 17 students did pass the pretest with a score of 60% or above. The posttest was given on the last day of the unit, and 14 of the 17 students passed with a score of 60% or higher (see Appendix B). The mean score was 15/20, or 75% (see Table 4.1). Throughout the unit, field notes were taken on formative assessments. The participant-researcher used the field notes and formative assessment data to focus on weaknesses and reteaching opportunities. This unit did not incorporate the VLS as part of instructional strategies used by the participant-researcher.
Table 4.1 Class Average Scores

<table>
<thead>
<tr>
<th>Unit</th>
<th>Pretest mean score</th>
<th>Posttest mean score</th>
<th>Gain score mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolution</td>
<td>9/20</td>
<td>15/20</td>
<td>5.41</td>
</tr>
<tr>
<td>Ecology</td>
<td>8/20</td>
<td>16/20</td>
<td>6.76</td>
</tr>
</tbody>
</table>

The ecology unit pretest was administered on the first day of the unit, and only one of the 17 students who took the pretest scored 60% or higher. The mean score was 8/20, or 40% (see Table 4.1). Throughout the ecology unit, the participant-researcher utilized the VLS in the classroom as part of the instruction and gave assignments through the VLS as well as encouraged students to actively engage in the VLS outside of classroom instruction. The posttest data showed that of the 17 students who completed the pre- and posttest, 15 scored 60% or higher with a group mean of 16/20, or 80%. The two students who did not have a passing score earned 11/20, or 55% (see Appendix B).

The field notes recorded throughout the study aided in providing the participant-researcher with the opportunity for reflection. Upon reflection on the field notes, the participant-researcher was able to conclude that not all students were utilizing the VLS to prepare for the concepts being taught, but most were using it to catch up or reinforce material. Students had work done for concepts discussed but did not work ahead. For instance, students were instructed to copy notes and watch a video on material that was to be taught. Of the 19 students in the course, only nine had actually done that. The other 10 just waited to do it in class. The students appeared to lack motivation to use the VLS technology as a way to engage their learning and build on their own prior knowledge before being taught by the teacher. The students were used to an essentialist approach to learning where they were the passive consumers of knowledge (Schramm-Pate, 2014).
The researcher concluded that at this point in the research, the VLS was not seen as part of the learning process but rather as a homework tool or a reference tool for missed work. Therefore, the VLS had to be utilized in such a way that modeled for the students during class how it could provide them with ongoing formative assessments throughout their learning. The VLS had to be modeled for the students as a tool to suggest how students could evaluate where they had individual learning opportunities. The participant-researcher would then be able to observe any trends in the areas of weakness for the entire study group. The participant-researcher decided to implement the VLS throughout classroom instruction so that students would know how to utilize the multiple formative assessment tools outside of class.

**Reflective Stance**

The data collection strategies remained the pretest and posttest; however, the amount of time between the pretest and posttest for the ecology unit was longer than the participant-researcher anticipated. This was determined through the field notes and the feedback student participants were providing in their formative assessments. Through the action research process, the participant-researcher determined that the students were not as easily engaged in the VLS as predicted. For instance, one student suggested that she did not need to use the VLS at home because she already had her assignment done. She said, “I don’t need to review; the test is not until next week,” and another student said, “I will wait until the study guide is given to see what I don’t understand.” Students were not engaging in the learning process throughout the unit. The participant-researcher concluded that the mentality of the students was to wait to the last minute, cram for the test, and hope all worked out. Many contributing factors to procrastination have been
identified in the research literature, including feelings of being overwhelmed, a lack of motivation, perfectionism, and poor time management and organizational skills (Burka & Yuen, 1990; Milgram, Marshevsky, & Sadeh, 1995; Rothblum, Solomon, & Murakami, 1986; Solomon & Rothblum, 1984). Instead of formatively assessing themselves, the students were waiting for the participant-researcher to do it for them.

For many of the students, their prior learning experiences had been with a more essentialist curriculum and pedagogy where the teacher directs most of the learning. They had not been taught or modeled the skills to take control of their own learning, make meaning, or relate the material to their own and real-world experiences. The participant-researcher concluded that she had to model the different uses of the VLS throughout the unit of study so that the students would know how to practice and engage in their learning on their own. As the unit of study progressed, the students became better at utilizing the VLS during the learning process and would play games, take practice quizzes, revisit notes, and watch videos outside of class to extend learning instead of just catching up on missed work. One student said, “I took a 10-question quiz on this last night, and I know exactly what I don’t understand.” Another student asked the participant-researcher to go back over the concept of ecological restoration because he did not understand the process and how it tied into ecosystem dynamics. The participant-researcher noted that students began participating in class, helping each other, and providing enriched dialogue because of utilizing the VLS.

As discussed previously, the field notes indicated that the pattern of results from formative assessments created more of a bell-shaped curve with averages in the unit with the VLS instead of being more polarized as seen in the evolution unit in which the VLS
was not utilized. This indicated to the participant-researcher that students were progressing at different rates with the utilization of the VLS and that the progression was more individualized. Conversely, this was not noted in the field observations during the evolution unit, which did not utilize the VLS. Student participants either understood the concepts or they did not. The participant-researcher concluded that the students were further in the learning of the concepts as the unit on ecology progressed than noted previously in the evolution unit where the VLS was not utilized. During the ecology unit, the participant-researcher asked the students if they felt the VLS was helping them with the content. The participant-researcher noted that three students said, “I do not know,” and one student replied, “I like that I can decide what topics I want to review instead of just doing what the teacher gives for homework.” Another student suggested, “We should choose our own homework, and you [teacher] should just have a certain number of activities required.” Students began to engage in metacognitive thinking because they were examining the connection between what they knew, what activities they did on the VLS, and where they were in their learning. Metacognitive students actively decide how to use resources effectively and make judgments about outcomes and learning (Pintrich, 2000).

**Field Notes**

The field notes contained observations regarding formative assessments, the daily progress students were making throughout the unit, and the participant-researcher’s observations of the students’ engagement in the tasks of each unit. The gap that was noticed in the field notes was that they did not provide insight on the perceptions of the students. Student quotes were recorded that indicated student preferences, such as “I like
this better” and “the video makes more sense to me than the notes,” but further discovery on what this meant to the learning of the content or how the students perceived the activities to aid in understanding was not noted. As discussed previously, students enjoyed the aspect of choice and freedom to explore what they wanted, but the field notes only expressed the beginnings of students’ engaging in metacognitive thinking. Some additional data that should be examined are the students’ perceptions of how they engaged in self-assessing. Student perceptions were not a part of this study but were important to include in the action plan. Being able to explore the student-participants’ perceptions of their own learning throughout both units will aid in the understanding of their progress in monitoring their learning and metacognitive skills. The participant-researcher believed the VLS was helping the students; however, some new questions arose about whether students were recognizing where they were in the learning process and if they were targeting their formative assessment tools to further help address specific areas of need. Experiences of deep engagement are dependent on the level of challenge in the environment and one’s perceived skills and resources being in balance with one another so that the individual perceives the demands and resources of a task as being in alignment with his or her own strengths and weaknesses (Blascovich, Mendes, Tomaka, Salomon, & Seery, 2003).

**Data Analysis and Interpretation**

This action research study was a quantitative study that examined pretest and posttest data (see Appendix B) while using the constant comparative method to determine the qualitative data from the formative assessments. The exam data consisted of a test
score comparison between the pretest and posttest, which determined the gain scores for each unit of study.

The qualitative data were comprised of field notes taken by the participant-researcher throughout the two units of study. The key findings revealed that (a) the VLS aided in student learning by producing higher gain scores in the unit in which it was utilized; (b) there was a significant difference in gain scores for females, students of color, and students with low-SES backgrounds; (c) students began making their own decisions and monitoring their progress through the use of the VLS; and (d) students were better prepared for class, allowing the participant-researcher to address student comprehension and misconceptions instead of practice.

**Quantitative Data**

Student success was measured using gain scores between pretest and posttest summative assessments for each unit of study. The first unit of study was on evolution. This unit did not utilize the VLS but was taught using formative assessments, activities, and labs throughout. The gain scores for the evolution unit ($M = 5.4$, $SD = 0.76$) were lower than the gain scores for the ecology unit ($M = 6.8$, $SD = 0.55$), which utilized the VLS. A graphical comparison (see Figure 4.1) of the exam score descriptive statistics also illustrates the difference between student achievement in the ecology unit, which utilized the VLS, and student achievement in the evolution unit, which did not.

Figure 4.1 indicates that the majority of students had a 2.00- to 4.00-point gain when the VLS was utilized. The confidence interval (see Table 4.2) suggested that students gained between 0.00 and 2.72 more points on the summative test when using the VLS in relation to when the VLS was not utilized. Confidence intervals were also
computed to determine the increase in scores between the pretest and posttest for each of the units of study.

![Difference in Gain Scores Between Units](image)

**Figure 4.1** Difference in gain scores between the ecology and the evolution units of study

The confidence intervals (Table 4.2) suggested that the upper limit of the gain scores was higher for the ecology unit, as was the lower limit. For the ecology unit (which utilized the VLS), the gain score increase was on average 5.6-7.8 points, and the evolution unit (which did not utilize the VLS) gain score increase was on average 3.8-7.0 points. Therefore, the majority of students had gains in each unit; however, the gains for the ecology unit, which utilized the VLS, were higher than the gains for the evolution unit. Further, when subgroups were analyzed, there were significant differences in gains for females, students of color, and students of low-SES backgrounds.
Table 4.2 Results of 95% Confidence Intervals

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample mean</th>
<th>Std. error</th>
<th>df</th>
<th>Lower limit</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolution gain scores</td>
<td>5.4117647</td>
<td>0.75760276</td>
<td>16</td>
<td>3.8057186</td>
<td>7.0178108</td>
</tr>
<tr>
<td>Ecology gain scores</td>
<td>6.7647059</td>
<td>0.54590327</td>
<td>16</td>
<td>5.6074426</td>
<td>7.9219691</td>
</tr>
<tr>
<td>Difference in gain scores</td>
<td>1.3529412</td>
<td>0.64705882</td>
<td>16</td>
<td>-0.01876225</td>
<td>2.7246446</td>
</tr>
</tbody>
</table>

**Female students.** Female students had higher gain scores between the ecology unit and the evolution unit (see Table 4.3). The female participants’ gain score difference was indicated by the higher mean in the ecology unit, which utilized the VLS ($M = 2.3$, $SD = 1.08$). The $p$ value ($p < .03$) indicates that the female student participants had greater gains when the technology was used as one of the instructional strategies. The distribution of gain scores (Figure 4.2) indicates that the majority of female participants gained a minimum of 2.0 points more with the utilization of the VLS.

Table 4.3 Average Scores by Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Sample size</th>
<th>Evolution pretest mean score</th>
<th>Evolution posttest mean score</th>
<th>Gain score mean</th>
<th>Ecology pretest mean score</th>
<th>Ecology posttest mean score</th>
<th>Gain score mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>7</td>
<td>10/20</td>
<td>14/20</td>
<td>4.43</td>
<td>8/20</td>
<td>16/20</td>
<td>6.71</td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
<td>9/20</td>
<td>15/20</td>
<td>6.10</td>
<td>9/20</td>
<td>15/20</td>
<td>6.80</td>
</tr>
</tbody>
</table>

**Students of color.** Students of color showed gain scores that were also significantly different. Students of color ($n = 10$) were differentiated from students who identified as White ($n = 7$).
Figure 4.2 Difference in gain scores for female students between the ecology and evolution units

The largest gains within the different groups of students of color were made by the students who identified as Black (see Table 4.4). Their average gain was 3.25 points between the ecology and evolution units. The gain distribution of the student-participants identifying as Black can be seen in Figure 4.3.

Table 4.4 Average Scores by Race

<table>
<thead>
<tr>
<th>Race</th>
<th>Sample size</th>
<th>Evolution pretest mean score</th>
<th>Evolution posttest mean score</th>
<th>Gain score mean</th>
<th>Ecology pretest mean score</th>
<th>Ecology posttest mean score</th>
<th>Gain score mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>7</td>
<td>9/20</td>
<td>16/20</td>
<td>7.10</td>
<td>8/20</td>
<td>15/20</td>
<td>7.40</td>
</tr>
<tr>
<td>Black</td>
<td>4</td>
<td>11/20</td>
<td>15/20</td>
<td>3.50</td>
<td>10/20</td>
<td>17/20</td>
<td>6.75</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4</td>
<td>8/20</td>
<td>13/20</td>
<td>4.50</td>
<td>9/20</td>
<td>14/20</td>
<td>5.50</td>
</tr>
<tr>
<td>Biracial</td>
<td>2</td>
<td>11/20</td>
<td>16/20</td>
<td>5.00</td>
<td>8/20</td>
<td>18/20</td>
<td>7.00</td>
</tr>
</tbody>
</table>
Six of the 10 students of color made gains of 2-4 points with one making a 6- to 8-point gain. The statistical difference ($p > .007$) between the gain scores is noted in Table 4.5.

**Table 4.5 Sample $t$ Test on Gain Scores for Students of Color**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample mean</th>
<th>Std. error</th>
<th>df</th>
<th>$t$ stat</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in gain score</td>
<td>2.1</td>
<td>0.6046119</td>
<td>9</td>
<td>3.4733024</td>
<td>.007</td>
</tr>
</tbody>
</table>

**Students of low-SES backgrounds.** Students of low-SES backgrounds also showed a difference in gain scores between the ecology and evolution units ($M = 1.5$, $SD = 0.74$, $p > .03$; see Table 4.6). Students of low-SES backgrounds had on average a
2.1-point score increase between the ecology and evolution units whereas student-participants of high-SES backgrounds gained on average 1.0 point (see Table 4.7).

Table 4.6 Sample t Test on Gain Scores for Students of Low-SES Backgrounds

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample mean</th>
<th>Std. error</th>
<th>df</th>
<th>t stat</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in gain score</td>
<td>1.5</td>
<td>0.74366007</td>
<td>11</td>
<td>2.0170506</td>
<td>.0344</td>
</tr>
</tbody>
</table>

Table 4.7 Average Scores by SES

<table>
<thead>
<tr>
<th>SES</th>
<th>Sample size</th>
<th>Evolution pretest mean score</th>
<th>Evolution posttest mean score</th>
<th>Gain score mean</th>
<th>Ecology pretest mean score</th>
<th>Ecology posttest mean score</th>
<th>Gain score mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>12</td>
<td>9/20</td>
<td>15/20</td>
<td>5.54</td>
<td>9/20</td>
<td>16/20</td>
<td>7.00</td>
</tr>
<tr>
<td>High</td>
<td>5</td>
<td>10/20</td>
<td>15/20</td>
<td>5.80</td>
<td>7/20</td>
<td>14/20</td>
<td>6.80</td>
</tr>
</tbody>
</table>

*Note. Low SES is identified as students qualifying for free and reduced lunch.*

The score distributions are shown in Figure 4.4. Half of the students of low-SES backgrounds had a gain score between 2.0 and 4.0 points, and two students gained more than 4.0 points.

Each of these subgroups—females, students of color, and students of low-SES backgrounds—made gains between the pretest and posttest when the VLS was utilized as an instructional strategy.

**Qualitative Data**

Throughout both units of study, formative assessments were administered to all student-participants, and observations were made by the participant-researcher in the form of field notes. The participant-researcher indicated previously that the field notes suggested that students in the evolution unit either understood the content or they did not.
Based on daily formative assessments, the participant-researcher noted multiple reteaching opportunities because students failed to pass the daily quizzes, could not complete a graphic organizer, and did not understand how to analyze data from a lab. For instance, during the adaptations lab, the participant-researcher noted there was little motivation among student-participants to stay on task. Motivation for science is the strongest predictor of achievement-related choices and performance (Wigfield, Tonks, & Klauda, 2009). The participant-researcher spent class time practicing with students on topics already discussed and helping students understand where their misconceptions were inhibiting their learning. Students were not engaging in the material outside of class.
However, the unit with the VLS was much different. Field notes indicated a slow start for the students because they were not accessing the VLS outside of class. The participant-researcher recognized this in the formative assessments given in the first few days of the unit. As a result, the participant-researcher had to reevaluate how the VLS was being utilized during class time to model for the students different ways of self-assessing. Implementation of technology is vital to the success it has in the learning process (Heemskerk, Brink, Volman, & ten Dam, 2005; Obi, Obiakor, & Graves, 2016; Ritzhaupt et al., 2013). The participant-researcher provided modeling to ensure equity in computer literacy competencies. The participant-researcher was not sure if students were not accessing the VLS outside of class because they did not know how or because they were not motivated to do so. Once students were able to see different uses of the VLS that were modeled by the participant-researcher, they were more familiar with what to do without the teacher present. They were also able to practice their computer competencies with the participant-researcher during class time so that they could ask questions and learn how to access the different materials. Students were able to use the VLS during class time and then choose activities to extend their learning from home based on self-assessment during class. By the middle of the unit, the participant-researcher noticed that the results of formative assessments in class were much less polarized and resembled a more bell-shaped curve. The participant-researcher concluded that the students were progressing at an individual pace, and she could evaluate better which students needed more assistance. Metacognitive practices and self-assessment techniques help learners become more independent and self-regulated in their learning (Nair, 2014). Additionally, students were recognizing in what areas of content they needed further understanding.
For example, the participant-researcher noted that a student said, “I know exactly what I need to study.” The field notes were evaluated using the constant comparative research method, and the participant-researcher concluded that the VLS aided in student learning once the students were taught how to utilize the tool.

**Answering the Research Question**

The primary purpose of this action research study was to explore the relationship between the use of a VLS and student achievement on a unit test in one CP biology class as related to the student achievement on a unit test where the VLS was not utilized in the same CP biology class. The VLS served as an instructional intervention for the participant-researcher to explore a more student-centered learning experience and its effect on student learning. The VLS enabled the student-participants to monitor their own learning throughout the ecology unit by accessing formative assessment tools in a synchronous and asynchronous environment. Student-participants were able to choose which platforms of learning they wanted to participate in outside of class, such as gaming tools, video lectures, online practice tests, or other online study tools accessed via the VLS.

The research question focused on what effect the VLS had on the CP students’ achievement on a summative unit test. According to the quantitative data, the student-participants had significantly different gain scores on the summative assessment for the unit in which they utilized the VLS as related to the summative assessment gain scores for the unit in which they did not access the VLS technology. The qualitative data that were analyzed using the field notes taken by the participant-researcher further suggested that students engaged in their learning throughout the unit with the use of the VLS during
Many of the students also engaged in the VLS as a tool for extension outside of class. One explanation for why the gain scores were higher for the unit that utilized the VLS could be that students wanted to use technology and enjoyed the choice it provided for them (Evans & Boucher, 2015).

Diversity (race, gender, and SES), technology, and innovation in education will prepare students for the multicultural, interdependent world they live in. According to Obi et al. (2016), “Harnessing human diversity effectively can have major implications for the advancement of science and society” (p. 3). Technology can be a powerful tool for investigation, problem solving, and creative expression. Instructional strategies that include technology create highly sophisticated learning environments in which both products and knowledge are constructed while being sensitive to each learner’s needs in an economically acceptable manner (Heemskerk et al., 2005; Li, 2008). Technology can be used as an assessment tool to help teachers monitor progress, and it can be used as a motivational tool for students. It has the potential to reach all students at all levels.

**Accessibility**

The VLS showed a difference in achievement for female students, students of color, and students of low-SES backgrounds but not for male students, students who identified as White, or students with high-SES backgrounds. One explanation could be that the accessibility of the technology was no longer a factor for certain subgroups of students. The students used the VLS during class. However, the VLS could also be leveraged through tablets, PCs, and smartphones, and the participant-researcher offered time in the morning and afternoon each day during the study period for students to come for extra practice. Advances in online formats and mobile technology provide new ways
to reach a more diverse set of learners. When technology is accessible through mobile devices, it minimizes the accessibility issue and provides all students with equal access to the learning tools (Tawfik et al., 2016). Because all students were able to access the VLS at different times throughout the learning period and when convenient to their diverse schedules and responsibilities, the learning gap was decreased. The assessment scores of the study group were moved more toward the center, showing the potential for student success. When integrating technology into classroom learning, it is important to know ahead of time some of the issues that may prevent students from accessing the technology. Sometimes, teaching students how to use technology and modeling the uses of the instructional strategies are the most important aspects of the implementation process (Warschauer, Knobel, & Stone, 2004).

**Metacognition**

Finally, students who engaged in the VLS were able to focus on their own learning needs or desires. Students were able to practice what they wanted or what they felt they needed help in reviewing. This began to engage students in metacognitively assessing what they wanted to explore in the course content. Aydin (2016) stated,

> Teachers can increase students’ metacognitive awareness by means of effective problem solving strategies and scientific discussions. This provides two benefits:

1) the teacher conveys the responsibility to students to watch their learning, and

2) students develop positive self-perception and motivation. (p. 54)

Because students could choose their practice activities while discussing what they thought they should do with the participant-researcher, they may have had a more positive experience, providing motivation for learning. The push toward providing a
more personalized learning experience to students has highlighted “the importance of autonomy to instructional design” (Evans & Boucher, 2015, p. 88). This has led to increasing emphasis on enabling students to take [a more] active role in their [own] learning. This [can be] reflected in instructional practices that focus on allowing students to set their own goals, make choices around their learning activities, and base decisions on self-identified needs and preferences (Schunk, 1992). (Evans & Boucher, 2015, p. 88) Such practices are based on a growing recognition that students must be given opportunities to experience autonomy to enhance their intrinsic motivation to engage in learning activities. Evans and Boucher argued, “When students feel autonomous, they are more likely to see the value in a given learning task and thus become engaged in the activity (Deci, Ryan, & Williams, 1996; Grolnick, Ryan, & Deci, 1991)” (p. 88).

Conclusion

The problem of practice for this action research study explored if the VLS technology could aid in student achievement in one unit of study by improving test scores as related to a unit of study in which students did not utilize the VLS. The quantitative data discussed showed a difference in gain scores between the unit in which students did not utilize the VLS (evolution) and the unit in which the participant-researcher did implement the VLS as an instructional strategy (ecology). The gain scores were on average about 1.4 points higher for the ecology unit. In particular, subgroups such as female students, students of color, and students with low-SES backgrounds increased their gain scores, indicating that the VLS aided in improving test scores. However, this was not the case for male students, White students, and students of high-SES
backgrounds; the VLS did not show a great difference in gain scores between the two units for these particular subgroups. Hence, the VLS aided in student achievement of the study group as a whole, but there was a more significant difference for certain subgroups. Upon analysis of the field notes, the participant-researcher was able to help the students understand how to use the technology and reflected with them throughout their learning in the unit. This could have influenced the growth the students made in this unit. The intervention changed the way the participant-researcher formatively assessed students and provided them with more individualized feedback. The pedagogical practices were different, and the VLS was the tool that prompted those interactions. This, too, could be the reason for the increase in gain scores between the two units of study.

By focusing on the implementation of the VLS and how it related to the student test scores, the participant-researcher noticed several themes through the analysis of the data. The key findings revealed that (a) the VLS aided in student learning by producing higher gain scores in the unit in which it was utilized; (b) there was a significant difference in gain scores for females, students of color, and students with low-SES backgrounds; (c) students began making their own decisions and monitoring their progress through the use of the VLS; and (d) students were better prepared for class, allowing the participant-researcher to address student comprehension and misconceptions. These factors are important to overall student achievement and success as well as the pedagogical practices of educators.
CHAPTER FIVE

CONCLUSION AND ACTION PLAN

The research study focused on the identified problem of practice, which was to explore if the VLS technology could aid in student achievement in one unit of study by improving test scores as related to a unit of study in which students did not utilize the VLS. The participant-researcher focused on the following research question: What is the effect of the VLS on 19 ninth- and 10th-grade, CP students’ achievement on a summative unit test? The primary purpose of this action research study was to explore the relationship between the use of a VLS and student achievement on a unit test in one CP biology class as related to the student achievement on a unit test where the VLS was not utilized in the same CP biology class. The secondary purpose was to explore the VLS as a model to improve the participant-researcher’s own pedagogical practices from a more traditional, essentialist lecture and note-taking approach to a more technology-based constructivist approach.

According to the quantitative statistical data, the VLS had an impact on the students’ scores on the summative assessment for the unit in which students utilized the VLS as related to the summative assessment gain scores for the unit in which students did not access the VLS technology. The student-participants engaged in the VLS during class and as an extension of the course content as indicated in the qualitative data collected through field notes and formative assessments. The data also suggested that the student-participants (female students, students of color, and students with low-SES
backgrounds) in subgroups that are often marginalized in science (Ceci, Williams, & Barnett, 2009; Emdin, 2011) had more significant gains, indicating that this teaching strategy could help to address achievement gaps in science for particular groups of students along with providing equity and access to higher level science courses. These findings framed the action plan, which consists of individual changes in pedagogical practices for the participant-researcher as well as communication of findings to the school and district in which the research was conducted. According to Mertler (2014), “School building action research projects can also serve as a basis for professional development” (p. 214).

This action research study was conducted from November 2016 through January 2017 in one CP biology class. The high school where the research took place is comprised of ninth through 12th grades; however, ninth graders and one 10th grader made up the enrollment for the biology course studied. The school district is very large and has urban and rural schools. White Hall High School is one of 18 high schools within Green County School District in an urban setting in upstate South Carolina.

As previously discussed, a quantitative research design was determined to be the most appropriate for this action research study. The participant-researcher gathered pretest and posttest data for the unit in which the VLS was utilized and related those data to the results of the pretest and posttest for the previous unit for which the VLS was not utilized as an instructional strategy. The participant-researcher also recorded observations in a field-notes journal using formative assessments throughout both units of study. The constant comparative method was used to determine the qualitative data from the formative assessments. The data indicated if there was a relationship between the use
of the VLS as a type of teaching strategy and the student achievement on the summative assessments, on the formative assessments, and as identified in teacher observations. The key findings revealed that (a) the VLS aided in student learning by producing higher gain scores in the unit in which it was utilized; (b) there was a significant difference in gain scores for females, students of color, and students with low-SES backgrounds; (c) students began making their own decisions and monitoring their progress through the use of the VLS; and (d) students were better prepared for class, allowing the participant-researcher to address student comprehension and misconceptions. These factors are important to overall student achievement and success as well as the pedagogical practices of educators.

Major Issues to Address Prior to Implementation

The participant-researcher examined patterns and themes in the findings that related to the problem of practice. Through reflection during the study, the participant-researcher felt there were three issues that were relevant to technology integration into classrooms. The participant-researcher believes these should be addressed prior to implementation of technology resources.

One issue that emerged at the beginning of the data collection phase was the lack of use of the VLS by students outside of class. Students were not engaging in the VLS properly. The participant-researcher determined that proper training on the use of technology had not been provided to students. One consideration that must always be made when integrating a new teaching strategy is the training of not only the teachers but also the students. Proper modeling must take place for the students. Additionally,
educators must be able to understand how to help the students who may have different ranges of computer literacies in one class.

Second, accessibility must be addressed prior to technology integration. The participant-researcher surveyed all students to determine if they had Internet access from home. All students indicated they did have access; however, the participant-researcher also felt it necessary to provide extended hours before and after school to accommodate the schedules of the students. Many student-participants had extracurricular activities, jobs, and family responsibilities. Technology provided access to material outside of school, but flexibility to access the technology also had to be provided. One way of doing this was to offer extra time during the school day for student-participants to access the technology.

Lastly, the participant-researcher had to help students at the beginning of the integration of the VLS technology to reflect on the formative assessments. The feedback from the formative assessments guided the learning path for each individual student-participant as he or she engaged and participated in the activities on the VLS. Students indicated in field notes that they either knew where they needed help or they were not sure. Therefore, proper modeling of and facilitating the reflection on the feedback helped students begin decision making on which activities to do and helped to engage them in metacognitively thinking about their learning.

**Key Questions Related to Findings and Implications**

The participant-researcher concluded that educators must understand how to help students with the technology throughout the learning process and model decision-making and metacognitive skills in order for the VLS to become an effective instructional
strategy. Proper training of both students and teachers is vital to the success of such a tool in improving student achievement. The following questions must be asked prior to the implementation of a VLS: (a) Do students have accessibility and flexibility in their schedule to access the online material? If not, can teachers provide time during the school day to offer students time with technology? (b) Are teachers properly trained on how to help integrate technology into the classroom and how to model for students the use of technology in the learning process? and (c) Do students know how to use formative assessments to monitor their own learning?

**Action Researcher**

The role of the participant-researcher was critical to the data collection, analysis, and reflection with the student-participants throughout the study. The participant-researcher created the VLS that was implemented in the research. The participant-researcher developed the pretest and posttest given to students, which provided the quantitative data, as well as collected the field notes and formative assessments. The participant-researcher also reflected with student-participants throughout the study period. The reflections were on formative assessments, students’ use of the VLS, and their gain scores from pretest to posttest for each unit as well as from unit to unit. The participant-researcher modeled decision-making skills and metacognitive thinking with students with regard to their individual learning paths. Tanner (2012) suggested that educators model the thinking processes involved in their field and sought in their courses by being explicit about “how you start, how you decide what to do first and then next, how you check your work, how you know when you are done” (p. 118). Metacognitive
students actively decide how to use resources effectively and make judgments about outcomes and learning (Pintrich, 2000).

The participant-researcher is considered an insider to the action research study because she was also the teacher of the study group. The participant-researcher was responsible for creating the VLS as well as promoting its use throughout the learning of the ecology unit. The participant-researcher also promoted a positive learning environment, engaged in student-centered-learning instructional practices, and analyzed and reflected on student achievement as suggested in the action research design. All of these suggest the participant-researcher assumed an insider role in the action research study. Mertler (2014) argued, “An action researcher’s ability to ensure anonymity and confidentiality of participants and their data is a vitally important component of the action research process and of any action research project” (p. 151). The participant-researcher also plays the role of an outsider in communicating the results of the action research study in a manner that protects the privacy of the student-participants. Parents and students signed consent forms to participate in the research, and all data collected were secured and confidential (Mertler, 2014).

Throughout the action research study, the participant-researcher faced many personal challenges. First, the school in which the action research study was conducted is not a one-to-one technology device facility. However, the school does have over 350 laptops for teacher use. The participant-researcher had to request 20 laptop computers (Chromebooks) for her own use during the research period in which the VLS was utilized. This required the participant-researcher to have permission to keep 20 Chromebooks in her classroom for 2 months. This interfered with some of the sharing of
technology at the school but was accommodated. If schools do not have one-to-one technology or access to computers regularly, this could hinder the focus on the VLS throughout the learning process.

Another challenge that occurred was the resistance of students to engage and participate at the beginning of the study in the use of the VLS. Student-participants were apprehensive about engaging in the VLS. The participant-researcher had to model its uses and incorporate it into the learning so that students would know how to use the VLS. The student-participants were required to use it during classroom instruction throughout the study period. Student motivation at the beginning of the ecology unit, which employed the VLS, was low because the new instructional strategy required more work than just sitting and taking notes as provided in a more essentialist environment experienced during the evolution unit, which did not employ the VLS. Once students had positive experiences utilizing the VLS, the motivational obstacle seemed to decrease. Additionally, the integration of the VLS into classroom instruction required more planning and work on the part of the participant-researcher. This type of instruction required more work on the front end developing the VLS and modeling for students, but that time was made up in the progress of the students. The participant-researcher noticed less time spent on whole-class remediation once the VLS became a classroom instructional strategy.

**Developing an Action Plan**

The VLS served as an instructional intervention for the participant-researcher to explore a more student-centered learning experience and its effect on student learning as measured on one summative test. The VLS enabled the student-participants to monitor
their own learning throughout the one unit of study by accessing formative assessment tools in a synchronous and asynchronous environment. Student-participants were able to choose which platforms of learning they wanted to participate in outside of class, such as gaming tools, video lectures, online practice tests, or other online study tools accessed via the VLS. Evans and Boucher (2015) suggested,

Translating the importance of autonomy to instructional design has led to increasing emphasis on enabling students to take an active role in their learning. This is reflected in instructional practices that focus on allowing students to set their own goals, make choices around their learning activities, and base decisions on self-identified needs and preferences (Schunk, 1992). (p. 88)

These practices are based on a growing recognition that students must be given opportunities to experience autonomy to enhance their motivation to engage in learning activities. Evans and Boucher argued, “When students feel autonomous, they are more likely to see the value in a given learning task and thus be more engaged in the activity (Deci, Ryan, & Williams, 1996; Grolnick, Ryan, & Deci, 1991)” (p. 88)

Upon reflection on the quantitative data, the unit in which students utilized the VLS showed differences in gain scores on the summative assessment as related to the summative assessment gain scores for the unit in which students did not access the VLS technology. The qualitative data that were analyzed using the field notes recorded by the participant-researcher further suggested that students engaged in their learning throughout the unit that incorporated the use of the VLS during class. Many of the students also engaged in the VLS as a tool for extension outside of class as noted in the field notes. One explanation for why the gain scores were higher for the unit that utilized
the VLS could be that students wanted to use technology and enjoyed the choice it provided for them. Further, students that had not previously engaged technology as part of the learning process where able to use the VLS tools to create more real world experiences. For example, the simulations allow students to manipulate variables to show cause and affect relationships. The students are able to participate in experiences that allow them to think and act like scientists (Heemskerk et al., 2005; Li, 2008). This provides equity and access to topics and experiences students would have otherwise seen irrelevant to their lives. Instructional strategies that include technology create sophisticated learning environments in which both products and knowledge are constructed while being sensitive to each learner’s needs in an economically acceptable manner (Heemskerk et al., 2005; Li, 2008). Technology can be used as an assessment tool to help teachers monitor progress, and it can be used as a motivational tool for students. It has the potential to reach all students at all levels.

The VLS showed a difference in achievement for female students, students of color, and students with low-SES backgrounds but not for male students, White students, or students with high-SES backgrounds; the reason could be that the accessibility of the technology was no longer a factor for the students who saw a greater difference. When technology is accessible through mobile devices, it minimizes the accessibility issue and provides all students with equal access to the learning tools (Tawfik et al., 2016). Because all students were able to access the VLS at different times throughout the learning period and when convenient to their diverse schedules and responsibilities, the learning gap was decreased. The assessment scores of the study group were moved more toward the center, showing the potential for student success. When integrating
technology into classroom learning, it is important to know ahead of time some of the issues that may prevent students from accessing the technology. Sometimes, teaching students how to use technology and modeling the uses of the instructional strategies are the most important aspects of the implementation process (Warschauer et al., 2004).

Finally, students who engaged in the VLS were able to focus on their own learning needs or desires. Students were able to practice what they wanted or what they felt they needed help in reviewing. This began to engage students in metacognitively assessing what they wanted to explore in the course content. Research has found that students are most motivated by tasks at this intermediate level of difficulty (Deci & Ryan, 1985; Pintrich & Schunk, 2002). Because students could choose their practice avenues while discussing what they thought they should do with the participant-researcher, they may have had a more positive experience, providing motivation for learning. Aligning choices with students’ developmental levels is closely related to Vygotsky’s (1934/1962) concept of teaching within a student’s zone of proximal development. According to Evans and Boucher (2015), “To ensure that choices are optimally challenging and thus competence-enhancing, teachers need tools and supports that allow them to continually assess their students’ knowledge, skills, and perceived competence in a given domain” (p. 89).

The student-participants played an active role in their own learning while the participant-researcher facilitated their progress and remediation. Students were able to use the formative assessments provided by the teacher and the VLS to choose areas of focus for content understanding. Students were also able to use the VLS for extension of learning. This provided a more tailored, individualized learning experience for students.
The participant-researcher was also able to reflect on formative assessment data for individual students and the class as a whole for patterns and trends. The participant-researcher could use the formative assessments to help assign tasks during classroom instruction and individual tasks for homework based on student needs. At the conclusion of the study, the participant-researcher reflected with each student on his or her summative test scores between the two units. The students were able to reflect with the participant-researcher on the two instructional strategies, on their participation in their learning, and on their achievement outcomes.

**Action Plan for the Classroom**

Upon reflection on the action research study, the participant-researcher recommends that further research be conducted in the use of the VLS in both college preparatory and honors-level Biology 1 courses at the same school. First, the use of the VLS with different levels of biology courses and students would indicate if the difference in instructional strategies is more effective with lower level students versus higher level students. The participant-researcher can employ an additional study in an honors-level biology class as well as a class that contains inclusion students in the fall semester of 2017 or spring semester of 2018. By varying the level of the biology course, the participant-researcher can explore if the VLS technology integration lends itself better to certain students depending on their course level and individual learning needs. The VLS provides learning experiences to students through the simulations and formative assessment tools that guide student learning. The participant-researcher recommends using more simulations to bring relevance and opportunity to all students to engage in activities that require students to be scientists (Heemskerk et al., 2005; Li, 2008). For
students who have not had access or experiences that have led them to think and act like a scientist, the VLS provides equity to their learning experiences by having them participate in these activities. In addition, the participant-researcher believes that students’ perceptions of how the VLS aided in their content proficiency are important to explore. Surveying student-participants on their perceptions of the VLS would enhance student feedback and reflections on their experience. It would also allow the participant-researcher to further explore with student-participants’ metacognitive practices while using the VLS. According to Dana and Yendol-Hoppey (2014), “Surveys can give students a space to share their thoughts and opinions about a teaching technique or strategy, a unit, or their knowledge about particular subject matter” (p. 114).

**Action Plan for the School**

Further, implementation of a VLS in other content areas would enable an exploration of whether the VLS lends itself to certain content areas over others. The participant-researcher also recommends sharing results with faculty at White Hall High School. The participant-researcher is a part of a professional learning community consisting of four teachers who all teach biology. If the team would also like to implement the use of the VLS in their CP biology courses, the participant-researcher can share the VLS and train the teachers on how to integrate the VLS as an instructional tool as done in the present research study. Each teacher would be responsible for collecting his or her own data; however, the teachers could discuss the results among the professional learning community and share those results with the administration at White Hall High School. The teachers should also explore how the students perceive the VLS
to affect their learning. This can be done through a survey given to student-participants. According to Dana and Yendol-Hoppey (2014),

When the process of teacher inquiry is used as a professional development mechanism to help teachers learn and improve their own practice locally as well as to contribute to school improvement efforts, teachers are not doing anything differently than they would normally do as a good, ethical teacher. (pp. 148-149)

Additionally, similar action research studies could be implemented in other classes to explore if the technology integration lends itself better to certain content areas over others. The participant-researcher plans on sharing the results of this action research study during the 2017-2018 school year. The principal at White Hall High School has already approached the participant-researcher and asked that she present the results of the study at a faculty meeting. The presentation will preferably take place within the first semester so that interested faculty may begin the process of developing their own VLS and getting appropriate school approval to conduct their own action research and data collection. The action research in other content areas can serve as instructional tools for their courses and bring awareness to providing students with equity and access to higher level courses in their particular content areas of study.

**Action Plan for the District**

The district in which the participant-researcher works is planning to add technology integration strategies into curriculum guides that are provided as instructional tools for all educators. The participant-researcher will meet with the science district coordinator in July of 2017 to share the action research results and begin planning for sharing the results with other schools within Green County School District. Sharing these
pedagogical practices with teachers enhances learning experiences and provides equity for all students.

The majority of the timeline for the action plan for the participant-researcher should take place from July 2017 to December 2017. However, the implementation of a VLS in other CP biology courses and content areas will depend on the teachers who are interested in employing their own action research. This study can serve as a model, and the participant-researcher can help facilitate the development of further inquiries but will not be responsible for collecting data from the teachers. Grants to assist in providing accessible technology could be written to give teachers their own class sets of Chromebooks, but this is not required to do further research. The teachers who want to pursue the inquiry will need to put in a request with the administration to use the technology the school already has for an extended period. Therefore, monitoring the computer use of the teachers interested in integrating a VLS as an instructional strategy would be necessary and important to the success of the additional action research.

**Facilitating Educational Change**

By using technology to address specific needs of students in content-area courses, educators and schools will be able to provide a more individualized learning experience. This potentially can help subgroups and schools address achievement gaps and provide more equity in the technology experiences students have. Schools can provide students with learning opportunities that better equip them for their future careers.

When implementing technology or any type of new instructional strategy, teachers need proper professional development and assistance. One challenge with this is
the time and money required to train educators as well as the desire and motivation of the teachers to employ new instructional strategies. Kincheloe (1991) wrote,

Teachers are preoccupied with daily survival—time for reflection and analysis seems remote and even quite fatuous given the crisis management atmosphere and the immediate attention survival necessitates. In such a climate those who would suggest that more time and resources be delegated to reflective and growth-inducing pursuits are viewed as impractical visionaries devoid of common sense. Thus, the status quo is perpetuated, the endless cycle of underdevelopment rolls on with its peasant culture of low morale and teachers as “reactors” to daily emergencies. (p. 12)

By sharing the action research and collaborating with others, this cycle of reacting to students’ needs will be broken, and teachers can build tools that are proactive to students’ learning. The challenge is not to try to roll this out to every person at White Hall High School but to have the teacher leaders who want to do it begin implementing small changes in their classrooms.

Another challenge in implementing technology as a tool for learning is modeling and assisting students in their computer literacies. Students have many different levels of computer competencies, and managing those different levels in one classroom requires teachers to be comfortable with and knowledgeable of the technology themselves. Again, this would require time and money for training not only the teachers but the students as well.

Teacher inquiry develops teacher leaders because the teachers can discuss common problems, share approaches, explore common constraints, and problem solve
(Dana & Yendol-Hoppey, 2014). This will allow positive educational change from the inside of classrooms. In the fall of 2017, the participant-researcher will further implement the VLS in honors and CP biology classes that she will teach at White Hall High School. Approval from the district of the integration of the VLS is not necessary at this time. The district is implementing personalized learning and has encouraged teachers to use creative and innovative practices in classrooms. Therefore, the principal believes the VLS is one innovative strategy that teachers should continue to implement. The principal at White Hall High School is also planning a professional development session in the fall of 2017 for the participant-researcher to present her findings from the action research study to the faculty. The district science academic specialist has also asked the participant-researcher to present the VLS and the study findings to department chairs of the middle and high schools in Green County School District during the 2017-2018 school year. By implementing change within individual classrooms and with individual teachers, a community of practitioners is developed and a culture created that meets the needs of the students and their learning.

**Summary of Research Findings**

The action research study showed that using a constructivist, student-centered approach to teaching with technology made a difference in student achievement scores. Integrating technology as a form of blended learning into pedagogical practices provides personalized learning and helps to provide students with opportunities to work on their computer literacies, which will prepare them for future careers.

Utilizing the VLS technology aided in cultivating habits of student self-monitoring while developing student decision making. Additionally, the VLS has the
potential to provide improved equity and access to higher level science courses by targeting achievement gaps in student populations and providing students with experiences to develop the skills and content understanding to be successful. Female students, students of color, and students of low-SES backgrounds all improved their summative test scores for the unit in which they utilized the VLS. Therefore, this potentially can help these subgroups close achievement gaps and enable schools to provide more equity in the technology experiences students have. Providing choice for students increases their decision-making and metacognitive skills. Through the VLS, students can personalize their learning while improving their academic achievement. By providing meaningful choice in the context of classroom activities, teachers can support students’ autonomy and foster deep and prolonged engagement in learning (Deci et al., 1996; Grolnick et al., 1991).

Technology can be used as an assessment tool to help teachers monitor progress, and it can be used as a motivational tool for students. It has the potential to reach all students at all levels.

**Suggestions for Future Research**

Future research should be conducted to explore the use of the VLS with different levels of biology courses and students. The participant-researcher can employ an additional study in an honors-level biology class as well as a class that contains inclusion students. By varying the level of the biology course, the participant-researcher can explore if the VLS technology integration lends itself better to certain students depending on their course level. Additionally, similar action research studies should be implemented in other classes to explore if the technology integration lends itself better to
certain content areas. The district in which the participant-researcher works is planning to add technology integration strategies into curriculum guides that are provided as instructional tools for all educators. The action research in other content areas can serve as instructional tools for their courses. By using technology to address specific needs of students in content-area courses, educators and schools will be able to provide a more individualized learning experience. This potentially can help subgroups and schools address achievement gaps and provide more equity in the technology experiences students have. More opportunities are needed for students to improve their ICT skills because their future careers will require them to be computer literate. Schools can provide students with learning opportunities that better equip them for their future careers and make them more marketable while improving their academic success (Ritzhaupt et al., 2013).

The participant-researcher should also further research student perceptions of learning when instruction utilizes a VLS. Student feedback from the present action research indicated students liked using technology during instruction, but no data were collected that explored if students believed the technology aided in their content proficiency. Understanding how students perceived the technology as a learning tool would help educators in the development of their instructional plans.

Conclusion

The goal of this action research study was to describe the effectiveness of a VLS on CP biology students’ pre- and posttest scores. Qualitative data were comprised of observations of students’ using the VLS for video lectures, practice tests, reviewing, and other online simulations. Quantitative data were comprised of the results of a pretest and
a posttest, designed by the participant-researcher, administered in two units before and after the implementation of the VLS. A t test was used to analyze the pre- and posttest quantitative data, which showed a difference in scores when the VLS was utilized for one unit of study. The constant comparative method was used to determine the qualitative data from the formative assessments. Findings include that the VLS aided in cultivating habits of student self-monitoring and developing student decision making. The participant-researcher modeled for students how to self-assess using the activities provided with the VLS and, through reflection, used that information to choose activities that would continue their individual learning paths for the content material. Through the use of the VLS, data showed that there was a significant difference for certain subgroups (female students, students of color, and students of low-SES backgrounds). Hence, the utilization of the VLS as a pedagogical practice helped in improving equity among all students. The VLS could also provide access to higher level science courses.

The action plan developed from this study will help educators at White Hall High School make informed decisions regarding the implementation of a VLS in their classrooms to enhance student learning.
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doi:10.1207/S15327957PSPR0703_03


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APPENDIX A

FIELD NOTES PAGE

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# APPENDIX B

## PARTICIPANT SCORES

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APPENDIX C

PARENT CONSENT FORM

October 10, 2016

Dear Parent or Guardian,

The Greenville County School District periodically asked students to complete tests, surveys, and questionnaires to gather information about various topics pertaining to curriculum and learning. During the school year, I will be implementing a virtual learning system (VLS) to gather information about student achievement on content assessments and technology use. This is a very important teaching strategy that will help me promote better classroom pedagogy and student engagement. This information will be used in my dissertation in practice for my doctoral degree at the University of South Carolina. Your agreement and your child’s participation in the study are completely voluntary. Please read the following information about the study and sign the form below:

Test Content
The tests gather information on and about your child’s overall understanding of the unit content.

It is Voluntary
Your child does not have to take the pretest and posttest. Students who participate will only have to answer the twenty questions on the pretest and posttest. They may stop at any time without penalty. If they do not want to take the tests, they will be given an alternative assignment.

It is Anonymous and Confidential
The assessments will be kept confidential (not seen by others) and anonymous (no names will be recorded and/or attached to the tests or data—Students cannot be identified).

Benefit of the Study
The study will help teachers plan and/or learn more about how to integrate technology as a teaching strategy that aids in the learning process.

Potential Risks
There are no known risks of physical harm to your child. Your child will not have to answer any questions unless s/he wants to.

Test Review (for surveys)
Beginning January 15, 2016, a copy of the pretest and posttest will be available for previewing by contacting Mrs. Jamie Whitlock at 864-355-0179 or jwhitlock@greenville.k12.sc.us

For Further Information
Mrs. Jamie Whitlock at 864-355-0179 or jwhitlock@greenville.k12.sc.us

If you do not want your child to participate, please sign and return to me by Wednesday, October 12, 2016.

___________________________________________________________________
Name of Child______________________________
I do not want my child to participate:______________________________

Parent/Guardian signature   Date

I do want my child to participate:______________________________

Parent/Guardian signature   Date
APPENDIX D

STUDENT CONSENT FORM

October 10, 2016

Dear Biology Student,

The Greenville County School District periodically asked students to complete tests, surveys, and questionnaires to gather information about various topics pertaining to curriculum and learning. During the school year, I will be implementing a virtual learning system (VLS) to gather information about student achievement on content assessments and technology use. This information will be used in my dissertation in practice for my doctoral degree at the University of South Carolina. Your agreement and participation in the study are completely voluntary. Please read the following information about the study and sign the form below:

Test Content
The tests gather information on and about your overall understanding of the unit content.

It is Voluntary
You will only have to answer the twenty questions on the pretest and posttest. You may stop at any time without penalty. If you do not want to take the tests, you will be given an alternative assignment.

It is Anonymous and Confidential
The assessments will be kept confidential (not seen by others) and anonymous (no names will be recorded and/or attached to the tests or data—Students cannot be identified).

Benefit of the Study
The study will help teachers plan and/or learn more about how to integrate technology as a teaching strategy that aids in the learning process.

Potential Risks
There are no known risks of physical harm. You do not have to answer any questions unless you want to.

Test Review (for surveys)
Beginning January 15, 2016, a copy of the pretest and posttest will be available for previewing by contacting Mrs. Jamie Whitlock at 864-355-0179 or jwhitlock@greenville.k12.sc.us

For Further Information
Mrs. Jamie Whitlock at 864-355-0179 or jwhitlock@greenville.k12.sc.us

If you do not want to participate, please sign and return to me by Wednesday, October 12, 2016.

______________________________________________________________________________

I, ____________________________, want to be included in the research project as described in the letter above.
I, _________________________, do not want to participate.
There is no penalty for not participating
The individual’s identities will remain strictly anonymous and confidential
Participants may withdraw from the study at any time without penalty

Signed_________________________   Date__________________
APPENDIX E

EVOLUTION UNIT TEST

**Concept 1 Multiple Choice**

1. One of the major elements of natural selection is that all species have genetic
   A. digression.
   B. melanism.
   C. stability.
   D. variation.

2. A population of bacteria is treated with hand sanitizer. Because of genetic variation in the population, what is a possible outcome?
   A. All of the bacteria are already resistant.
   B. Some may be resistant and survive.
   C. The population will grow quickly.
   D. They will get better at obtaining a food source.

3. One of the biggest ways that a species evolves is because some organisms with some traits survive and reproduce better than others. This process is known as
   A. coevolution
   B. convergent evolution
   C. natural selection.
   D. sexual selection.

4. Genes for traits that help an organism be more successful reproductively can be expected to
   A. become more common in the future.
   B. cause it to evolve into a new species.
   C. cause the extinction of the species.
   D. eventually be eliminated by natural selection

5. An adaptation is
   A. a gene an organism has.
   B. a trait that helps an organism survive in its environment.
   C. any trait an organism possesses.
   D. how an organism evolves during its own lifetime.
6. Genetic diversity is **ultimately** the result of
   A. asexual reproduction.
   B. mitosis.
   C. mutations.
   D. viruses.

7. Which of the following does **NOT** increase genetic variation?
   A. Crossing over
   B. Gene flow
   C. Mitosis
   D. Mutations

8. Which of the following is not a principle of natural selection?
   A. Evolution will occur as an organism gets older and learns more.
   B. In every population, adaptations allows some organisms to survive and reproduce better than others.
   C. Most species produce more offspring than will actually reproduce.
   D. Organisms compete for limited resources

9. Individuals that are well adapted to their environment will survive and produce
   A. better traits
   B. fewer mutations
   C. more offspring
   D. stronger gene.

**Concept 2 Multiple Choice**

10. If scientists wanted to learn more about evolution by studying biochemistry, they would study all but one of these molecules. Which molecule would NOT offer much information about the history of life?
    A. DNA
    B. proteins
    C. lipids (fats)
    D. nucleic acids

11. Scientists can explore whether two different animal species have evolved from a common ancestor, using evidence from all of the sources below except
    A. analysis of strands of DNA
    B. comparisons of bones and muscles
    C. comparison of the experiences of each organism
    D. studies of embryos during development
12. The diagram shows, left to right, the leg bones of an orangutan, a dog, a pig, a cow, a tapir, and a horse. Most of the animals have the same bones, although some are shaped differently and placed in different positions.

What does this suggest about mammals?

A. Mammals evolve to become more and more like each other.
B. The shape of the legs is only due to their environments.
C. They developed these similarities randomly.
D. They shared a common ancestor.

13. The table (myoglobin chart) shows the order of amino acids present in a protein from five different organisms. Based on this evidence, a researcher could conclude that the two closest relatives are

A. Amino acids cannot be used to determine relatedness.
B. Cows and hamsters
C. Cows and pigs.
D. Lemurs and gibbons.

<table>
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Key: Cys = Cysteine, Lys = Lysine, Trp = Tryptophan, Leu = Leucine, Val = Valine, Asp = Asparagine, Glu = Glutamate, Phe = Phenylalanine.
14. Two bodily structures, found in different species, have different bone structures but serve a similar purpose in each organism. This is the best description of
   A. analogous structures
   B. homologous structures
   C. natural selection
   D. vestigial structures

15. Ostriches have wings, but do not fly. Humans have an appendix with no apparent function. Whales contain bones for rear legs. Each of these are examples of
   A. analogous structures
   B. homologous structures
   C. natural selection
   D. vestigial structures

16. Evidence of evolution from the field of paleontology examines
   A. embryos of different species.
   B. fossils compare to living species.
   C. sequences of DNA and protein.
   D. the location of different species across the planet.

17. Early during development, organisms as diverse as a human, a mouse, and a bat can appear indistinguishable. All of their embryos look nearly identical, suggesting that
   A. during development, humans go through stages of being a mouse and a bat.
   B. similar structures have developed because of convergent evolution.
   C. these very different species have a shared ancestry with all mammals.
   D. this is a coincidental resemblance between them.

**Concept 3 Multiple Choice**

18. According to the phylogenetic tree to the right,
   A. An ancestor of Eubacteria gave rise to all life on Earth.
   B. Archaeabacteria came from eubacteria.
   C. Fungi gave rise to plantae and animalia.
   D. Eubacteria and archaeabacteria have no common ancestor.
19. Which one of these is most closely related to the oak weevil?

20. Which of the following orders of classification goes from the most broad to the most specific?
   A. Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species
   B. Domain, Phylum, Kingdom, Order, Family, Genus, Class, Species
   C. Kingdom, Class, Domain, Order, Phylum, Genus, Family, Species
   D. Phylum, Order, Class, Domain, Kingdom, Family, Genus, Species
Concept 1 Multiple Choice

1. What pattern of growth will a population with limited resources show?
   A. density-dependent
   B. density-independent
   C. exponential
   D. logistic

2. Conditions in the environment that impact the size of the population are called
   A. habitats
   B. limiting factors
   C. populations
   D. villains

3. A population of mice occupies a tree stump. For ten years, the population has been stable. Which of the following would likely cause the number of mice to begin to decrease?
   A. a decrease in competition between the mice
   B. a decrease in disease
   C. an increase in mating season
   D. an increase in predation (predators)

4. In an ecosystem, which of the following is a density-independent limiting factor?
   A. competition
   B. parasitism
   C. predation
   D. natural disaster

5. Which of the following is true of density-dependent limiting factors?
   A. They have a larger impact on big populations.
   B. They have a larger impact on small populations.
   C. They impact big and small populations equally.
   D. They tend to be caused by abiotic factors.
6. What type of population growth is shown in the graph?
   A. carrying capacity growth
   B. density-dependent growth
   C. exponential growth
   D. logistical growth

![Daphnia Population Growth Graph](image)

**FIG. 14.2**

**Concept 2 Multiple Choice**

7. In natural ecosystems, predators will tend to lower the prey population, meaning less __________ between members of the prey population.
   A. competition
   B. infestation
   C. parasitism
   D. symbiosis

8. For the carbon cycle and the nitrogen cycle to function properly, which organisms must always be present?
   A. Decomposers
   B. Herbivores
   C. Parasites
   D. Predators

9. The main result of photosynthesis is
   A. absorbing nitrogen for the plant to use.
   B. CO₂ is removed and captured by plants.
   C. decreased atmospheric oxygen.
   D. global warming caused by CO₂ being removed.
10. In the carbon cycle, decomposers return carbon to the soil. Which of the following is NOT something that decomposers can break down?
   A. carbon dioxide found in the air.
   B. scraps of discarded food.
   C. the bodies of dead plants and animals.
   D. waste products like urine or feces.

11. Humans **increase** carbon dioxide (CO$_2$) in the atmosphere, and contribute to the carbon cycle by
   A. combustion from driving cars.
   B. conserving energy with alternative energies.
   C. planting trees to improve photosynthesis.
   D. using more solar power electricity.

**Concept 3 Multiple Choice**

12. Examine the following pictures. Place them in the correct order, starting at the beginning of primary succession and moving to the end.

   A. A→B→C→D→E
   B. A→C→E→D→B
   C. D→C→B→A→E
   D. E→D→A→C→B

13. Organisms that are the first to move into an area, and begin forming soil for an ecosystem, are known as
   A. a climax community.
   B. bushes.
   C. hardwood trees.
   D. pioneer species.
14. A climax community
   A. is the beginning of succession.
   B. is found in the middle of succession.
   C. is the end stage of succession.
   D. is when an ecosystem is destroyed.

15. The correct order of stages in primary succession of a volcanic island is
   A. shrubs-mosses-coconut trees-sea grasses.
   C. volcanic rock-shrubs-coconut trees-sea grasses.
   D. volcanic rock-sea grasses-coconut trees-shrubs.

16. A logger clears a forest and the forest re-grows over many years. Which type of succession represents the regrowth of this forest?
   A. Primary succession
   B. Pioneer species
   C. Climax community
   D. Secondary succession

17. One negative result of our need for energy would include
   A. an oil tanker spills and destroys the habitats of many animals.
   B. decreased runoff from deforestation.
   C. inventing engines that can run on energy from the sun.
   D. the creation of cleaner fuels.

18. A renewable resource is one that
   A. can be recycled.
   B. is replenished as fast as it is used.
   C. is used faster than it is replenished.
   D. is used like fossil fuels.

19. The development of nuclear power has provided electricity for less money, but with a tradeoff. What may be considered a negative impact of nuclear power?
   A. It takes a lot of energy to run a nuclear power plant.
   B. Large amounts of energy are produced very cheaply.
   C. Nuclear power plants provide new jobs for a community.
   D. The radioactive waste is unsafe and hard to store safely.

20. Temperatures on Earth may continue to increase because
   A. decomposers essential to recycling matter are being destroyed.
   B. Earth tilts toward the sun in the summer.
   C. increasing carbon dioxide in the atmosphere will trap more heat.
   D. too much oxygen is now given off by plants.