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An Examination of the Predictive Relationship Between Mode of Instruction and Student Success in Introductory Biology

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AN EXAMINATION OF THE PREDICTIVE RELATIONSHIP BETWEEN MODE OF INSTRUCTION AND STUDENT SUCCESS IN INTRODUCTORY BIOLOGY

by

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ABSTRACT

AN EXAMINATION OF THE PREDICTIVE RELATIONSHIP BETWEEN MODE OF INSTRUCTION AND STUDENT SUCCESS IN INTRODUCTORY BIOLOGY

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Community colleges continue to increase online course offerings as these institutions strive to offer open access, cost effective education to a growing student population. With an increased student demand for online learning, community colleges should explore the possibility of offering all courses in the online environment, including science courses. The purpose of this quantitative research was to investigate the success of non-science major students in biology 102 on campus comparing students who completed biology 101 online to students who completed biology 101 on campus within Virginia community colleges. This was the first multi institutional, multi semester study of community college online biology and the first investigation to look at potential relationships between student success and student demographic characteristics, filling several gaps within the professional literature.

Ex post facto data were collected from the Virginia Community College System and analyzed through binary logistic regression. Mode of instruction in biology 101 was not predictive of student success in biology 102 on campus. Mode of instruction did not significantly impact the predictive relationship between student demographic characteristics and student success except for student gender. Male students who completed biology 101 online were significantly less likely to be successful in biology 102 on campus. Overall, the findings indicate that online biology is a viable option for

community colleges to effectively serve a diverse student population. As emerging research, this study provides a baseline of student success within online biology and offers suggestions as to gaps remaining within the literature that can be investigated in future research.

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CHAPTER 1

INTRODUCTION

Within United States higher education more than 6.7 million college and university students participated in at least one online course in Fall 2011 (Allen & Seaman, 2013). Within community colleges specifically, distance learning course enrollment increased nine percent between 2009 and 2010 and 81% of the community colleges offered at least one online degree (Instructional Technology Council, 2011). Of the 139 community colleges surveyed, 73% indicated offering noncredit online courses and 68% could not keep up with the overall demand for distance learning courses (Instructional Technology Council, 2011). Respondents (members of the Instructional Technology Council and the American Association of Community Colleges) also promoted the quality of online course offerings with 95% of participants reporting online classes were equivalent or superior to the on campus course (Instructional Technology Council, 2011).

Distance education or distance learning is a field of education that utilizes technology and teaching methods to deliver educational content to students who are not physically present in an on campus classroom (Simmonson, 2008). The recent increase in this educational form at community colleges is due to several factors. First, online technology improvements such as faster Internet connectivity and standardized course delivery systems facilitate online learning. The technological advances have created a new learning environment allowing both instructors and students to interact with one another and the course material in a flexible and collaborative fashion (Glahn & Gen, 2002). Second, community colleges serve many nontraditional students who are older

and have families and careers (Clark, 2012). These busy students desire a flexible course schedule that is not restricted by time or location (Stumpf, McCrimon, & Davis, 2005). Some students live in remote areas and commute long distances to a community college. Increasing gas prices make an online course is a desirable alternative (Lorenzetti, 2005; Stumpf, et al., 2005). Allen and Seaman (2011) determined higher education administrators recognized student's desire for flexibility and 63.3% supported online courses for scheduling flexibility. Overall, online students reported satisfaction with the distance learning courses (Reeves & Osho, 2010) indicating this field of education is effectively serving community college students.

Even with the increase in online course offerings and a high student demand, some educators hold negative attitudes towards online instruction. Instructors are opposed to distance education due to intellectual reluctance, resistance to change, cost, and lack of support (Mitchell & Geva-May, 2009). When asked if they thought faculty accepted the value and legitimacy of online education, 30.2% of higher education administrators agreed, 57.2% were neutral, and 12.6% disagreed indicating the existing discrepancy in faculty opinion (Allen & Seaman, 2013). Specifically, laboratory based science courses were deemed poorly suited for distance learning (Bradley, 2007; Instructional Technology Council, 2011). However, these studies did not fully explain the reasons why science courses were not fitting of the online environment. If distance course offerings are increasing within community colleges and students desire to learn through this instructional mode, administrators should explore the possibility of offering all subjects through distance education, including online science courses.

Background to Study

The current literature illustrates the success of higher education online courses in regards to student performance and satisfaction. In an undergraduate nursing statistics class there was no significant difference in grades between online and on campus students (Summers, Waigandt, & Whittaker, 2005). Similarly, at two community colleges in Nevada, 71.6% of on campus students and 75.3% of online students successfully completed the same class (Doherty, 2006). At Bronx Community College, online and on campus medical terminology students were equally satisfied and exhibited no significant difference in final course grades (Somenarain, Akkaraju, & Gharbaran, 2010). In comparison to on campus courses, there was no difference in student satisfaction scores in the online environment (Allen, Bourhis, Burrell, & Mabry, 2002; Karatas & Simsek, 2009). In some studies, online courses had higher levels of student satisfaction verses the comparable on campus offering (Lim, Kim, Chen, & Ryder, 2008; Reeves & Osho, 2010). Overall, community college students appreciated the flexibility of online classes because they could complete coursework on their own schedule and in an environment of their choice (Doherty, 2006; Sullivan, 2001).

Although students are successful in online courses, distance learning is not for all community college students. Harrell and Bower (2011) determined auditory learning ability, GPA, and basic computer skills were significant predictors in community college online student persistence. While students received comparable grades in online courses, retention, another useful measure of student success, in distance courses was lower than in face-to-face courses (Mitchell, 2010). Within community colleges, noncompletion rates ranged from 20.6% to 24% for on campus courses as compared to 25.9% to 30.2%

for online courses (Moore, Bartkovich, Fetzner, & Ison, 2003). Community college students cited many reasons for withdrawing from online courses including time constraints, the amount of time required to receive instructor responses, technical or computer issues, institutional problems, and incompatible learning styles with the online environment (Aragon & Johnson, 2008; Packham, Jones, Miller, & Thomas, 2004). Online courses are appealing to busy students due to the flexibility of the course delivery yet some students appear to be too occupied to successfully complete their studies.

There are few published studies investigating online biology courses within higher education. Four-year institutions are using online biology laboratory activities predominately as a supplement for the on campus lab. Biology students who completed the online activities in addition to the on campus laboratory performed significantly better on exams as compared to students who only completed the on campus laboratory (Swan & O'Donnell, 2009; Toth, Morrow, & Ludvico, 2008). The higher performance of the students who utilized both delivery methods supports the effectiveness of online biology. Toth, et al. (2008) determined that the order of online and on campus experiences made a difference. Students who completed the online lab followed by the on campus activity performed better on a post-test as compared to students who did the on campus lab before the online lab (Toth et al., 2008). A study by Gilban (2006) found that students who completed an online laboratory instead of an on campus laboratory performed better on the related quiz indicating improved understanding of the concepts. The online laboratory also took the students less time to complete showing that online labs can be more efficient while delivering equal content.

Qualitative data from biology students at four-year institutions showed students enjoyed participating in the online environment and they felt more confident in the hands on laboratory as a result (Swan & O'Donnell, 2009). Students also appreciated that they could access the online material multiple times to review, spend extended periods of time on a topic that they rushed through on campus, and that they received immediate feedback through online quizzes (Swan and O'Donnell, 2009). Although the majority of the students enjoyed the online biology laboratories, the students who did not value the experience stated that they missed being able to communicate immediately with the instructor and their classmates (Gilban, 2006).

Quantitative analysis of online biology laboratories at community colleges showed equivalent student learning in the online and the on campus environment. Lunsford and Bolton (2006) compared an online, non-major introductory biology laboratory to an on campus counterpart using a 50-question multiple choice test. The online students mean test score (69.77) was almost identical to the on campus mean test score (70.00) indicating no difference in student knowledge (Lunsford & Bolton, 2006). Johnson (2002) examined student course grades and found no significant difference between online (M=81.86) and on campus (M=78.46) students in a non-science major biology laboratory. Both of these studies demonstrate the effectiveness of online biology courses at community colleges.

There is a discrepancy in the current literature regarding student perceptions of community college online biology courses. Stucky-Mickell and Stucky-Danner (2007) surveyed community college students in a non-science major human biology course that used both on campus and online laboratories. Survey results indicated 86.9% of the

students strongly agreed the on campus lab increased their understanding of course concepts while only 60.8% strongly agreed that the virtual lab increased their knowledge (Stuckey-Mickell & Stuckey-Danner, 2007). The students said they missed the face-to-face interactions with both students and faculty and the ability to receive immediate feedback during the online laboratories (Stuckey-Mickell & Stuckey-Danner, 2007). Conversely, in Johnson's (2002) study, online and on campus students expressed no difference in attitudes towards biology before or after their respective laboratories. Their viewpoints did not change based on the mode of instruction as all students were confident in their biology knowledge (Johnson, 2002). Online students did express significantly less interest in working in groups and significantly more favorable opinions towards computer based learning suggesting that online education is a better fit for students that exhibit certain learning styles (Johnson, 2002).

Overall, current research, although sparse, points to the effectiveness of online biology courses in both community colleges and four-year institutions. Online biology students gain just as much if not more knowledge as compared to their on campus counterparts (Johnson, 2002; Lunsford & Bolton, 2006). Community colleges are ahead of four-year institutions with more completely online biology course offerings. This difference is not surprising as community colleges serve a broader population with students that have busy lives with full time jobs and long distances to commute (Lorenzetti, 2005; Stumpf et al., 2005).

Problem Statement

Community colleges face an increased demand for distance learning however these institutions reported that laboratory based science courses are very challenging to

teach in the online environment (Instructional Technology Council, 2011). There is more research regarding online biology offerings at four-year institutions (Swan & O'Donnell, 2009; Toth et al., 2008: Gilban, 2006) and the few previous studies in the specific area of community college online biology courses were small scale and conducted at single institutions (Johnson, 2002; Lunsford & Bolton, 2006). Although the literature points to the effectiveness of online biology courses within higher education, more research is needed. One way to inform faculty and administrators and to learn about student success within online biology courses is to conduct larger studies with more students, multiple institutions, and tracking over several semesters.

Purpose of Study

If online introductory biology courses are an effective alternative to on campus biology courses, community college students who pass biology 101, the first semester of introductory biology, should be equally successful in biology 102 on campus, the second semester of introductory biology, independent of previous instruction mode. The purpose of this study was to investigate the success of non-science major students in biology 102 on campus comparing students who completed biology 101 online to students who completed biology 101 on campus within Virginia community colleges. The independent variable was the mode of instruction in biology 101 (online verses on campus) and the dependent variable was student success in on campus biology 102 (receiving a C or higher).

Research Questions

This study was guided by the following research questions:

1. How will the mode of instruction in biology 101 be predictive of student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
2. What are the demographic characteristics of non-science major students who completed biology 101 online and biology 102 on campus at Virginia community colleges? The demographic characteristics examined include age, gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101.
3. What are the demographic characteristics of non-science major students who completed both biology 101 and biology 102 on campus at Virginia community colleges? The demographic characteristics examined include age, gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101.
4. How will the mode of instruction in biology 101 moderate the predictive relationship between student demographic characteristics and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
    a. How will the mode of instruction in biology 101 moderate the predictive relationship between student age and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
    b. How will the mode of instruction in biology 101 moderate the predictive relationship between student gender and student success in

biology 102 on campus for non-science major students within Virginia Community Colleges?

c. How will the mode of instruction in biology 101 moderate the predictive relationship between student ethnicity and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

d. How will the mode of instruction in biology 101 moderate the predictive relationship between student prior online course experience and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

e. How will the mode of instruction in biology 101 moderate the predictive relationship between student enrollment status during the semester of biology 101 and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

Professional Significance

Community colleges have been leaders in distance education for many years (Harrell & Bower, 2011). As technology improves and more students become technologically savvy community colleges must determine if a biology course, both lecture and laboratory, can be effectively taught in the virtual world. Online biology courses hold several benefits for community college faculty, administrators, and students. Online biology courses give instructors the opportunity to explore new and potentially more effective ways of learning (Cancilla & Albon, 2008). Instructors considering teaching online biology courses will benefit from this research as data regarding the

relationship between mode of instruction and student success will help future instructors decide if they want to teach online. The demographic data will allow biology instructors to better predict the characteristics of community college students who enroll in both online and on campus introductory biology. Although this study will use data from Virginia institutions instructors throughout the United States will be able to utilize the findings due to the diversity present within the Virginia community colleges.

Online learning provides open access education to community college biology students (Geith & Vignare, 2008). Many community colleges incorporate the concept of open access into the institution's mission statement illustrating the important connection between distance learning and the institutional goals of the community college (Bower & Hardy, 2004). Online education is also an integral component of the long-term strategic plan at many higher education institutions (Allen, & Seaman, 2011, 2013). In 2001 the Virginia Community College System (VCCS) published a distance learning strategic plan. This plan outlined the VCCS's vision, leadership approach, and funding strategies to ensure consistently high quality distance learning instruction (Virginia Community College System, 2001). More recently within the VCCS's Rethink: Reengineering Virginia's Community Colleges, one area of focus is fostering a culture of high performance including innovation through technology (Reengineering Virginia's Community Colleges, 2012). Online courses fall within this topic and therefore findings from this study will directly impact and help Virginia community colleges with online course structure and implementation. At a time when the VCCS is experiencing increased student enrollments but decreased state funding online courses can help

community colleges serve more students efficiently (Reengineering Virginia's Community Colleges, 2012).

Community college students will also benefit from this research. As many degree seeking community colleges students must complete two science courses with laboratories the results of this study will help future biology students make informed decisions regarding course delivery options. Jaggars and Xu (2010) followed a cohort of VCCS students who first enrolled in 2004 and found 48% of students attempted an online course. However, within natural sciences (including biology) online courses represented a below average proportion of enrollments (Jaggars and Xu, 2010). The results from Jaggars and Xu's study suggest that community college students, similar to faculty, may have a bias against online science courses. The proposed study will add to the current literature and assist students in making educated decisions about biology courses and the effectiveness of science distance education.

Overview of Methodology

This study employed a quantitative design using ex post facto data (Clark & Creswell, 2009). The participants met the following criterion: non-science major students in on campus Biology 102, the second semester of introductory biology, at Virginia community colleges that offer both completely online and completely on campus biology 101. The method of course delivery in biology 101, online or on campus, was the independent variable for research question one, research question two, and research question three. The mode of course instruction acted as the moderator variable in research question four. Student success as measured by final course grade in biology 102 was the dependent variable in research question one and research question

four. A successful student received a grade of C (70%) or higher (Larson & Chung-Hsien, 2009; Xu & Jaggars, 2011). A grade of C or better allows a community college student to receive credit for biology 102 upon transfer to a four-year institution. The student demographic characteristics of age, gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101 were the dependent variables for research questions two and three and the independent variables in research question four. The study utilized two semesters of data creating a large enough sample size to control for potential differences due to instructors (Arbaugh, 2004; Crewswell, 2009; Price, 2006; Slavin & Smith, 2009).

The researcher received approval from the Academic Services and Research Department at the Virginia Community College System and the Darden College of Education Human Subjects Review Committee at Old Dominion University before beginning the study. The VCCS Academic Services and Research Department was contacted requesting student enrollment, final grade, and demographic data for non-science major students who completed online or on campus Biology 101 in the Fall 2009 or Spring 2010 semesters and subsequently completed Biology 102 on campus within the next academic year. This information was provided without the individual student's identity as each student was designated by a random, unique numeric code. The coding protected the students and ensured confidentiality throughout the research process. The data from all community colleges were aggregated and the students were divided into two groups, online biology 101 and on campus biology 101. The objective was to create two groups that are approximately equal in size to allow rigorous statistical testing (Eng, 2003).

To address the first research question, the final biology 102 grades of the students who completed biology 101 online or on campus were statistically analyzed through binary logistic regression. Binary logistic regression was appropriate due to the dichotomous nature of both variables (Meyers, Garnst, & Guarino, 2006). Descriptive statistics summarized the data related to the demographic characteristics of the students in research question two and research question three (Sprinthall, 2007). Binary logistic regression analysis was used to determine if differences in student success existed between demographic subgroups in research question four. Binary logistic regression was the best analysis choice because both the independent and the dependent variables were dichotomous and categorical (Meyers et al., 2006). Thus this study compared the success of community college online and on campus biology students both en mass and between demographic groups in an effort to fully understand similarities and differences between students.

Delimitations

This research focused on Virginia community college non-science major introductory biology students, the largest population served by biology 101 and biology 102. Most associate's degrees require two science lab courses and many non-science major students choose to take biology instead of chemistry or physics (personal observation). The scope of this study did not include students declared as science majors in an effort to properly address the most widely served student population within Virginia's community colleges. Participants enrolled in on campus biology 102 must have completed biology 101 within the past year to ensure consistency in student retention of biological information (Custers, 2010). Data were only collected over two

semesters to create a large sample size but ensure manageability (Arbaugh, 2004; Crewswell, 2009; Price, 2006).

The current study investigated the effectiveness of completely online biology courses through quantitative methods. Although hybrid biology courses (online lecture and on campus lab) are also offered within the Virginia community college biology curriculum hybrid offerings were not included within the investigation. Limiting the research to only online biology courses created a focused inquiry during a period of community college growth in online learning. While qualitative research is also needed to better understand the experiences of students in online biology courses the current study did not explore this facet.

Definition of Terms

The key terms for the current study focus on aspects of distance learning and explain the demographic characteristics investigated through the research. The terms for the research include the following:

Age is discussed in this study by dividing participants into two groups: traditional age students between the age of 17 and 24 years old and nontraditional age students older than 24 years old (Coldwell, Craig, Paterson & Mustard, 2008).

Distance Learning describes the physical separation of teachers and learners that has become popular in recent years, particularly in the United States. While used interchangeably with distance education, distance learning puts the emphasis on the learner and is especially appropriate when students take on greater responsibility for their learning as is frequently the case when doing so from a distance (Simonson, 2008).

Ethnicity indicates a shared genealogy and cultural traits. Ethnicity of participants is examined based on two groups, Caucasian (white) or non-Caucasian (African American, Hispanic, American Indian, Asian, or Other) (Aragon & Johnson, 2008).

Face-to-face is a traditional form of education requiring a student attend a physical class at a predetermined day and time. This physical class meeting allows students to see their instructor and vice versa. This term differentiates between the learning that takes place in a physical classroom and learning that takes place at a distance (Tomei, 2010).

Hybrid course is a class that is conducted both by face-to-face classroom meetings and distance learning activities (Rovai et al., 2008; Simonson, 2008).

On campus refers to face-to-face or traditional classroom learning. This arena deals with the traditional view of education, with teacher and students present occupying the same time and space in a classroom (Tomei, 2010).

Online course is a course where students complete all coursework at times and locations most convenient to them according to a prescribed sequence and timetable, acquiring course materials and interacting with the professor and their peers via the Internet. Often, but not always, students and instructor are separated by space or time with technology bridging the gap (Tomei, 2010).

Online learning is where most or all (at least 80 percent) of the content is delivered online. Typically there are no face-to-face meetings (Allen & Seaman, 2011).

Student success is defined as a final course grade of C (70%) or better (Larson & Sung, 2009; Xu & Jaggars, 2011). This grade is transferable for a community college student transitioning to a four-year institution upon graduation.

Organization of the Study

Chapter 1 presented a brief background of current online biology course research, the statement of problem, purpose statement, and research questions. Chapter 1 also included the professional significance of the study, an overview of the methodology, the delimitations of the study, and definitions of important terminology. Chapter 2 will present a historical background of distance education, the theoretical framework of the proposed research, and discuss in more detail current research related to the effectiveness of online courses at community college focusing specifically on biology classes. The methodology and data gathering procedures are discussed in Chapter 3. Chapter 4 will analyze the results of the study and present statistical findings. Chapter 5 will synthesize the results and present the conclusions of the research in addition to recommendations for further study.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter presents a review of the literature relating to community college online biology courses. It discusses the importance of the topic and theories of distance education focusing on Keegan's equivalency theory. The review continues with the history of distance learning in higher education and specifically within community colleges. The chapter will highlight distance education within the Virginia Community College System (VCCS), the location of the current study. The review will also present a general overview of community college biology research to illustrate important trends within the field. There will be a discussion of current literature regarding online course offerings in relationship to factors that impact student success and retention. Finally, the chapter will focus on online science courses and specifically discuss research related to online biology illustrating the need for the proposed research.

Methodology for Collecting and Analyzing Literature

Extensive research was conducted using Old Dominion University's education databases. These databases accessed both peer reviewed and full text journal articles. The literature search included the following databases: Education Research Complete, Education Full Text, Education: A SAGE Full-Text Collection, and ERIC. Appropriate search terms were used to access Old Dominion University's library catalog and Tidewater Community College's library catalog to locate related books. Search terms included online learning, distance learning, distance education, community college, biology, science, chemistry, student success, retention, persistence, age, gender, ethnicity, learning style, course load, history, science, student satisfaction, and theory. Search

terms were joined together to narrow the search. Common term combinations included community college and biology, distance education and age, distance education and gender, and distance education and student success. All literature searches occurred between January 2012 and August 2013.

Importance of Topic

Online learning in higher education is growing rapidly with over 6.7 million students participating in at least one online course in Fall 2012 (Allen & Seaman, 2013). Community colleges, leaders for years in the distance education arena, saw a nine percent increase in online course enrollment between 2009 and 2010 (Harrell & Bower, 2011; Instructional Technology Council, 2011). Online learning provides open access education to community college students (Geith & Vignare, 2008). As a result, online education is an integral component of the long-term strategic plan at many higher education institutions (Allen, & Seaman, 2011).

The recent increase in distance learning at community colleges is due to several factors. First, online technology improvements such as faster Internet connectivity and standardized course delivery systems facilitate online learning. The technological advances have created a new learning environment allowing both instructors and students to interact with one another and the course material in a flexible and collaborative fashion (Glahn & Gen, 2002). Second, community colleges serve many nontraditional students who are older and have families and careers (Clark, 2012). These busy students desire a flexible course schedule that is not restricted by time or location (Stumpf et al. 2005). A number of students live in remote areas and commute long distances to a community college. Increasing gas prices make an online course a desirable alternative (Lorenzetti,

2005; Stumpf, et al., 2005). Some instructors hold negative attitudes towards online instruction due to intellectual reluctance, resistance to change, cost, and lack of support (Mitchell & Geva-May, 2009). Research regarding the success of students served by online courses is important to develop standards of best practice and improve the quality of current and future distance offerings.

This literature review will focus on student success and student perceptions of online courses. In an effort to properly concentrate on the online student experience the literature review will not discuss the faculty perspective of online learning.

Distance Education Theory

Theories of distance education directly impact practices within the field of online learning and allow administrators to make informed decisions regarding online students. Although the first distance education theories emerged in the 1840s based on the correspondence course model a firm theoretical foundation was not established until the 1970s (Simonson, Schlosser, & Hanson, 1999; Simonson, Smaldino, Albright, & Zvacek, 2003). Distance education both parallels and complements face-to-face learning but some theorists believe it is a separate entity within education (Simonson et al., 1999). Currently, educators utilize several distance education theories and divide them into three groups; theories of industrialization of teaching, theories of independence, and theories of interaction and communication (Keegan, 1996).

Within the theories of independence, Charles Wedemeyer's theory of independent study emphasized the student's autonomy and responsibility for learning in the distance environment (Pyari, 2011; Simonson et al., 2003). Wedemeyer believed the instructor acted as a guide but the learner was not dependent upon the instructor to gain knowledge

(Keegan, 1996; Simonson et al., 1999). Michael Moore's theory of independent study also focused on learner autonomy throughout dialog with the instructor (Simonson et al., 2003). Moore concentrated on the frequency of two-way communication and the responsiveness of the instructor to the needs of the learner (Keegan, 1996; Simonson et al., 1999). Otto Peters developed an alternative theory of distance education relating the learning form to the industrial production of goods (Simonson et al., 2003). Through Peters' theory the process of teaching at a distance became more automated and mechanical (Simonson et al., 1999). Borje Holmberg created the theory of interaction and communication promoting student independence, motivation, learning, and engagement with the institution (Simonson et al., 2003). Holmberg focused on the learning of the individual student and how online instruction could support this learning through open, two-way conversations (Keegan, 1996; Pyari, 2011). Although each distance education theorist had an alternative perspective, all of the theories identify a practical method to both teaching and learning in the online environment and ultimately support the independence of the learner.

Keegan's equivalency theory of distance education (Keegan, 1996) served as the theoretical framework for this study. Equivalency theory suggests that distance education should be built on the equivalency of learning experiences (Keegan, 1996). If the learning experiences of online learners are comparable to face-to-face learners the educational outcomes for the learners will also be equivalent (Simonson et al., 1999). Learning at a distance and learning on campus are fundamentally different experiences and Keegan advocated that online courses should be designed and instructed in a fashion appropriate for the virtual environment. Keegan did not believe online courses held less

value when compared to on campus courses as long as they met the needs of the online students and provided individuals with equivalent learning experiences (Simonson, 1999). The key elements of equivalency theory include:

- Equivalency: although distance and face-to-face learners experience different learning environments it is the instructor's responsibility to provide experiences of equal learning value.
- Learning experience: any aspect that promotes learning and will therefore vary by student. The sum of the learning experiences for each student should be equivalent.
- Appropriate application: learning experiences suitable to the unique needs of each student should be available in a proper and timely fashion.
- Students: should be defined by their enrollment in the course rather than their location.
- Outcomes: There are two categories of outcomes, instructor determined and learner determined. Outcomes are measurable significant cognitive changes in learners because of their participation in a course. Outcomes are independent of the mode of instruction.

Keegan (1996) encouraged distance education instructors to re-create the instructor to learner interaction in the asynchronous environment. Keegan also supported instructors providing complete learning packages to online students including enrollment, counseling, and other support services in addition to classroom instruction. Equivalency theory allows instructors, students, and administrators to hold distance learning as

equivalent to on campus instruction increasing the acceptance of online courses (Simonson et al., 1999).

History of Distance Education

Correspondence Courses

Distance learning began with correspondence courses in Sweden in 1833 and in England in 1840 (Bower & Hardy, 2004; Lease & Brown, 2009; Parchoma, 2010; Simonson et al., 2003; Tracey & Richey, 2005). This form of education became more standardized with Sir Isaac Pitman's establishment of the Phonographic Correspondence Society in 1843. Pittman adapted his shorthand to fit onto postcards to mail to his correspondence students (Bower & Hardy, 2004; Casey, 2008). Within the same time period, correspondence courses were offered for the first time in Germany. By the late 1800s both English and Swedish correspondence institutions offered extensive distance education courses (Simonson et al., 2003).

The United States proved an excellent location for the expansion of distance learning due to the large geographic size and people's desire for knowledge (Casey, 2008). The Society to Encourage Studies at Home founded by Anna Eliot Ticknor in Boston, MA in 1873 became the first true correspondence course institution in the United States. This society enrolled mostly female students offering over 20 different courses to more than 10,000 women over 24 years (Bower & Hardy, 2004; Casey, 2008; Simonson et al., 2003). The society functioned like a college with different departments, membership rules, and fees to cover postage and printing. Similar to a community college, there were no pre requisite requirements for entry and students worked at their own pace (Bergmann, 2001). The first commercial distance education school, the

International Correspondence Schools, was founded in Pennsylvania in 1891 and served more than a quarter of a million students in the first decade (Bower & Hardy, 2004; Tracey & Richey, 2005).

Correspondence courses grew within higher education in the late 1800s following two parallel tracks, one within higher education and the other in the private sector (Saba, 2011). Illinois Wesleyan, the Correspondence University of Ithaca, and the University of Chicago offered both undergraduate and graduate degrees through integrated correspondence courses (Bower & Hardy, 2004; Casey, 2008; Lease & Brown, 2009). The University of Chicago even created an extension division devoted to learning at a distance (Tracey & Richey, 2005). In 1885 the University of Wisconsin began offering short courses leading to the establishment of a correspondence study program. However, at both the University of Chicago and the University of Wisconsin, interest in these extension programs decreased and both were discontinued after a few years (Simonson et al., 2003). Other correspondence programs, however, such as the departments at Moody Bible Institute are still in existence today (Parchoma, 2010).

The goal of all of the discussed correspondence courses was to offer adult education in a flexible setting available to everyone, not just the elite (Saba, 2011). Still today, adult students are the primary group of individuals who utilize distance education. Correspondence courses, however, did not afford extensive learner to instructor interactions. The learner was isolated in the learning process leading to potentially high attrition rates (Parchoma, 2010). The expansion of correspondence courses within higher education was not without controversy as some believed this form of distance education was inferior to classroom education. Others did not support the expansion of education

to the masses, a departure from the earlier ideal that higher education was reserved only for the privileged (Tracey & Richey, 2005). Individuals were right to be cautious about early correspondence courses because they were not standardized in content or delivery. In response the United Stated Department of Education recognized and accredited the Distance Education and Training Council and tasked the organization with developing educational and ethical standards for distance education courses (Lease & Brown, 2009).

Electronic Communication and Technology

In the 1920s universities created radio stations devoted to delivering distance education courses. The development of audiotapes allowed information to be pre-recorded in short segments and later assembled for airing on the radio (Lease & Brown, 2009). The new radio technologies let students hear instructors and eliminated problems such as time delay or loss of correspondence in the mail (Bower & Hardy, 2004; Casey, 2008). Some educators worried that listening to the radio promoted passive learning and expressed concern that the radio stations produced the programs rather than educators (Saba, 2011). Regardless, between 1918 and 1946 the Federal Communication Commission (FCC) granted radio licenses to over 200 colleges (Casey, 2008, Saba, 2011). Radio classes laid the foundation for integrating technology and distance education.

By the 1950s televised courses for college credit were offered at University of Iowa, Purdue University, and Kansas State College (Lease & Brown, 2009; Simmonson et al., 2003). Series such as the Sunrise Semester presented by New York University created continuous higher education programming (Tracey & Richey, 2005). The Educational Broadcasting Facilities Act in 1962 provided millions of dollars for the

continued developmental of educational television (Lease & Brown, 2009). The FCC established the Instructional Television Fixed Service in 1963 enabling low cost access to television courses (Casey, 2008). Improved satellite technology in the 1960s increased the delivery speed of televised teaching. The Public Broadcasting Act of 1967 supported noncommercial television and radio programming through the founding of the Corporation for Public Broadcasting (Casey, 2008; Saba, 2011). Federal funding in the 1970s enabled institutions in the United States and Canada to further integrate satellites and television into courses. Coastline Community College offered the first completely televised college courses in 1970 (Casey, 2008). Although televised courses allowed students to see their instructor, they did not help the instructor provide differential responses to individual students based on the student's needs (Saba, 2011). The development of fiber-optic communication in the 1980s expanded electronic communication and distance learning promoting two-way high quality audio and video communication (Lease & Brown, 2009; Simonson et al., 2003). Both satellite and fiber optic communication were costly upgrades in creating accessible student networks but they proved to be beneficial allowing students and instructors to interact with one another in real time (Casey, 2008; Saba, 2011).

Use of computers and the Internet in the 1990s led to rapid growth within higher education distance learning (Saba, 2011). Although many course offerings were asynchronous, new computer conferencing software enabled students and instructors to communicate in real time (Simonson et al., 2003). Specific software's such as WebCT and Blackboard provided state of the art course management systems (Casey, 2008). Chat sessions and online discussion boards within these management systems promoted

quality synchronous and asynchronous student-to-student and student-to-instructor interactions (Bower & Hardy, 2004; Saba, 2011). Technology enhancements also allowed online students to access administrative functions such as registration and financial aid creating a virtual institution (Parchoma, 2010). The Internet provided easy access to course materials and institutional information saving students time and increasing efficiency (Bower & Hardy, 2004; Parchoms, 2010).

As distance education became mainstream users needed guidelines and best practices in the use of distance education applications. In 1964 the University of Wisconsin created the Articulated Instructional Media (AIM) Project with the goal of identifying and categorizing distance learning practices. AIM also offered suggestions for effective implementation of distance learning practices (Casey, 2008). The establishment of the Distance Learning Education Demonstration program by the United States Department of Education in 1999 continued to develop distance education guidelines to improve the quality of distance learning. Organizations dedicated to online learning in the 1990s such as the Sloan Consortium and MERLOT (Multimedia Resource for Learning and Online Teaching) offered resources to online educators and supported online teaching. The importance of online learning within higher education was further established with the creation of scholarly journals, for example, the Journal of Distance Education and the Journal of Online Learning and Teaching (Perry & Pilati, 2011). The involvement of the federal government and the establishment of both publications and organizations dedicated to online education support the validity of distance learning within higher education (Casey, 2008).

Technological improvements led to the founding of distance education institutions throughout the world. The Open University of the United Kingdom was established in 1971 and remains one of the largest and most influential distance teaching institutions with a wide range of courses and full degree programs (Bower & Hardy, 2004). Fern Universitat in Germany, founded in 1975, is another prominent distance education university offering over 17,000 courses in seven disciplines (Casey, 2008; Simonson et al., 2003). These universities became models used for creating distance learning institutions in Italy, Greece, China, Belgium, Malaysia, France, Greece, and other countries throughout the world (Casey, 2008).

Distance Education in Community Colleges

Community colleges have always worked to educate a wide range of students and as a result, emerged as a leader in distance education (Bower & Hardy, 2004). The expansion of distance education within community colleges followed a similar pathway to other higher education institutions by first utilizing telecommunication strategies including radio and television to deliver educational programming to a wider audience within the service region (Lever, 1993; Shumaker, 1992). Television courses, both open and close circuit, offered educational opportunities to both community college students and community members. Televised instruction became so popular in community colleges that by the 1980s two thirds of community college instructors had access to media production facilities (Cohen & Brawer, 2003). Satellite courses were also a popular distance education option within community colleges beginning in the 1970s allowing students at a distance to participate in both academic and occupational courses (Gross, 1997). The advancement of computer and Internet technologies in the 1990s

resulted in further expansion of community college distance education. The support of the American Association of Community Colleges for distance education through online technologies helped community colleges nationwide as they expanded their online course offerings (Pierce, 1998).

Summary

From its conception through correspondence courses distance education evolved to incorporate technological improvements thereby serving a larger population of students (Casey, 2008; Simonson et al., 2003). Throughout its history, distance education catered to adult learners who desired a flexible schedule. Technological developments coupled with student demand provided fuel for the expansion of online learning (Bower & Hardy, 2004; Parchoma, 2010). Regardless of the delivery method, all classes have the common theme of providing instruction in a format where the teacher and student do not have to be in the same place at the same time. The success of distance education is illustrated by its longevity, its ability to evolve with changing technologies, and its acceptance within higher education (Casey, 2008).

Virginia Community College System and Online Education

The Virginia General Assembly established the Virginia Community College System (VCCS) in 1966 to fulfill the state's need for a comprehensive higher education system. Virginia wanted to develop an educated and skilled workforce in an effort to expand the state's economy (Our History, n.d.). Today the VCCS includes 23 colleges located on 40 different campuses in rural, suburban, and urban areas throughout the state. Each community college developed its own online program based on the goals of the

college, the available resources, and needs of the student population (Xu & Jaggars, 2011).

The VCCS recognized the importance of providing quality online education and created a distance learning strategic plan in 2001. The plan was formulated in response to the changing needs of Virginia learners and the increased student demand for access to higher education. In 2001, the VCCS had over 28,000 students using distance education resources (Virginia Community College System, 2001). In developing the strategic plan, the VCCS reviewed the distance learning environments of all 23 community colleges and found an inequality in institutions' readiness and ability to successfully deliver online courses and support services. Therefore, the distance learning strategic plan included a vision and strong leadership in the effort to provide accessible, high quality distance learning across all Virginia community colleges. This plan emphasized a student centered approach to online learning and offered support services for both students and faculty. The VCCS outlined a governance model detailing the responsibilities of both the college and the VCCS distance learning service center, funding strategies, an implementation timeline, and a communication plan.

The strategic plan has allowed Virginia community colleges to develop a compressive distance learning program and effectively serve students. The VCCS continues to track online students and in the 2006-2007 academic year recorded an enrollment of 73,871 students within distance education courses. This headcount represented 16.3% of the VCCS full time equivalents (FTES). By 2012-2013 Virginia community colleges had 141,140 students enrolled in online courses corresponding to 27% of the FTES (Distance Learning Enrollment Summary, 2013). These data indicate

an increase in online student enrollment and it is anticipated online course enrollment will continue to grow.

The VCCS investigated online course offerings publishing a large study in 2010 entitled "Online Learning in the Virginia Community College System" (Jaggars & Xu). The research examined both college ready and developmental students in online courses throughout Virginia community colleges. The study focused on patterns of online course taking, retention and performance, and subsequent educational outcomes. Jaggars and Xu (2010) tracked 24,000 program placed first time VCCS students from 2004 through 2008. Within the first year 14% of students attempted one online course and 43% of students attempted an online course during the four-year period. Women, Caucasian students, English speaking students, and academically prepared students were more likely to participate in an online course. Also, students older than 25 years old, students who previously completed an online course, and students who had taken a computer literacy course were more likely to enroll in an online course during their first year (Jaggars & Xu, 2010). The researchers incorporated financial aid information and found high rates of online course enrollment for students who were independent and had dependents, indicating a large degree of external responsibility and a need for course schedule flexibility. Among students who took a VCCS online course, 31% attempted only one course while 28% took three to five online courses and 22% took six or more (Jaggars & Xu, 2010).

Jaggars and Xu (2010) also investigated the types of courses offered online throughout the VCCS. Typically online courses were three credit college level courses. High percentages of online courses were offered in Humanities, Social Sciences, and

occupational areas such as Health and Business. Subjects including English, Physical Science, Engineering, and Natural Sciences showed a lower proportion of online course enrollments (Jaggars & Xu, 2010). Online courses were more popular during summer semesters but in any semester it was rare for a VCCS student to enroll in an entirely online curriculum (Jaggars & Xu, 2010). The research identified two trends responsible for the increase in online course enrollments over the four-year period. First, students were more likely to enroll in an online course as they completed more total VCCS courses. Second students who actively participated in online courses increased the proportion of online credits over time (Jaggars & Xu, 2010). Therefore, online courses were successfully serving a select population of Virginia community college students.

When compared to on campus courses, VCCS students enrolled in online courses had a lower course completion rate in both college level and developmental classes (Jaggars & Xu, 2010). Students who completed an online developmental class in math or English were less likely to progress to the college level curriculum as compared to students who completed developmental classes on campus. Jaggars and Xu (2010) found students who participated in an online course within the first semester or the first year were significantly less likely to persist to the following semester. There was no significant difference, however, in student degree obtainment or transfer between VCCS students who completed an online course and students who only participated in face-to-face classes (Jaggars & Xu, 2010).

In an effort to determine how VCCS online student experiences had changed since 2004, Jaggars and Xu (2010) conducted additional analyses on 28,000 program placed students entering in summer or fall 2008 and tracked through spring 2009. Within

the first year, 27% of students attempted an online course, an increase from the original 2004 study. Students who had previously taken an online course or had earned prior credits were more likely to enroll in an online course (Jaggars & Xu, 2010). The most common online courses did not significantly change from 2004 to 2008 but there was a small decrease in Social/Military sciences. Although more students in the 2008 cohort completed at least one online course (46%) only 7% of students completed six or more online classes (Jaggars & Xu, 2010). Online course completion rates were lower as compared to on campus courses for the 2008 cohort but not significantly different from the 2004 cohort. Students who completed at least one online course in Fall 2008 had a 73% chance of returning in Spring 2009 as compared to a 75% chance for students who completed only face-to-face courses. These percentages are similar to the 2004 cohort findings (Jaggars & Xu, 2010). Overall, the second analysis illustrated very few changes in Virginia community college student online course participation and achievement patterns.

In a second analysis, Xu and Jaggars (2011) focused on the success of VCCS students completing their first college level math or English course online. As these courses have high student enrollment and are required to move forward in most associate degrees it is important for the VCCS to understand how online sections are serving students. Using the data set previously described from 2004 through 2008 multi-level logistic regression and propensity score matching compared online and on campus math and English students (Xu & Jaggars, 2011). The analyses indicated that students who completed their first college level math or English course online had a significantly higher chance of withdrawing as compared to students who completed the same courses

on campus. Furthermore, online students who completed the college level math or English course had a significantly lower chance of receiving a grade of C or higher, a successful and transferable grade, as compared to students in the on campus course (Xu & Jaggars, 2011). The findings suggest that online courses might not be the best option for VCCS students completing their first college level course within either math or English. Introductory biology (biology 101 and biology 102) is the first college level course within the biology sequence but VCCS student success within this sequence has not been studied.

Summary

The large, multiyear study of online student success conducted by the VCCS illustrates the institution's support for online education and the desire to effectively serve students with online courses. The study successfully investigated multiple aspects of Virginia community college education creating a complete snap shot of online course offerings and how these courses impacted distance students. The follow up study comparing 2004 students to 2008 students further expanded the picture illustrating the permanency of online education within the VCCS. Although the findings of the study were not all positive having a baseline will allow for comparisons and accurate measures of future improvements and changes. The focused investigation of online English and math determined the required courses challenged distance learning students. Many Virginia students complete introductory biology to fulfill a science with laboratory degree requirement yet the VCCS has not studied online student success within this course. Jaggars and Xu (2010) discussed the need for more research to help identify effective online teaching strategies and institutional policies to support online courses.

The current study helps the VCCS learn more about online biology course options as a part of this larger goal.

Community College Biology

Community colleges have always focused on liberal arts transfer courses but even the earliest two-year institutions offered curriculum within the sciences (Cohen & Brawer, 2003). Currently, community colleges strive to provide students with a general education curriculum; a scaffolding of learning that allows students to develop life skills including critical thinking, core values, and respect for diversity. The holistic curriculum introduces students to the humanities and fine arts, the social sciences, and the natural sciences (Cohen & Brawer, 2003). Biology courses fall within natural sciences. Community colleges offer a biology curriculum centered on courses appropriate for transfer to a four-year institution, for example, introductory biology. Introductory biology is typically a four-credit survey course (three credits for lecture, one credit of lab) taught over two semesters (Marcus, 1993). Community colleges also have biology courses such as Anatomy and Physiology for students entering careers in health science (Beeber & Biermann, 2007). To accommodate students planning a career within science the VCCS offers an associate of science degree including courses within biology, chemistry, and physics (Virginia Community College System, n.d.). Frequently community college students who are not science majors participate in biology courses because associate degrees require one to two laboratory science course electives (Muchovej, 2009). Many community college students choose to take biology instead of physics or chemistry (Cohen & Brawer, 2003). Therefore, introductory biology serves a diverse student population (Marcus, 1993).

One focus of community college biology literature is curriculum development. Specifically research about biology laboratories discusses inquiry based learning. Inquiry based laboratory learning includes four different approaches: open induction where the students formulate the entire project, an investigative lab where students complete initial prescribed activities and use what they learn to create their own experiments, open ended inquiry in which students are given the procedure but create their own hypotheses, analyze results, and draw conclusions, and guided inquiry in which the students perform experiments based on procedures created by the instructor (Sundburg & Moncada, 1994). Basey, Mendelow, and Ramos (2000) surveyed the first semester biology laboratory curriculum across Colorado community colleges noting levels of inquiry and technology. None of the schools extensively utilized inquiry learning within their laboratory activities and the researchers concluded students needed more practice in defining variables and creating methodologies. Microscopes were the most commonly used form of laboratory technology but these tools did not enhance inquiry based learning (Basey et al., 2000). Lunsford (2003) discussed the implementation of a long-term inquiry based laboratory experiment within a community college freshman biology lab. The twelve students who participated the study had various majors and only one had taken a previous science course. Students enjoyed complete freedom to design and implement their experiments even asking for more class time to work outside of scheduled lab hours (Lunsford, 2003). The success of the inquiry based laboratory within a diverse group of students illustrated how introductory biology can provide a positive learning experience for a wide range of individuals.

Other research investigates different ways in which community college biology instructors can effectively teach the diverse students population enrolled in introductory biology. Marcus (1993) analyzed nine different introductory biology textbooks and determined that the textbooks focused extensively on molecular biology and new biology vocabulary. The varied community college biology class student population may not be able to grasp the extensive terminology and details associated with molecular biology. Therefore, Marcus suggested focusing more on evolution and genetics because non-biology major students can better understand these topics and relate them to their lives outside of the classroom. Micikas (1996) drew similar conclusions suggesting instructors find opportunities for community college students to focus on the big picture and learn how biology is connected with everyday life. Establishing strong connections between biology concepts and the student's life outside of the classroom will create knowledgeable citizens and support the general education curriculum of the community college.

Community college instructors are also incorporating alternative testing and study techniques to help students succeed in biology courses. Phillips (2008) recognized the low study skills of some community college introductory biology students and implemented short open book tests in an effort to enhance student's use of the textbook and improve study skills. The open book tests significantly improved student study skills especially among the weaker students who failed the first open book exam (Phillips, 2008). Non-science major students in a biology course at Tallahassee Community College had the opportunity to complete optional online quizzes between lectures. The purpose of the quizzes was to increase understanding and to earn participation points

(Muchovej, 2009). Although some of the quiz questions appeared on later exams students who completed the quizzes performed significantly better on only 37% of the repeat questions as compared to their classmates who did not take the quizzes. Only 3% of the entire class took all of the available quizzes indicating a lack of interest or motivation within the non-science major students in spite of the instructor's efforts to help them (Muchovei, 2009). Briscoe and LaMaster (1991) discussed the successful use of concepts maps in a community college introductory biology course. After learning how to create concepts maps in class, students reported creating their own maps to study. The concept maps helped students visualize the big picture connections between topics instead of simply memorizing all of the information (Briscoe & LaMaster, 1991). The results of these studies point to the effort of community college biology instructors to effectively serve the diverse student population. Although the primary objective within the biology course is to teach biology content, instructors are also aiming to help students learn skills that will benefit them throughout their educational careers.

Researchers have also investigated student learning style and the impact of prior biology courses on student success within introductory community college biology courses. Johnson and Lawson (1998) found that student reasoning ability was a significant predictor of student achievement in both an inquiry based and an expository based non-major introductory biology course. The research also indicated that measured prior knowledge had no impact on student success (Lawson, 1998). Therefore, community college biology instructors should focus on teaching inquiry skills and scientific reasoning in order to help students succeed in introductory biology courses. As an alternative to student learning styles, Lawson and Johnson (2002) measured

community college students' ability to think verses feel in both an inquiry based and an expository based non majors biology course. Regardless of instructional method, students who relied on thinking reasoning patterns were more successful suggesting that instructors should work to help students improve their reasoning abilities (Lawson & Johnson, 2002). A community college in Texas utilized the Keller Method to address the different needs of students in an anatomy and physiology class. The Keller Method breaks information into short modules and the students worked at their own pace and retested until they reached competency (Fike, Raehl, McCall, Burgoon, Schwarzlose, & Lockman, 2011). With the implementation of the Keller Method underprepared minority anatomy and physiology students achieved final learning outcomes equivalent to their academically ready classmates. All students within the course achieved a mean learning improvement of 40% illustrating the effectiveness of the Keller Method within community college biology courses (Fike et al., 2011).

In an effort to further help community college students succeed in biology courses, a subset of research discusses utilizing developmental level courses to prepare students for upper level biology classes. Kingsborough Community College implemented a biology foundations course as a prerequisite for anatomy and physiology students (Beeber & Biermann, 2007). Students were required to either complete this course, the first semester of introductory biology, or pass an exemption exam before entering first semester anatomy and physiology. A survey of students enrolled in anatomy and physiology after completing the foundations course illustrated 80% of respondents believed the foundations course provided them with the skills necessary to succeed in the upper level biology course (Beeber & Biermann, 2007). Biermann and

Sarinsky (1993) tracked community college student success by measuring course grade in introductory biology and anatomy and physiology after students had completed a preparatory biology course that emphasized hands on learning. The students who participated in the developmental course performed significantly better than students who entered directly into introductory biology or anatomy and physiology (Biermann & Sarinsky, 1993). Therefore, preparatory biology courses help underprepared students learn the skills necessary to succeed in upper level biology courses. These courses allow community colleges to better serve a wide student population and help these students reach their educational goals.

Summary

Community colleges serve a diverse population of both science major and non major students with biology course offerings. Biology instructors are aware of the varied needs of their students and integrate different teaching methodologies in both the laboratory and the lecture classroom in an effort to better serve students who enroll in biology courses. With the presence of many different educational techniques in community college biology literature there is currently not a single method guaranteed to be the best fit across all biology instructional situations. Non-science major students who are indifferent offer a challenge to biology instructors due to student lack of interest or motivation. Regardless, the research does offer suggestions such as inquiry based learning and the Keller Method to enable biology instructors to assist their students (Fike et al., 2011; Lunsford, 2003). The literature also illustrates that not all community college students are prepared for biology courses. Community colleges are working to

help underprepared students with developmental biology course options (Beeber & Biermann, 2007; Biermann & Sarinsky, 1993).

Student Success

There are many different definitions of student success. The most common definitions relate to course grades, persistence, retention, number of credits earned, length of time to complete degree, and graduation. Educators also examine scores on standardized entrance tests and field-specific examinations to define student success (Definitions and Conceptual Framework, 2007). A community college graduate who transfers to a four-year institution or receives a job upon graduation would also be considered a successful student (Roksa, 2009). Studies have additionally looked at student personal development and student engagement as measures of student success (Kuh, 1995; Kuh, 2003). The current research investigated student success through student final course grade in the second course in the introductory biology sequence.

Previous studies in various disciplines have used student grades in subsequent courses as a measure of student success at both community colleges and at four-year institutions. Thornton (2006) assessed student success at the University of Southern Maine with student final grades in upper level psychology courses after completing either a one or two semester introductory psychology course. The two semester course had no significant advantage as compared to the one semester introductory psychology class (Thornton, 2006). A study of Los Angeles community college math students traced student progress from entry in Fall of 1995 through 2004 investigating the impact of grades received in the first math courses on grades received in future math courses (Hagedorn, Lester, & Cypers, 2010). Green, Stone, Zegeye, and Charles (2009) found

that pre-requisite math course sequence impacted student success and course grade in a future business statistics course. The varied use of student grades in upper level courses supports the implementation of this student success measure in the current study.

Student Success in Online Courses

When investigating student success in online courses, educators typically ask, is the online course as good as the on campus course? The measure of success most commonly used in the across mode comparisons is student grade. However, to account for potential faculty differences in pedagogy and educational philosophy, converting grades into letters instead of percentages creates a more consistent measure of student success (Moskal, Dziuban, Upchurch, Hartman, & Truman, 2006). Successful grades are A, B, and C while students who withdraw or receive a D or an F or an incomplete grade would be unsuccessful.

Online courses are not a viable option if online students are not as successful as students completing on campus courses. Many studies have investigated online learning at four-year institutions. At England's Open University there was no significant difference in pass rates between online and on campus students (Price, 2006). Lim, Kim, Chen, and Ryder (2008) compared undergraduate students in online, on campus, and hybrid versions of a required wellness course and found students in the online and hybrid courses had higher levels of achievement as compared to the on campus students. In an undergraduate nursing statistics class there was no significant difference in grades between online and on campus students (Summers et al., 2005). In a true experimental design, upper level undergraduate psychology students were randomly placed into on campus lecture, online synchronous lecture, or online asynchronous lecture. There was

no significant difference in student grades between instructional modes and online students indicated they felt they learned the material better (Newlin, Lavooy, & Wang, 2005). Although this study was short examining a 20 minute lecture in each delivery mode, the researchers standardized many of the variables and successfully created an experimental procedure as compared to most online educational research that utilizes quasi-experimental designs. At the University of Central Florida (UCF), student success (receiving an A, B, or C) ranged from 84-88% between Summer 2004 and Spring 2006 across all completely online courses. Withdrawal rates for online courses at UCF were low between 5-7% (Moskal et al., 2005). Karatas and Simsek (2009) studied first semester students at Gazi University and found on campus students scored significantly higher on the final exam as compared to online students. Students who participated in the on campus course also scored significantly higher in permanency of learning (Karatas & Simsek, 2009). Although most research at four-year institutions points to the success of students in online courses student knowledge retention may be lower as compared to on campus students.

Researchers have also investigated student success in community college online courses. At two community colleges in Nevada, 71.6% of on campus students and 75.3% of online students successfully completed the same class (Doherty, 2006). At Bronx Community College, online and on campus medical terminology students were equally satisfied and exhibited no significant difference in final course grades (Somenarain et al., 2010). Ashby, Sadera, and McNary (2011) compared community college student's final grades in a developmental Algebra course offered online, on campus, and as a hybrid and found no significant difference in final course grade between the different learning

environments. Students in the online sections had the highest course grades while students in the hybrid section received the lowest grades and the researchers concluded the learning environment impacted math student success (Ashby et al., 2011). A meta-analysis of online learning studies published by the United States Department of Education (2010) found online instruction to be as effective as face-to-face instruction. Overall, community college students participating in online courses are as successful as students enrolled in comparable on campus offerings.

A subset of research within instructional technology referred to as the "No Significant Difference" phenomenon specifically investigates how the course delivery mode impacts the success of the student. Much of the literature, as discussed above, illustrates that if course content and teaching techniques are kept constant students completing courses at a distance are neither more nor less successful that students completing courses on campus (Russell, 2010). Clark (1983, 1994) said the course media was a truck delivering the message but not impacting student success. In studies comparing online and on campus courses a finding of no significant difference does not mean that the two media are equally effective. Rather, the results indicate the treatment did not impact learning (Clark, 1983). As long as the media does not change the educational message the method used to deliver the message, online or on campus, will not affect student success (Russell, 2010). Surry and Ensminger (2001) surveyed instructional technology researchers to determine how they valued media comparison studies. Although the results of the survey showed some researchers valued the studies while others did not there were three main reasons why the participants did not value media comparison studies. Researchers needed to better understand different

technologies and how these options affected learners in order to design more effective studies. Media comparison studies also had many confounding variables making it challenging to draw valid conclusions. Finally, many researchers argued that one media is no better nor worse than the second (Surry & Ensminger, 2001). The media is simply the way to deliver the message, pointing back to the "No Significant Difference" phenomenon.

In opposition to the "No Significant Difference" phenomenon Kozma (1994a, 1994b) stated researchers had failed to establish the relationship between media and learning due to the constrains of the theories that shaped the instructional design field. Kozma proposed investigating the interaction between the cognitive act of learning and the type of learning environment in an effort to discover the relationship between media and learning. Researchers value media comparison studies because they are logical in design and easy to conduct. Media comparison studies are desirable due to changing technological formats creating new products that can be compared and analyzed. Administrators also value media comparison studies because they produce quick, usable results that can inform course offering and purchasing decisions (Surry & Ensminger, 2001). There are researchers who believe the studies within the "No Significant Difference" phenomenon have significant design problems leading to inaccurate conclusions. Joy and Garcia (2000) examined five media comparison studies and found the studies did not adequately control for method of instruction, prior knowledge of students, time on task, and student learning style. As a result, it was impossible to determine if differences in student success resulted only from alternative instructional methods (Joy & Garcia, 2000). As much of the literature does point to equal student

success in online courses as compared to on campus courses the debate continues as to the role of the media in course delivery and student learning.

Online Student Retention and Persistence

As previously discussed retention and persistence are useful measures of student success. Online courses have lower retention rates as compared to on campus courses (Mitchell, 2010). Within community colleges, noncompletion rates ranged from 20.6% to 24% for on campus courses and 25.9% to 30.2% for the online course (Moore, et al., 2003). Community college students cited many reasons for withdrawing from online courses including time constraints, the amount of time required to receive instructor responses, technical or computer issues, institutional problems, and incompatible learning styles with the online environment (Aragon & Johnson, 2008; Packham et al., 2004). Online students most frequently discussed lack of time and the ability to procrastinate as reasons for non-completion (Doherty, 2006; Moore et al., 2003). Interviews with students who withdrew from online courses indicated the largest reasons for course withdrawal were changes with employment and job related responsibilities (Packham, et al., 2004; Willging & Johnson, 2004). Therefore, unsuccessful online community college students are overcommitted juggling work, family, and school and are unable to complete course requirements in a timely fashion. Online courses are appealing to busy students due to the flexibility of the course delivery yet some students appear to be too occupied to successfully complete their studies.

Kemp (2002) determined life events, family, home, and financial obligations did not influence whether an adult undergraduate student completed or failed to complete an online course. Students who created healthy relationships, could determine right from

wrong, and maintained a positive view were more likely to complete an online course (Kemp, 2002). Conversely, Park and Choi (2009) found a direct positive relationship between student persistence and family and organizational support. Students were more likely to drop out of an online course if they did not believe the course had a direct relevance to their lives (Park & Choi, 2009). Online courses that students were most likely to not complete included health education, English, history, math, and communications (Moore et al., 2003). Harrell and Bower (2011) created a regression model to predict community college online student persistence and determined auditory learning style and high basic computer skills negatively impacted course persistence while a higher GPA positively impacted persistence at a significant level. Students who are engaged in their education and supported by their family will be more likely to successfully complete an online course.

Student Satisfaction

Community college students appreciated the flexibility of online classes because they could complete coursework on their own schedule and in an environment of their choice (Doherty, 2006; Sullivan, 2001). Students found convenience in the self-paced online learning format (Hartmann, Patsy, & Chuck, 2005). This trend of online course convenience and flexibility was also apparent at four-year institutions (Lim, et al., 2008; Rodriguez, Ooms, & Montanez, 2008; Song, Singleton, Hill & Koh, 2004). Online student satisfaction increased based on supportive interactions with the instructor and the ability to apply the course to their everyday life (Jackson, Jones, & Rodriguez, 2010; Lee, Srinivasan, Trail, Lewis, & Lopez, 2011; Paechter, Maier, & Macher, 2010; Thurmond, Wambach, & Connors, 2002). Structured and organized online courses also received

higher student satisfaction ratings (Jackson et al., 2010; Paechter et al., 2010; Song et al., 2004). Thurmond et al. (2002) determined that online student characteristics (computer skills or age) did not help predict student satisfaction. Rather, environmental factors were highly predictive of online student satisfaction. In comparison to on campus courses, there was no difference in student satisfaction scores in the online environment (Allen et al., 2002: Karatas & Simsek, 2009). In some studies, online courses had higher levels of student satisfaction verses the comparable on campus offering (Lim, et al., 2008; Reeves & Osho, 2010). The high ratings of student satisfaction point to the success of the virtual learning environment.

In discussing negative aspects of learning online, students mentioned difficulty with online communication and the lack of face-to-face contact with the instructor and classmates (Doherty, 2006, Rodriguez et al., 2008). Specifically, students discussed the lack of immediacy in instructor response as a negative feature of online courses (Hartmann et al., 2005; Summers et al., 2005). Missing real time face-to-face interactions is a common theme within the online student satisfaction literature independent of course subject and institution type (Hartmann et al., 2005; Sullivan, 2001; Summers et al., 2005). Song et al. (2004) interviewed online students and they reported technical problems and a lack of sense of community as challenges in the online environment. Therefore, online course design should focus not only on course content and technology, but also course delivery and implementing a sense of community through all online contexts.

Student Demographic Characteristics as Predictors of Success

Age.

An online student's age impacted the individual's success in the virtual environment. Even though older online students may have been unfamiliar with the technology utilized, they were more successful due to their maturity, motivation, critical thinking, and time management skills (Dibiase & Kidwai, 2010; Doherty, 2006; Garcia & Qin, 2007; Hoskins & van Hooff, 2005; Muilenburg & Berge, 2005; Ransdell, Kent, Gaillard-Kenney, & Long, 2011). Older students were also more connected to their online classmates displaying more active participation in discussion boards (Hoskins & van Hooff, 2005; Ransdell et al., 2011). Garcia and Qin (2007) studied students enrolled in a variety of distance courses at North Arizona University and found younger students perceived online courses to be easier. Younger students looked for short cuts and devoted less time as compared to older students (Garcia & Qin, 2007). Dibiase and Kidwai, (2010) compared older and younger online geography students and determined younger students logged into the course one-third less and spent 50% less time once logged in. This difference in time spent within the online course did not affect geography student performance based on age (Dibiase & Kidwai, 2010). Ransdell et al. (2011) found similar trends in an online graduate level health science course as older students exhibited more active participation. Conversely, Coldwell et al. (2008) found no significant difference in participation between older and younger students in an online course. The maturity of older students influenced how they approached online courses regarding the overall time applied and communication techniques.

In relationship to student age, Diabiase and Kidwai (2010) determined older students were more satisfied with online courses while Yukselturk (2009) found no relationship between student satisfaction and age. Overall, younger students missed the face-to-face interactions and although older students were overall satisfied they lamented the lag time of instructor responses (Hartmann, Moskal, & Dziuban, 2005). Independent of age, all online students appreciated the flexibility and convenience of online learning (Park & Choi, 2009). The impact of student age on course completion is not completely understood as Hartmann et al. (2005) found age did not effect student completion but Moore, Bartkovich, Fetzner, and Ison (2003) determined students under the age of 25 were less likely to successfully complete an online course. The apparent differences in age of students in relationship to student success and perceptions of online courses are important within the community college due to the wide range of students served.

Gender.

Access to computers is not a barrier to either gender allowing wide participation in online courses (Price, 2006). Although both male and female students enroll in online courses for flexibility and convenience, more female students cited flexibility as an important characteristic of their online learning experiences. Females specifically mentioned family and children in reference to the flexibility provided by online courses (Sullivan, 2001). Female students had a higher level of perceived learning as compared to male students due to their ability to develop a sense of community in the online environment (Lin & Kim, 2003; Rovai, & Baker, 2005). Female students participated significantly more in online discussion boards, exhibited more self confidence, and communicated more with instructors indicating a high level of engagement (Coldwell,

Craig, Paterson, & Mustard, 2008; Price, 2006; Rovai, & Baker, 2005). Women also exhibited a greater willingness to learn from classmates (Price, 2006). This openness led to a more rewarding and educationally effective experience for female online students (Rovai, & Baker, 2005).

Current research on the relationship between gender and online course completion is inconclusive. Sullivan (2001), Kemp (2002), and Park and Choi (2009) found no difference between gender while Aragon and Johnson (2008) and Packham, Jones, Miller, and Thomas (2004) determined females had a significantly higher completion rate as compared to men. Even with their success in the virtual environment, more female students missed face-to-face interactions and immediate responses from instructors (Price, 2006; Sullivan, 2001). Male students were better able to work independently in the online environment (Sullivan, 2001). Male students also rated potential barriers to learning in the online environment higher than females (Muilenburg & Berge, 2005). Even though male students were successful at working independently in online courses the higher rating of potential barriers could explain the lower completion rate for men in online classes.

There is a discrepancy regarding the relationship between gender and student success in online courses. Sullivan (2001) found no difference between male and female course pass rate and Yukselturk (2007) determined gender did not significantly contribute to student success. Conversely, Price (2006) calculated the odds of a female passing an online course were more than twice the odds for a male. This same trend of higher female success is present within community colleges (Doherty, 2006). Lin and Kim (2003) found females exhibited a significantly higher degree of learning as compared to

males. Female students also scored higher than males in both continuous assessments and examinations (Price, 2006). There was no difference, however, in motivation or satisfaction between male and female online students (Reeves & Osho, 2010; Yukselturk, 2009; Yukselturk & Bulut, 2009). Male and female students valued different aspects of the online course as males appreciated interest in the topic and females valued the usefulness, repetition of material, and the chance to use new knowledge (Lim & Kim, 2007). The higher level of engagement by females and their ability to create a sense of community in the online environment may account for their success within the virtual environment.

Ethnicity.

Sullivan (2001) found no difference in online student performance as related to ethnicity. Similarly, in a study at a rural community college, there was no difference in online course completion between white and non-white students (Aragon & Johnson, 2008). Students of different ethnic backgrounds were equally satisfied with online course offerings (Reeves & Osho, 2010). Although Muilenburg and Berge (2005) did not directly evaluate student performance, they determined Asian and Hispanic students rated potential barriers to online learning higher when compared to Caucasian and African American students. In regards to online course completion, Moore et al. (2003) determined community college African American students had lower completion rates than students of other ethnic backgrounds. African American students cited lack of computer access as an important factor affecting their ability to complete the course (Moore et al., 2003). It appears that access to technology can impact the achievement of

different ethnic groups in an online environment and therefore technology must be readily available to ensure student success.

Student Educational Characteristics as Predictors of Success

Learning style.

Although not directly addressed within the current study, researchers have investigated student success in online courses based on student learning style. Online courses are viable options for students with different preferred learning styles. In comparing online and on campus graduate students enrolled in an instructional design course, students utilized similar study strategies and learning aids independent of course delivery method. Overall, online students were more reflective and exhibited a higher level of abstract conceptualization while on campus students participated more in active experimentation (Aragon et al., 2002; Doherty & Maddox, 2002). Although there were apparent differences in learning preferences between online and on campus students, there was no difference in student achievement indicating learning style does not impact student success in online courses (Aragon et al., 2002; Yukselturk, 2007). Similarly, within community colleges, the frequency of student learning styles did not significantly differ between online and on campus students (Doherty, 2006).

Course load and online course experience.

At the community college, students who successfully completed online courses enrolled in more online classes (Aragon & Johnson, 2008). Students who had completed more total courses, both online and on campus, were more likely to successfully complete an online course (Doherty, 2006; Moore et al., 2003). Hachey, Wladis, and Conway (2012) found a strong correlation between prior online course experience and future

online course success (as measured by a course grade of C or higher) in community college students. Students who completed online courses also had a higher GPA as compared to students who did not complete online courses (Aragon & Johnson, 2008). However, Doherty (2006) identified a slight negative correlation between student success and the total number of credit hours taken during the semester of the online course indicating students were more likely to withdraw or fail an online course if they had a heavy overall course load. Similarly, Moore et al. (2003) found full time students when compared to part time students had a lower online course completion rate. The completion rate of part time students was higher in online courses as compared to on campus courses indicating online courses may better serve the part time student population (Moore et al., 2003).

Competency with computers and the Internet impacted student success in online courses more than the number of previous online courses completed. Computer self-efficacy had the highest significant relationship with online student satisfaction and intent to enroll in future online courses (Artino, 2010; Lim, 2001). Lim (2001) determined computer self-efficacy was negatively correlated with academic status and age and positively correlated with years of compute use, frequency of computer use, and number of courses taken online. Although Lim's study occurred at a four-year institution the focus on adult learners makes the results applicable within a community college setting. Kemp (2002) found no significant difference in online course completion between students who had previously taken an online course but withdrawn and students who had previously completed the online course. These results indicated little to no impact of prior online experiences on student retention in future online courses (Kemp, 2002).

In a study of MBA students, Arbaugh (2004) determined that student satisfaction with online courses significantly increased with subsequent online courses. Although there was no significant change in student learning, student perceptions of learning quality, effectiveness, and ease of online environment increased greatly between the first and second online course (Arbaugh, 2004). After surveying over 1000 students at different higher education institutions Muilenburg and Berge (2005) found students who had never participated in an online course scored barrier factors such as lack of social interaction and instructor issues much higher as compared to students who participated in multiple online courses. These results contradict Kemp's (2002) study indicating prior online experience impacts future course selection decisions. Overall research supports the idea that students should take at least two online courses to draw appropriate conclusions about the feasibility of delivery method in relationship to their educational goals (Arbaugh, 2004).

Employment.

Lim and Kim (2003) studied how employment influences student success in online courses and determined unemployed online undergraduate students had a higher learning application than part time and full time students enrolled in the same course. At E-College Wales online students employed in private sector jobs exhibited a 50% withdrawal rate as compared to unemployed online students who had a 40% withdrawal rate (Packham, et al., 2004). Students with full or part time jobs need to take online courses due to the flexibility provided yet these individuals might not have the time necessary to devote to the course to ensure their success.

Summary

The current literature points to several important trends in online student success. Most students take online courses due to the flexibility and convenience afforded but these students are also busy with family, career, and school leading to high rates of non completion (Aragon & Johnson, 2008; Doherty, 2006; Hartmann et al., 2005; Lim et al., 2008; Moore et al., 2003; Packham et al., 2004; Sullivan, 2001). Busy students who have support, are organized, and can see the application of the online course in their daily lives are more likely to complete an online course (Jackson et al., 2010; Lee, et al., 2011; Paechter et al. 2010; Park & Choi, 2009). Overall, older students and female students are more successful in the online environment (Dibiase & Kidwai, 2010; Doherty, 2006; Garcia & Qin, 2007; Lin & Kim, 2003; Packham et al., 2004; Price, 2006; Ransdell et al., 2011). Although lack of access to technology can be a barrier to successful online course completion student comfort in the virtual world increased with more online course attempts (Arbaugh, 2004; Moore et al., 2003; Muilenburg & Berge, 2005).

Much of the research discussed occurred at four-year institutions and although these institutions serve a different student population, community colleges can learn from these studies. As community colleges serve a diverse student population these institutions will benefit from online course research focused on differences in students in regards to their age, ethnicity, learning style, and employment. The literature indicates potential gaps in research regarding the relationship between student success and ethnicity, employment, and previous online experience. These areas can be explored further in future research.

Online Science

Science students, independent of learning environment, must demonstrate proficiency in laboratory concepts and techniques requiring instructors to create a supportive learning environment. This task proves challenging online due to the lack of current literature providing suggestions for best practices (Kennepohl & Shaw, 2010). The largest hurdle is offering quality hands on laboratory experiences in the online environment. Laboratory activities are important for science students as they provide practical skills, allow the application of the scientific method, and promote teamwork, communication, and problem solving (Reid & Shah, 2007). Laboratory experiments frequently require expensive equipment or hazardous chemicals making experiments potentially dangerous without proper safety and supervision (Lyall & Patti, 2010). Laboratory skills are essential and replicating these experiences in the virtual world is difficult (Kennepohl & Shaw, 2010). Due to these barriers, educators have negative stereotypes towards online science courses (Bradley, 2007; Instructional Technology Council, 2011).

Online Chemistry

Higher education students, both online and on campus, find chemistry laboratories intimidating due to complicated procedures and chemical hazards (Kennepohl, 2007). Completing the chemistry laboratory in the familiar home environment with a lab kit or online simulation can reduce student anxiety and increase learning effectiveness. Despite potential issues of logistics, chemical safety, and intricate experiments, chemistry instructors must ensure the online students receive the same experience as on campus chemistry laboratory students (Boschmann, 2003; Kennepohl, 2007). Currently,

completely online chemistry courses are more common in Canada than within the United States.

At both four-year institutions and community colleges online chemistry laboratories were successfully delivered utilizing a lab kit allowing students to complete activities at home (Boschmann, 2003; Casanova, Civelli, Kimbrough, Heath, & Reeves, 2006; Kennepohl, 2007; Reeves & Kimbrough, 2004). Kennepohl (2007) compared online and on campus chemistry laboratory students at Athabasca University in Canada and determined no significant difference in student success as illustrated by final grades. Additionally, there was no significant difference between online and on campus students' perceptions of laboratory activity quality (Kennepohl, 2007). The large amount of data in Kennepohl's research spanning fifteen years supports the successful implementation of home laboratory kits. At Cape Fear Community College, online chemistry students received significantly higher grades on a common final exam as compared to on campus students with over 96% of online students receiving a grade of C or better. The kitchen laboratories were also successfully assessed and compared to on campus laboratories with a checklist covering relevant skills and knowledge (Cassanova et al., 2006). Reeves and Kimbrough (2004) discussed the online general chemistry course offered at the University of Colorado at Denver, the University of North Carolina at Wilmington, and Cape Fear Community College. Online students scored higher as compared to on campus students on a laboratory practical exam. The study examined the online chemistry students in an on campus laboratory and the students were as competent as on campus students in utilizing laboratory equipment such as beakers that they did not have access to at home during the kitchen labs (Reeves & Kimbrough, 2004). After participating in a

take home chemistry laboratory at Indiana University Purdue University Indianapolis online and on campus students were equally satisfied with their experiences (Boschmann, 2003). Similarly, online students at Cape Fear Community College said they would recommend the course to their peers (Cassanova et al., 2006). The literature points to kitchen laboratories as an effective tool for online chemistry students.

Online students appreciated the flexibility of the chemistry lab kits and the freedom of unlimited time to complete experiments but also recognized the requirements of discipline and motivation to be successful (Boschmann, 2003; Cassanova et al., 2006; Kennepohl, 2007). One potential concern with completely online labs conducted at home is the decrease in student-to-student and student-to-instructor interactions (Kennepohl, 2007). However, online students demonstrated more active participation in discussion boards indicating a different, successful form of interaction in the online environment (Seng & Mohamad, 2002). Another concern with online chemistry courses utilizing kitchen laboratories is the high attrition rate. Cassanova et al. (2006) determined only 53% of online chemistry students who originally enrolled took the final exam as compared to 90% of on campus chemistry students. However, when asked, students who dropped indicated personal reasons for withdrawing such as family difficulties. Although student experiences were not identical in the online chemistry laboratory, they were equivalent supporting Keegan's equivalency theory (Cassanova et al., 2006; Kennepohl, 2007).

Another effective technique for students to study chemistry online is through computer software including tutorials, simulated laboratories, and student remote access to on campus analysis instruments. Martínez-Jiménez, Pontes-Pedrajas, Polo, and

Climent–Bellido, (2003) compared on campus and online first year technical engineering student chemistry performance with a virtual chemistry laboratory software. Students using the online software had better knowledge of the equipment, basic operation procedures, and improved problem solving skills (Martínez-Jiménez et al., 2003). Similarly, Baron, Currie, and Kennepohl (2004) determined equivalent learning experiences for students with on campus and remote access to chemistry experiments. Remote access allowed students freedom and flexibility promoting problem solving skills and creativity (Baron, et al., 2004). To aid in student success instructors supplied remote access students with guided tutorials teaching them the necessary skills to operate the equipment effectively. While a high level chemistry learning experience is possible with computer software and remote equipment access it requires more instructor development.

Other Online Sciences

Similar to chemistry, distance learning physics labs utilized both online simulations and laboratory kits enabling hands on experimentation. Al-Shamali and Connors (2010) believe an overuse of simulations can potentially lead to student misconceptions regarding scientific construction and support a balance between both techniques. Although there is debate as to if a physics lab can be successfully replicated in the home environment, the physical world surrounds the students at all times, not just in a classroom. Therefore, online students can successfully complete laboratories at home (Al-Shamali & Connors 2010). Both Athabasca University and the North Carolina Community College System (NCCCS) offer online physics courses with lab kits mailed to students at very little cost (Connors, 2004; McAlexander, 2003). The pass rate in Athabasca University's online physics courses was not significantly different from other

online science offerings and students who passed online physics earned high grades (Connors, 2004). NCCSS offered conceptual physics online, a course that serves a diverse student population and has the highest enrollment within the physics department. Although McAlexander (2003) did not investigate student success in the online conceptual physics course, the community college online physics students appreciated the flexibility of the virtual course with their busy schedules. The Colorado Community College System (2012) compared final grades between online and on campus physics students. Even though the method of laboratory instruction was not discussed, on campus students had significantly higher final grades as compared to online students. In total, the literature points to the success of physics laboratories in the online environment (Connors, 2004; McAlexander, 2003) but further research is needed at both four-year and two-year institutions.

Earth science educators recognize the importance of online learning in serving a select group of science students and are working to create successful online course options (Dibiase, 2000). Similar to chemistry and physics, most online earth science courses utilized a mixture of hands on experiments and online simulations (Cloutis, 2010). Oregon State University implemented a completely online undergraduate non-major soil course where students purchased an inexpensive lab kit used in conjunction with household items to complete hands-on activities similar to an on campus lab. Student enjoyed the laboratory and gained interest and knowledge about soils through their participation in the online course (Reuter, 2007). At the end of the semester both online and on campus students took a practical laboratory exam receiving identical average scores of 4.5 out of 6 (Reuter, 2010). In comparing overall course grades, Reuter

(2010) found significantly higher post assessment scores for online soil students (68%) as compared to on campus students (57%). Online students also showed a greater increase in knowledge between the pre and posttest with an increase of 42% as compared to 21% on campus (Reuter, 2010). At Hillsborough Community College online and on campus earth science students used identical course materials and there was no significant difference in student exam grades over six semesters (Werhner, 2010). Even though the current reports of online earth science courses are positive, much of the research is anecdotal pointing to the need for further study regarding the effectiveness of these courses in the virtual environment (Cloutis, 2010).

Online Biology

Many four-year institutions use online biology laboratory activities as a supplement for the on-campus lab. In a large, freshman introductory biology course online laboratories engaged students and motivated them throughout the class (Swan & O'Donnell, 2009). Students who completed the online activities in addition to the on campus biology laboratory performed significantly better on course exams as compared to students who only completed the on campus laboratory (Swan & O'Donnell, 2009; Toth et al., 2008). These results support the conclusion that online biology laboratories are effective and allow students to gain knowledge that will help them in the on campus laboratory. The order in which one completes online and on campus experiences made a difference. Introductory biology students who completed the online gel electrophoresis lab followed by the on campus activity performed better on a post-test as compared to students who participated in the on campus lab before the online lab (Toth et al., 2008). A study by Gilman (2006) suggested freshman introductory biology students who

completed an online cell cycle laboratory instead of an on-campus laboratory performed better on the related quiz indicating improved understanding of the concepts. The online cell laboratory also took the students less time to complete showing that online labs can be more efficient while delivering equal content. This finding mirrors the results discussed previously in chemistry courses with online students outperforming on campus counterparts (Cassanova et al., 2006).

Research within plant sciences at four-year institutions found conflicting results regarding the effectiveness of online instruction. Plant science instructors have explored online options to save money on plant specimens and time setting up live plant identification exams. Furthermore, outdoor lab time is subject to inclement weather and not all plants grow year round (Kahtz, 2000). Online plant tools are desirable because they give students continuous access to specimens allowing them to study outside of the laboratory or the greenhouse (Anderson & Walker, 2003). Students at Virginia Tech who utilized an online woody plant identification software program performed better on an in person identification exam as compared to students who did not use the software (Seiler, Popescu, & Peterson, 2002). Similarly, Kahtz (2000) found students who utilized online woody plant identification software performed equally well on exams as students who worked with live specimens in the classroom independent of student learning style. In a separate study, students scored significantly higher on web based plant identification exams as compared to on campus exams. However, the online exams were not proctored and did not have a time limit so there was no way to control student use of notes or textbooks (Anderson & Walker, 2003). Taraban, McKenney, Peffley, and Applegarth (2004) compared introductory horticulture students randomly assigned online plant

identification activities to students who completed the same activities within a greenhouse. Both groups took the same live plant identification test in the greenhouse at the end of the semester. Online students scored significantly lower on the exam as compared to on campus students (Taraban et al., 2004). Student questionnaire responses showed they enjoyed the greenhouse learning experience more than the online environment even though both groups did not differ in previous computer experience (Taraban et al., 2004). Although the technology is available to help students learn about plants in the online environment it appears a hands on approach still has merit.

Upper level biology courses at four-year institutions are successfully utilizing computer simulations in completely online laboratories. Annetta, Klesath, and Meyer (2009) discussed how the implementation of a virtual insect collecting field trip within an online entomology course allowed students to engage and actively participate while learning about insects from the comfort of their homes. Students in an online bioinformatics laboratory course preferred the online lab as compared to an on campus lab and found working through the laboratory activities in online groups helped them understand the course material (Weisman, 2010). Overall, the research points to the success of online biology laboratories at four-year institutions using online simulations to mimic the on campus laboratory experience.

Although the literature points to the success of virtual laboratories at four-year institutions, research regarding biology laboratory kits is sparse. Laboratory kits were successfully implemented in an undergraduate online non major biology course at North Carolina State University (NCS). Similar to the online chemistry laboratories, the biology students used materials from the lab kits to complete experiments in their

kitchens (Mickle & Aune, 2008). While the authors did not directly compare online and on campus student success, anonymous surveys from online biology students showed they enjoyed the labs although they were work intensive. Students also reported interest and help from family members during the laboratory activities and how this family participation motivated students to complete the labs on time (Mickle & Aune, 2008). Mickle and Aune (2008) found the online laboratories afforded distance students opportunities that were not possible in the on campus laboratory due to logistical constraints, for example, visiting ecological field sites. Online biology courses at Monash University in Australia also utilized laboratory kits. Moss and Wright (2010) surveyed students in first, second, and third year online biology courses investigating student confidence. Online students were more confident than on campus students in laboratory skills the first and second year. On campus students within all three years were more confident in their ability to work with other students, a skill not required within the virtual environment (Moss & Wright, 2010). Overall, the laboratory kit and the kitchen lab are useful tools for distance students at four-year institutions but more research is needed to investigate lab kit use in relationship to student academic success.

Qualitative data from biology students at four-year institutions showed that students enjoyed participating in the online environment and they felt more confident in the hands-on laboratory as a result (Swan & O'Donnell, 2009). Students also appreciated being able to access the online material multiple times to review, spend extended periods of time on a topic that they rushed through on-campus, and that they received immediate feedback through online quizzes. Students specifically noted utilizing virtual pictures and videos associated with the online labs to view specimens at their own pace (Swan &

O'Donnell, 2009). Although the majority of the students enjoyed the online biology laboratories, the students who did not value the experience stated that they missed being able to communicate immediately with the instructor and their classmates (Gilman, 2006). This student sentiment of lacking one-on-one interactions in the online world is evident throughout distance education research but may be more important within the online laboratory setting due to the experimental aspects of the course.

Quantitative analysis of online biology courses at community colleges showed equivalent student learning in the online and the on campus environment. Lunsford and Bolton (2006) compared an online introductory biology laboratory to an on campus counterpart using a 50-question multiple-choice test. The online students mean test score (69.77) was almost identical to the on campus mean test score (70.00) (Lunsford & Bolton, 2006). Although the results point to equal learning in both the online and on campus laboratory, the researchers did not compare identical courses as the online class was for non majors and the on campus class contained biology major students only. Within the online lab, the students were able to successfully perform inquiry based experiments at a distance using the online discussion board to post hypotheses, methodologies, and results, and receive feedback from both classmates and the instructor (Lunsford, 2008). The incorporation of inquiry learning online reinforces the importance of this criteria in biology labs at community colleges independent of course delivery method.

In further online community college biology research, Johnson (2002) examined student course grades and found no significant difference between online (M=81.86) and on-campus (M=78.46) students in a non-majors biology laboratory. Johnson also found

no difference in student withdrawal rates between the online and on campus biology courses. Although the design of the study was sound using a pre and post-test comparison, the sample sizes were small with 64 online students and 50 on campus students. At a community college in New York, students taking medical terminology had the option of enrolling in an on campus section, an online asynchronous section, or an online synchronous section. At the end of the semester there was no significant difference in student satisfaction or average final grade point between course delivery methods (Somenarain, Akkaraju & Gharbaran, 2010). Within the Colorado Community College System, on campus biology students had significantly higher grades as compared to online students even though there was no difference in student cumulative GPA or number of credit hours completed (Colorado Department of Higher Education, 2012). Although overall the studies demonstrate the effectiveness of biology courses in the virtual environment at community colleges more research is needed incorporating student demographic characteristics.

There is discrepancy in the current literature regarding student perceptions of community college online biology laboratories. In a non-major human biology course, community college students completed both on-campus and virtual laboratories. Almost 87% of respondents strongly agreed that the on campus lab increased their understanding of course concepts while only 60.8% strongly agreed that the virtual lab increased their knowledge (Stuckey-Mickell & Stuckey-Danner, 2007). Although community college biology students appreciated the convenience and flexibility of online classes they missed the face-to-face interactions with both students and faculty and the ability to receive immediate feedback (Stuckey-Mickell & Stuckey-Danner, 2007). Conversely, in

Johnson's 2002 study, online and on campus students expressed no difference in attitudes towards biology before or after their respective laboratories. Their viewpoints did not change based on the mode of instruction as all students were confident in their biology knowledge (Johnson, 2002). Online students did express significantly less interest in working in groups and significantly more favorable opinions towards computer based learning suggesting that online science education is a better fit for students that exhibit certain learning styles (Johnson, 2002).

Summary

Independent of discipline, online science courses provide flexibility for students (Boschmann, 2003; Cassanova et al., 2006; Kennepohl, 2007). Online science laboratories afford students the opportunity to conduct an experiment multiple times with no additional costs or resources enabling students to gain practice and further understanding. The preferred method of delivery for online science courses is a take home lab kit (Boschmann, 2003; Casanova et al., 2006; Connors, 2004; Kennepohl, 2007; McAlexander, 2003; Reuter, 2007; Reuter, 2010). Online science students were equally successful as on campus students indicating the feasibility of science delivery in the virtual environment (Cassanova et al., 2006; Connors, 2004; Johnson, 2002; Kennepohl, 2007; Lunsford & Bolton, 2006; Martínez-Jiménez et al., 2003; Swan & O'Donnell, 2009; Toth et al., 2008). Although students appreciated the flexibility of online science courses they missed student-to-student and student-to-instructor interactions (Gilman, 2006; Kennepohl, 2007; Stuckey-Mickell & Stuckey-Danner, 2007). Online science courses provide a service to a mature, motivated student population who may not have the time to come to campus to participate in a science

course (Cancilla & Albon, 2008; Johnson, 2002). Overall, it is possible for students to have meaningful laboratory experiences outside of the on campus laboratory setting if given the right tools and instruction.

Much of the online science research was conducted at four-year institutions. Community colleges can learn from four-year institutions regarding effective techniques and student responses to online courses but must also remember that four-year institutions serve a different student population with different educational needs and career goals. Therefore, more research at the community college level is necessary. Furthermore, many published papers discuss online science course implementation rather than measuring the effectiveness of the course in regards to student success. Perhaps this research is lacking due to the newness of online science courses. Future research must evaluate effectiveness and student success to ensure online science course implementations benefit students and their learning.

It is important to remember that both online and on-campus students self-select their method of laboratory instruction. Therefore, the literature discussed in this review of online science courses is quasi-experimental in nature. Although overall the literature supports to the success of online science classes within higher education more research is necessary pointing to the need for the current study. Previous studies of online biology courses at community colleges were small scale and did not always compare identical classes (Johnson, 2002; Lunsford & Bolton, 2006). Previous investigations did not look at potential differences in student success in relationship to student demographic characteristics. Furthermore, no research currently investigates the success of online

biology students in future biology courses, the proposed methodology of the current study.

Conclusion

Distance education has evolved to continually meet student needs from the first correspondence courses to present day online courses. The demand for online course offerings within higher education will continue to increase due to improvements in technology and student desires of flexibility (Glahn & Gen, 2002; Lorenzetti, 2005; Stumpf et al., 2005). Although some faculty and administrators do not fully support distance education in the virtual environment research overall illustrates the success of online courses and the satisfaction of online students (Allen, et al., 2002; Hartmann et al., 2005; Karatas & Simsek, 2009; Lim et al., 2008; Mitchell & Geva-May, 2009). Online courses serve students who juggle work, family, and school but the busy lives of these online students can impact their ability to successfully complete online courses (Aragon & Johnson, 2008; Doherty, 2006; Moore et al., 2003; Packham et al., 2004). Researchers have investigated the success of different online student groups, for example by age or gender or ethnicity, but these studies have not yet focused on online science students.

Distance education within the Virginia Community College System illustrates similar trends to national literature. As online course offering expand, Virginia community college students who participate in online courses are typically older, busy students who desire flexibility. Online VCCS courses had lower completion and student persistence as compared to on campus classes (Jaggars & Xu, 2010). Although the VCCS investigated the success of online students in first semester college level English and math courses (Xu & Jaggars, 2011) there has been no research to date focused on the

success of Virginia community college students enrolled in online introductory biology courses. This research will benefit the VCCS as many community college students complete introductory biology to fulfill associate degree requirements.

Higher education institutions are successfully offering online science laboratory courses in multiple disciplines using both take home lab kits and online simulations. Students in online science courses appreciate the flexibility and exhibit equal learning to on campus students (Cassanova et al., 2006; Connors, 2004; Johnson, 2002; Kennepohl, 2007; Lunsford & Bolton, 2006; Martínez-Jiménez et al., 2003; Swan & O'Donnell, 2009; Toth et al. 2008). However, laboratory based science courses were deemed poorly suited for distance learning (Bradley, 2007; Instructional Technology Council, 2011). One way to inform faculty and administrators and to learn about student success within community college online biology courses is to conduct larger studies with more students, multiple institutions, and tracking over several semesters. The current research will expand the existing literature in an effort to better understand the effectiveness of online biology courses.

CHAPTER 3

METHODOLOGY

This study employed a quantitative design using ex post facto data. The design of the study facilitated the collection and analysis of numerical data which were utilized to examine the potential relationship between mode of course delivery in a preliminary course and student success in a subsequent course (Clark & Creswell, 2009; Cohen, Manion, & Morrison, 2000).

Purpose of Study

The purpose of this study was to investigate the success of non-science major students in biology 102 on campus comparing students who completed biology 101 online to students who completed biology 101 on campus within Virginia community colleges. The independent variable was the mode of instruction in biology 101 (online verses on campus) and the dependent variable was student success in on campus biology 102 (receiving a C or higher).

Research Questions

This study was guided by the following research questions:

1. How will the mode of instruction in biology 101 be predictive of student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
2. What are the demographic characteristics of non-science major students who completed biology 101 online and biology 102 on campus at Virginia community colleges? The demographic characteristics examined include age,

gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101.

3. What are the demographic characteristics of non-science major students who completed both biology 101 and biology 102 on campus at Virginia community colleges? The demographic characteristics examined include age, gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101.
4. How will the mode of instruction in biology 101 moderate the predictive relationship between student demographic characteristics and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
    a. How will the mode of instruction in biology 101 moderate the predictive relationship between student age and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
    b. How will the mode of instruction in biology 101 moderate the predictive relationship between student gender and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
    c. How will the mode of instruction in biology 101 moderate the predictive relationship between student ethnicity and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

d. How will the mode of instruction in biology 101 moderate the predictive relationship between student prior online course experience and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

e. How will the mode of instruction in biology 101 moderate the predictive relationship between student enrollment status during the semester of biology 101 and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

Study Context

The Virginia Community College System (VCCS) is comprised of 23 colleges located on 40 different campuses in rural, suburban, and urban areas throughout the state. Policies established by the VCCS govern the curriculum at all Virginia community colleges including degree requirements, course offerings, and grading schemes. The VCCS Master Course File contains all approved course titles, credits, pre and corequisites, course descriptions, and weekly lecture and laboratory contact hours. Virginia Community Colleges must adhere to the information within the VCCS Master Course File. According to Section 5 of the VCCS Policy Manual (2005) online courses must deliver the same content and produce the same student learning outcomes as on campus courses. The community colleges have flexibility to deliver online courses within the outlined parameters. For example, one community college could conduct the online biology laboratory using lab kits while another community college might implement virtual laboratory experiments. The data set for the current study included all Virginia community colleges that offer both completely online (lecture and laboratory)

and completely on campus biology 101. Currently 15 community colleges offer online biology 101. The participants of the study were non-science major students who completed online or on campus biology 101 in the Fall 2009 or Spring 2010 semesters and biology 102 on campus within the next academic year.

Within the VCCS Master Course File biology 101 and biology 102 are described as follows:

> Biology 101 (General Biology 1): Explores fundamental characteristics of living matter from the molecular level to the ecological community with emphasis on general biological principles. Introduces the diversity of living organisms, their structure, function and evolution. Part I of II. Lecture 3 hours. Recitation and laboratory 3 hours. Total 6 hours per week. 4 credits.
>
> Biology 102 (General Biology 2): Explores fundamental characteristics of living matter from the molecular level to the ecological community with emphasis on general biological principles. Introduces the diversity of living organisms, their structure, function and evolution. Part II of II. Lecture 3 hours. Recitation and laboratory 3 hours. Total 6 hours per week. 4 credits (Master Course File, n.d., courses, biology).

All 23 Virginia community colleges offer both biology 101 and biology 102. The commonality across campuses created by the biology course descriptions within the VCCS Master Course File allowed the current study to be conducted across multiple colleges while ensuring uniformity of course content.

Operationalization of Research Variables

This study investigated the relationship between non-science major student success in biology 102 and mode of course instruction in biology 101 (online or on campus) while looking at potential differences due to student demographic characteristics. All variables were measured dichotomously. A summary of the variables can be viewed in the Appendix.

Mode of Instruction

The two potential modes of instruction for biology 101 are completely online (both lab and lecture) or completely on campus (face-to-face lab and lecture). The mode of instruction was the independent variable for research questions one, two and three. The mode of instruction served as a moderator variable in research question four.

Student Success

Student success is defined as a final course grade of C (70%) or better (Larson & Sung, 2009; Xu & Jaggars, 2011). A grade of C or better allows a community college student to receive credit for biology 102 upon transfer to a four-year institution. A final course grade in biology 102 includes both a lecture and a laboratory component grade. Depending on the institution, the laboratory grade constitutes between 33% and 40% of the overall biology 102 grade (personal observation). Student success in on campus biology 102 acted as the dependent variables in research question one and research question four.

Demographic Characteristics

The demographic characteristics investigated in the current study were age, gender, ethnicity, prior online course experience, and enrollment status during the

semester of biology 101. These demographic characteristics were chosen because they have been investigated in previous online learning studies, as discussed in chapter two, but not within research focusing on online biology courses. The demographic characteristics are also important because community colleges serve a diverse student population. The demographic characteristics served as dependent variables in research questions two and three. In research question four the demographic characteristics were the independent variable. Each demographic characteristic was investigated dichotomously.

Age. Traditional age students were defined as students between the age of 17 and 24 years old. Students older than 24 years old were categorized as nontraditional age students (Coldwell et al., 2008).

Gender. Students were divided into two groups based on gender, either male or female.

Ethnicity. Students were examined based on two ethnic groups, Caucasian (white) or non-Caucasian (African American, Hispanic, American Indian, Asian, or Other) (Aragon & Johnson, 2008).

Prior online course experience. Students were separated based on the number of online classes successfully completed. Students who had taken a previous online course (one or more) were grouped together and students who took their first online course with biology 101 were placed into a separate group (Aragon & Johnson, 2008; Arbaugh, 2004).

Enrollment status during the semester of biology 101. A full time student course load is defined as 12 or more credits. Students were designated as either full time or part time students during the semester of enrollment in biology 101.

Data Source and Analysis

Data Source

Data were obtained from the VCCS Academic Services and Research Department in Richmond VA and included all Virginia community colleges that offer both completely online (lecture and laboratory) and completely on campus biology 101. Currently 15 community colleges offer online biology 101. Hybrid offerings of biology 101 (online lecture and on campus laboratory) were not included in the study. This was the first investigation of online biology within Virginia community colleges. The selected community colleges are diverse in size and located in various regions throughout the state including rural, suburban, and urban areas.

All Virginia community colleges utilize Student Information System (SIS) software called Peoplesoft ® to manage student information. Each semester, SIS tracks students' courses, grades, and demographic information. The VCCS Office of Institutional Research compiles student data from all 23 Virginia Community colleges. Obtaining ex post facto data from the VCCS directly simplified data collection and created a statewide sample. The data pool for the current study included non-science major students at Virginia community colleges who completed online or on campus biology 101 in the Fall 2009 or Spring 2010 semesters. The students must have then completed biology 102 on campus within the next academic year (by Spring 2011). The unit of analysis was the student. Utilizing two semesters of data created a large enough

population to sample from and control for potential differences due to instructors (Arbaugh, 2004; Creswell, 2009; Price, 2006; Slavin & Smith, 2009). Including students who completed biology 102 within one year of biology 101 ensured consistency of the sample population and similar retention of biological information (Custers, 2010).

The VCCS Academic Services and Research Department was contacted to request data for the previously defined dependent, independent, and attribute variables. This information was provided without the individual student's identity as each student was designated by a random, unique numeric code. The data from all community colleges were collected in aggregate form and the students were divided into two groups, online biology 101 and on campus biology 101. The objective was to create two groups of approximately equal size to allow rigorous statistical testing (Eng, 2003).

Ethical Protection of Students

Before beginning the research, approval was received from the Academic Services and Research Department at the VCCS and the Darden College of Education Human Subjects Review Committee at Old Dominion University. This official permission ensured the data were collected in an ethical manner and protected both the participating institutions and their students ensuring confidentiality throughout the research process. To further protect students, the data set received from the VCCS did not include any student personal information. All data were coded with a random, unique numeric identification ensuring anonymity for each participant. The researcher only had access to data provided by the Academic Services and Research Department at the VCCS. All data were password protected and stored on a secure computer. The data

were destroyed within one year of completion of the research to ensure participant and institution identity protection.

The researcher's experiences teaching both online and on campus community college biology courses were bracketed throughout the investigation. The researcher was not currently employed at the community colleges participating in the research reducing potential bias. The coding of the data received from each community college did not provide information regarding course instructors or instructional techniques that could potentially influence the investigator's opinion. Effort was made to reduce the halo effect and not let the researcher's knowledge of online and on campus biology influences the analysis of the data (Cohen et al., 2000).

Data Analysis

All data were analyzed using Statistical Program for Social Science (SPSS) Mac© version 21.0. Both descriptive and inferential statistics were analyzed to fully understand the data set. Descriptive statistics allowed data to be described in an abbreviated, representative form while inferential statistics generalized the larger population based on the measured sample (Sprinthall, 2007). The researcher coded the dichotomous variables using the values of 1 and 0 as illustrated in Table 1. Data are presented through tables as well as text.

Table 1

Coding of Dichotomous Variables

Variable	Categories	Code
Student Success	Successful	1
	Unsuccessful	0
Instruction mode	Online	1
	On Campus	0
Age	17-24	1
	25 and older	0
Gender	Male	1
	Female	0
Ethnicity	Caucasian	1
	Non-Caucasian	0
Prior online	Yes	1
	No	0
Enrollment	Full time	1
	Part time	0

The relationship between mode of instruction in biology 101 and student success in biology 102 analysis. To answer the first research question, the relationship between mode of instruction in biology 101 and course success in biology 102 was assessed statistically using binary logistic regression. Binary logistic regression was

appropriate because of the large sample size and the dichotomous nature of both the independent variable and the dependent variable. Linear regression was not an option because using the least squares technique with a dichotomous dependent variable violates the assumptions of normality and equal variance. Linear regression and the least squares method would potentially produce values of the dependent variable greater than one or less than zero which are not theoretically possible (Meyers et al., 2006; Peng, Lee, & Ingersoll, 2002). The data were entered as a 0 or 1 in coding for the dichotomous outcome (Meyers et al., 2006; Peng et al., 2002).

Once the model was created it was necessary to determine how well the logistic regression model represented the relationship between the variables. This process included an overall assessment of the model, testing the predictors separately, analyzing the goodness of fit, and validating the predicted probabilities (Peng et al., 2002). The Hosmer and Lemeshow Test accounted for the overall model and determined its goodness of fit. A Wald test estimated how well the predictor of mode of instruction explained the variance in student success (Meyers et al., 2006; Peng et al., 2002).

Demographic characteristics analysis. In research question two and research question three descriptive statistics, such as percentages, were used to summarize the data related to the demographic characteristics of the participants who completed biology 101 online or biology 101 on campus (Sprinthall, 2007).

Demographic characteristics as related to student success analysis. The relationship between student demographic characteristics and success in on campus biology 102 was the focal relationship in the fourth research question. The mode of instruction in biology 101 served as a moderator variable with a potential affect on the

direction or strength of the focal relationship. Student success in biology 102 in relationship to student demographic characteristics was analyzed with binary logistic regression. Logistic regression was the preferred statistical technique because all variables were measured dichotomously (Meyers et al., 2006). As discussed previously, the dichotomous nature of the dependent variable violated the assumptions of the least squares technique within linear regression (Meyers et al., 2006; Peng et al., 2002).

Two regression models were created to address each sub-question within research question four. The first model contained the independent variables of the student demographic characteristic, for example student age, and mode of instruction during the semester of biology 101. The second model added the interaction term of age*mode of instruction. The two regression models were compared to see if the mode of instruction in biology 101 affected the relationship between the student demographic characteristic and student success in biology 102 on campus. Each relationship between the demographic characteristic and student success was tested independently resulting in five separate analyses. The same tests of the Hosmer and Lemeshow Test and the Wald test were used to determine how well the logistic regression models represented the relationship between the variables (Meyers et al., 2006; Peng et al., 2002). All statistics were tested at a significance level of .05.

Limitations of Research Design

The quantitative nature of the current study limited data investigation to statistical analysis. Non-statistical relationships may be present between the variables but the researcher was unable to explore these links due to the numerical nature of the data (Creswell, 2009). Although the ex post facto approach was the most appropriate for the

current research there were concerns regarding internal validity, the sustainability and accuracy of the ex post facto data in relationship to the research study (Cohen et al., 2000). Due to the lack of control of the independent variable the researcher was unable to draw a strong causal relationship between the independent and dependent variable (Cohen et al., 2000; Silva, 2010). As the data was examined retrospectively it was not possible to control all variables or ascertain which variables were the most important. For example, it was not feasible to have the same instructor teach the online and the on campus biology sections at each institution. A large sample size and sound statistical analyses helped control for the potential weaknesses (Slavin & Smith, 2009).

Conclusion

The study's quantitative, ex post facto design allowed the researcher to draw conclusions regarding the relationship between the method of course delivery in biology 101 and the success of Virginia community college non-science major students in on campus biology 102. The research design permitted the collection of demographic data to investigate how the characteristics of age, gender, ethnicity, prior online course experience, and student enrollment status potentially influenced student success in online biology.

CHAPTER 4

FINDINGS

The purpose of this study was to investigate the success of non-science major students in biology 102 on campus comparing students who completed biology 101 online to students who complete biology 101 on campus within Virginia community colleges. This study analyzed data collected from Virginia community colleges that offered completely online biology 101 and completely on campus biology 102 in Fall 2009 and Spring 2010 semesters. Participants were non-science major, program placed students who completed biology 102 by Spring 2011. Student success was measured dichotomously and defined as a final course grade of C (70%) or better in biology 102 because this is a transferable grade (Larson & Sung, 2009; Xu & Jaggars, 2011). The main independent variable was mode of instruction in biology 101, either online or on campus. Five demographic characteristics of the participants were also investigated in a dichotomous fashion to see if they impacted student success. The demographic characteristics were age, gender, ethnicity, previous online course experience, and enrollment status during the semester of biology 101.

The findings of the research are presented in this chapter. The results include descriptive statistics and binary logistic regression analyses. All results are described in text and represented in tables.

Data Screening

The VCCS provided data for the study in two separate excel files, one with student information from Fall 2009 and one with student information from Spring 2010. The file for each semester included demographic information, degree information, mode

of instruction, and final course grade in biology 101 and biology 102. The files did not contain any student personal information. There were a total of 10344 students who completed biology 101 in Fall 2009 and 6644 students who completed biology 101 on Spring 2010 at Virginia community colleges that offered both online and on campus biology 101 and on campus biology 102. Students who did not complete biology 102 by Spring 2011 were removed from the sample (n=10443). Students who were not program placed in an associate degree were not included in the sample (n=220). Individuals who were science majors (including engineering and health sciences) were removed from the sample (n=1352). Anyone under the age of 17 years old at the time of enrollment was also removed from the sample (n=14). Then, the data from both semesters were combined totaling 4959 participants. There were no missing data for any students for any of the variables.

The researcher coded the dichotomous variables using the values of 1 and 0. Students who received a grade of A, B, or C in biology 102 on campus were coded as 1. Students who were awarded a grade of D, F, or W in biology 102 on campus were not successful and coded as 0. Students who completed biology 101 online were coded as 1 while students who completed biology 101 on campus were coded as 0. For the demographic characteristics, college age students (17-24 years) were coded as 1, males were coded as 1, Caucasian students were coded as 1, students who had completed an online course prior to biology 101 were coded as 1, and full time students were coded as 1. The other category for each dichotomous demographic characteristic was coded as 0. Interaction terms between mode of instruction and demographic variables were generated to investigate a possible moderator effect of mode of instruction in biology 101 on the

relationship between various demographic variables and student success in biology 102 on campus. The moderator variable was mode of instruction.

Findings for Research Question 1

Research question 1 asked if the mode of instruction in biology 101 would be predictive of student success in biology 102 on campus for non-science major students within Virginia community colleges. There were 96 students who completed biology 101 online and biology 102 on campus and 4863 individuals who completed both biology 101 and biology 102 on campus. A binomial logistic regression analysis indicated that mode of instruction in biology 101 was not predictive of student success in biology 102 on campus for non-science major students within Virginia community colleges, *Wald* (1) = .228, $p > .05$. The final model did not increase the classification accuracy of the constant only model at 83.1%. The adjusted odds ratio of 1.134 was very close to a value of 1.0 corresponding to an independent variable was not predictive of the dependent variable. Table 2 shows the results of the statistical analysis including the regression coefficient (B), the Wald statistics, the significance levels, and the odds ratio [Exp(B)].

Table 2

Logistic Regression Results with Mode of Instruction as a Predictor of Student Success in Biology 102 On Campus (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Mode	.126	.228	1	.633	1.134
Constant	1.466	31.446	1	.000	4.333

Findings for Research Question 2

Research question 2 investigated the demographic characteristics of non-science major students who completed biology 101 online and biology 102 on campus within Virginia community colleges. There were 96 students who completed biology 101 online and biology 102 on campus. More college age students completed biology 101 online and biology 102 on campus (77.1%) as compared to older students. There were also more female students (65.6%) and more Caucasian students (76%) who completed biology 101 online and biology 102 on campus. Students who completed biology 101 online and biology 102 on campus were more likely to have completed a prior online course (62.5%) and most students (74%) were enrolled at a full time status during the semester of biology 101. Table 3 illustrates the dichotomous data for students who completed biology 101 online and biology 102 on campus.

Table 3

Descriptive Statistics for Non-Science Major Students Who Completed Biology 101 Online and Biology 102 On Campus (N=96).

Variable	Categories	Frequency	Percent
Age	17-24	74	77.1
	25 and older	22	22.9
Gender	Male	33	34.4
	Female	63	65.6
Ethnicity	Caucasian	73	76.0
	Non-Caucasian	23	24.0
Prior online	Yes	60	62.5
	No	36	37.5
Enrollment	Full time	71	74.0
	Part time	25	26.0

Findings for Research Question 3

Research question 3 investigated the demographic characteristics of Virginia Community College non-science major students who completed biology 101 and biology 102 on campus. There were 4863 individuals who fell into this category. Overall, more college age students completed both biology 101 and biology 102 on campus (81.9%). More of the students were female (58%) and the majority of the students were Caucasian (59.4%). Many full time students completed biology 101 and biology 102 on campus

(77.3%) and the majority of the students had not completed an online course prior to biology 101 (67.6%). Table 4 shows the dichotomous demographic data for students who completed both biology 101 and biology 102 on campus.

Table 4

Descriptive Statistics for Non-Science Major Students Who Completed Biology 101 and Biology 102 On Campus (N=4863).

Variable	Categories	Frequency	Percent
Age	17-24	3987	81.9
	25 and older	882	18.1
Gender	Male	2046	42.0
	Female	2823	58.0
Ethnicity	Caucasian	2893	59.4
	Non-Caucasian	1976	40.6
Prior online	Yes	1576	32.4
	No	3293	67.6
Enrollment	Full time	3766	77.3
	Part time	1103	22.7

Findings for Research Question 4

Research question 4 asked if the mode of instruction in biology 101 moderated the predictive relationship between student demographic characteristics and student

success in biology 102 on campus. Each demographic characteristic was analyzed separately creating five individual logistic regression analyses. Two logistic regression models were utilized for each comparison. The first model tested the ability of mode of instruction in biology 101 and the demographic characteristic selected to predict student success in biology 102 on campus as compared to the baseline model created by the SPSS program. The second model added the interaction term of mode of instruction*demographic characteristic. The researcher compared the first and second models to see if the mode of instruction in biology 101 had a moderator effect on the relationship between the student demographic characteristic and student success in biology 102 on campus.

Age

The results of the logistic regression model indicated that mode of instruction did not moderate the predictive relationship between student age and student success in biology 102, *Wald* (1) = .440, $p > .05$. The final model including the interaction term of mode*age did not increase the predictive capacity (83.1%) when compared to first model. Therefore the relationship between student age and student success in biology 102 would remain the same for students in the two biology 101 instruction mode groups. Table 5 illustrates the regression coefficient (B), the Wald statistics, the significance levels, and the odds ratio [Exp(B)]. The Hosmer and Lemeshow Test statistic was not significant, χ^2 $(2, N = 4959) = 1.479, p = .477$, indicating a goodness of fit for the final model.

In a follow up analysis using simple binary logistic regression, age was a significant predictor of student success in biology 102 on campus, *Wald* (1) = 32.628, $p <$ .05. The regression coefficient (B) illustrated an inverse relationship between student age

and student success in biology 102 on campus as shown in Table 6. The model suggests that college age students were less likely to succeed in biology 102 on campus with 81.6% of younger students passing as compared to 89.6% of older students passing biology 102 on campus.

Table 5

Logistic Regression for Student Age and Success in Biology 102 as Moderated by Mode of Instruction in Biology 101 (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Mode	.218	.123	1	.726	1.244
Age	-.234	9.420	1	.002	.792
Mode_Age	-.455	.440	1	.507	.634
Constant	1.695	1070.826	1	.000	5.447

Table 6

Logistic Regression Results with Student Age as a Predictor of Student Success in Biology 102 On Campus (N=4863).

Predictor	B	Wald	df	Sig.	Exp(B)
Age	-.664	32.628	1	.000	.515
Constant	2.154	390.689	1	.000	8.617

Gender

In comparison to Model 1, mode of instruction in biology 101 had a moderator effect on the relationship between student gender and student success in biology 102 on campus. The Wald statistic indicated that mode of instruction*gender had a significant contribution to the model, $Wald\,(1) = 4.564$, $p < .05$. As a result the relationship between student success and student gender would depend on the instruction mode of the previous biology 101 course. The regression coefficient (B) illustrated an inverse relationship between the interaction term and the final model suggesting that male students who completed biology 101 online were less likely to be successful in biology 102 on campus. Male students who completed biology 101 on campus were more likely to be successful in biology 102 on campus. Table 7 shows the regression coefficient (B), the Wald statistics, the significance levels, and the odds ratio [Exp(B)]. The classification accuracy of the final model was identical to that of the first model as 83.1% overall. The Hosmer and Lemeshow Test statistic was not significant, $\chi^2\,(2, N = 4959) = 4.820$, $p = .090$. This result indicated goodness of fit for the final model and no significant difference between the observed and expected values.

Two additional binary logistic regression analyses investigated the relationship between student gender and student success in biology 102 for students who completed biology 101 online separately from students who completed biology 101 on campus. Student gender was a significant predictor of student success in biology 102 on campus for students who completed biology 101 online, $Wald\,(1) = 6.329$, $p < .05$. The analysis results are shown in Table 8. The model predicted that male students were, relative to female students, less likely to succeed in biology 102 on campus after completing biology

101 online. Of students who completed biology 101 online the model predicted 90.3% of female students passed biology 102 on campus as compared to 68.8% of male students who passed on campus biology 102. Student gender was also a significant predictor of student success in on campus biology 102 for students who completed biology 101 on campus, Wald (1) = 7.524, $p < .05$. The model indicated that male students who completed biology 101 on campus were, relative to female students, less likely to succeed in biology 102 on campus. Among students who completed both biology 101 and biology 102 on campus the model predicted 84.3% of female students passed biology 102 while 81.3% of male students successfully completed biology 102 on campus. Table 9 shows the regression coefficient (B), the Wald statistics, the significance levels, and the odds ratio [Exp(B)].

Table 7

Logistic Regression for Student Gender and Success in Biology 102 as Moderated by Mode of Instruction in Biology 101 (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Mode	.395	.954	1	.329	1.484
Gender	-.210	7.483	1	.006	.810
Mode_Gen	-1.176	4.564	1	.033	.309
Constant	1.685	1055.588	1	.000	5.390

Table 8

Logistic Regression Results with Gender as a Predictor of Student Success in Biology 102 On Campus for Students who Completed Biology 101 Online (N=96).

Predictor	B	Wald	df	Sig.	Exp(B)
Gender	-1.445	6.329	1	.012	.236
Constant	2.234	27.037	1	.000	9.333

Table 9

Logistic Regression Results with Gender as a Predictor of Student Success in Biology 102 On Campus for Students who Completed Biology 101 On Campus (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Gender	-.221	7.524	1	.006	.810
Constant	1.682	1054.764	1	.000	5.378

Ethnicity

There was no moderator effect between mode of instruction in biology 101 and the relationship between student ethnicity and student success in biology 102 on campus, *Wald* (1) = 1.285, $p > .05$. The results are illustrated in Table 10. Therefore the relationship between ethnicity and student success in biology 102 on campus would remain the same among the online and on campus students in the previous biology 101 course. The final regression model including the interaction term of mode*ethnicity did

not increase the predictive capacity from the original model (83.1% overall). The Hosmer and Lemeshow Test statistic was not significant, χ^2 (2, N = 4959) = 1.130, p = .514, showing no significant difference between the observed and expected values and goodness of fit in the final model.

In the follow-up binary logistic regression analysis ethnicity was a significant predictor of student success in biology 102 on campus, *Wald* (1) = 8.401, $p < .05$. Caucasian students are predicted to be more likely to succeed in biology 102 on campus with 84.3% of Caucasian students passing biology 102 on campus as compared to 81.2% of students of other ethnicities passing the same course. The results of the analysis are show in Table 11.

Table 10

Logistic Regression for Student Ethnicity and Success in Biology 102 as Moderated by Mode of Instruction in Biology 101 (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Mode	.440	.501	1	.479	1.553
Ethnicity	.235	9.300	1	.002	1.265
Mode_Ethn	-.780	1.285	1	.257	.458
Constant	1.457	640.493	1	.000	4.293

Table 11

Logistic Regression Results with Ethnicity as a Predictor of Student Success in Biology 102 On Campus (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Ethnicity	.221	8.401	1	.004	1.248
Constant	1.461	650.117	1	.000	4.312

Prior Online Course

The results of the logistic regression model indicated that mode of instruction in biology 101 did not moderate the predictive relationship between student success in biology 102 and student prior online course experience, *Wald* (1) = .750, $p > .05$. Therefore the predictive relationship between student prior online course experience and student success in biology 102 would not depend on mode of instruction in biology 101. Table 12 illustrates the regression coefficient (B), the Wald statistics, the significance levels, and the odds ratio [Exp(B)]. The final regression model including the interaction term of mode*previous did not increase the predicative capacity (83.1% overall) when compared to first model. The Hosmer and Lemeshow Test was not significant χ^2 (2, N = 4959) = .757, p = .685. There was no difference between the observed and expected values in the final model.

The results of a second regression analysis indicated that prior online course experience was a significant predictor of student success in biology 102 on campus, *Wald* (1) = 8.517, $p < .05$. The positive regression coefficient (B) illustrates a direct

relationship where students who had completed a prior online course were more likely to be successful in biology 102 on campus. Eighty-five percent of students who completed a previous online course passed biology 102 on campus while 82% of students who had never taken an online course passed on campus biology 102. The regression coefficient (B), the Wald statistics, the significance levels, and the odds ratio [Exp(B)] are shown in Table 13.

Table 12

Logistic Regression for Student Prior Online Course Experience and Success in Biology 102 as Moderated by Mode of Instruction in Biology 101 (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Mode	.096	.046	1	.831	1.101
Previous	.260	9.404	1	.002	1.297
Mode_Prev	-.483	.750	1	.387	.617
Constant	1.513	1114.983	1	.000	4.542

Table 13

Logistic Regression Results with Prior Online Course Experience as a Predictor of Student Success in Biology 102 On campus (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Previous	.243	8.517	1	.004	1.275
Constant	1.541	1127.951	1	.000	4.547

Enrollment Status

The results fail to support a moderator effect of mode of instruction on the predictive relationship between student enrollment status and student success in biology 102 on campus, *Wald* (1) = .648, $p > .05$. Therefore the predictive relationship between student enrollment status and student success in biology 102 on campus would not depend on the instruction mode in biology 101 courses. Table 14 displays the results of the analyses. The final model had the same classification accuracy as the first model (83.1% overall) but the Hosmer and Lemeshow Test statistic was not significant, χ^2 (2, N = 4959) = .660, p = .719, supporting the goodness of fit of the final model.

Table 14

Logistic Regression for Student Enrollment Status and Success in Biology 102 as Moderated by Mode of Instruction in Biology 101 (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Mode	.305	.241	1	.624	1.356
Status	-.122	.1.700	1	.192	.885
Mode_Status	-.553	.648	1	.421	.575
Constant	1.688	413.443	1	.000	5.407

A second binary logistic regression analysis indicated that student enrollment status was not a significant predictor of student success in biology 102 on campus, *Wald* (1) = 2.061, $p > .05$. Accordingly, the full time students had the same probabilities of

success in biology 102 on campus as their counterparts as part time students. The regression coefficient (B), the Wald statistics, the significance levels, and the odds ratio [Exp(B)] are found in Table 15.

Table 15

Logistic Regression Results with Student Enrollment Status as a Predictor of Student Success in Biology 102 On Campus (N=4959).

Predictor	B	Wald	df	Sig.	Exp(B)
Status	-.133	2.061	1	.151	.874
Constant	1.694	424.096	1	.000	5.440

Summary

This chapter presented the results of the study including descriptive statistics for students who took biology 102 on campus after completing either biology 101 online or biology 101 on campus. The chapter discussed the results of several binary logistic regression analyses and identified variables and interaction terms that significantly contributed to the final regression model. The binary logistic regression models tried to explain what relationship existed between mode of instruction in biology 101 and student success in biology 102. The next chapter will summarize the findings of the study, discuss the implications of the results, and offer suggestions for further investigations.

CHAPTER 5

CONCLUSIONS

The current study investigated the success of non-science major students in biology 102 on campus comparing students who completed biology 101 online to students who completed biology 101 on campus. This is the first higher education biology research to use a measure of student success focused on performance in a subsequent course. The current inquiry was the first to investigate student success in online biology within Virginia community colleges. The sample included students from multiple institutions and several semesters fulfilling a gap in the literature for a larger scale study of community college online biology. The current study also looked at potential relationships between student demographic characteristics and biology student success. Although these relationships have been studied in other online courses the current research is the first to investigate patterns within online biology. The results indicated that mode of instruction in biology 101 was not predictive of student success in biology 102 on campus for non-science major students within Virginia community colleges. Mode of instruction did not significantly impact the predictive relationship between student demographic characteristics and student success except for student gender. This chapter will summarize the purpose of the study, the research questions, the methodology, and the findings. The chapter will then discuss the findings in relationship to the literature, implications for practitioners, and ideas for future research.

Study Summary

Problem Overview

Community colleges are facing an increased demand for online courses, but these institutions have experiences which indicate that laboratory based science courses are very challenging to teach in the online environment (Instructional Technology Council, 2011). There is more research regarding online biology offerings at four-year institutions (Gilban, 2006; Swan & O'Donnell, 2009; Toth, et al., 2008) and the few previous studies in the specific area of community college online biology courses were small scale and conducted at single institutions (Johnson, 2002; Lunsford & Bolton, 2006). Although the literature points to the effectiveness of online biology courses within higher education, more research is needed. One way to inform faculty and administrators and to learn more about student success within online biology courses is to conduct larger studies with more students, multiple institutions, and tracking over several semesters.

Purpose Statement

The purpose of this study was to investigate the success of non-science major students in biology 102 on campus comparing students who completed biology 101 online to students who completed biology 101 on campus within Virginia community colleges. The independent variable was the mode of instruction in biology 101 (online verses on campus) and the dependent variable was student success in on campus biology 102 (receiving a C or higher).

Research Questions

This study was guided by the following research questions:

1. How will the mode of instruction in biology 101 be predictive of student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
2. What are the demographic characteristics of non-science major students who completed biology 101 online and biology 102 on campus at Virginia community colleges? The demographic characteristics examined include age, gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101.
3. What are the demographic characteristics of non-science major students who completed both biology 101 and biology 102 on campus at Virginia community colleges? The demographic characteristics examined include age, gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101.
4. How will the mode of instruction in biology 101 moderate the predictive relationship between student demographic characteristics and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
    a. How will the mode of instruction in biology 101 moderate the predictive relationship between student age and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?
    b. How will the mode of instruction in biology 101 moderate the predictive relationship between student gender and student success in

biology 102 on campus for non-science major students within Virginia Community Colleges?

c. How will the mode of instruction in biology 101 moderate the predictive relationship between student ethnicity and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

d. How will the mode of instruction in biology 101 moderate the predictive relationship between student prior online course experience and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

e. How will the mode of instruction in biology 101 moderate the predictive relationship between student enrollment status during the semester of biology 101 and student success in biology 102 on campus for non-science major students within Virginia Community Colleges?

Review of Methodology

Design

This study employed a quantitative design using ex post facto data. The method of course delivery in biology 101, online or on campus, was the independent variable for research question one, research question two, and research question three. The mode of course instruction acted as the moderator variable in research question four. Student success as measured by final course grade in biology 102 was the dependent variable in research question one and research question four. A successful student received a grade of C (70%) or higher as this grade is transferable to a four-year institution (Larson &

Chung-Hsien, 2009; Xu & Jaggars, 2011). The student demographic characteristics of age, gender, ethnicity, prior online course experience, and enrollment status during the semester of biology 101 were the dependent variables for research questions two and three and the independent variable in research question four. All demographic characteristics were measured dichotomously.

Data Collection

Data were obtained from the Virginia Community College System Academic Services and Research Department and included all Virginia community colleges that offer both completely online (lecture and laboratory) and completely on campus biology 101. Hybrid offerings of biology 101 (online lecture and on campus laboratory) were not included in the study. The participants for this study included non-science major program placed students at Virginia community colleges who completed online or on campus biology 101 in the Fall 2009 or Spring 2010 semesters. The students must have then completed biology 102 on campus within the next academic year (by Spring 2011). The data were provided without the individual student's identity as each student was designated by a random, unique numeric code. The coding protected the students and ensured confidentiality throughout the research process. The data from all community colleges were aggregated, and the students were divided into two groups, online biology 101 and on campus biology 101.

Data Analysis

To address the first research question, the final biology 102 grades of the students who completed biology 101 online or on campus were statistically analyzed through binary logistic regression. Binary logistic regression was appropriate due to the

dichotomous nature of both variables (Meyers et al., 2006). Descriptive statistics summarized the data related to the demographic characteristics of the students in research question two and research question three (Sprinthall, 2007). Binary logistic regression analysis was used to determine if differences in student success existed between demographic subgroups in research question four. Binary logistic regression was appropriate for this analysis because both the independent and the dependent variables were dichotomous and categorical (Meyers et al., 2006). Thus this study compared the success of community college online and on campus biology students both en mass and between demographic groups. The different levels of comparison led to a more comprehensive understanding of similarities and differences between students in online and on campus introductory biology courses.

Summary of Major Findings

Research Question 1

The mode of instruction in biology 101 was not predictive of student success in biology 102 on campus for non-science major students within Virginia community colleges, $Wald\,(1) = .228, p > .05$. The final logistic regression model did not increase the classification accuracy of the constant only model at 83.1%.

Research Question 2

There were 96 students within the sample who completed biology 101 online and biology 102 on campus. Most students were female (66%) and college aged (77%). The majority of the students were Caucasian (76%) and attending school as a full time student (74%). Most students who completed biology 101 online and biology 102 on campus had participated in a prior online course (63%) before enrolling in biology 101 online.

Research Question 3

There were 4863 participants who completed both biology 101 and biology 102 on campus. Most of the students were Caucasian (59%) and female (58%). Most of the students were college aged (82%) and enrolled as full time students (77%). Only 32% of students who completed biology 101 and biology 102 on campus had completed an online course prior to enrollment in biology 101.

Research Question 4

Research question four investigated if the mode of instruction in biology 101 moderated the relationship between student demographic characteristics and student success in biology 102 on campus. As indicated by the non-significant Wald test values, mode of instruction did not moderate the predictive relationship between student age and student success, *Wald* (1) = .440, $p > .05$, between ethnicity and student success, *Wald* (1) = 1.285, $p > .05$, between prior online course experience and student success, *Wald* (1) = .750, $p > .05$, or between enrollment status and student success, *Wald* (1) = .648, $p > .05$. Mode of instruction in biology 101 did moderate the predictive relationship between gender and student success, *Wald* (1) = 4.564, $p < .05$. As a result the relationship between student success and student gender would depend on the instruction mode of the previous biology 101 course. The regression coefficient (B) illustrated an inverse relationship between the interaction term of mode*age and the final model indicating that male students who completed biology 101 online were significantly less likely to be successful in biology 102 on campus.

In follow up analyses using simple binary logistic regression, age was a significant predictor of student success in biology 102 on campus, *Wald* (1) = 32.628, $p <$

.05. The relationship suggested that college age students are less likely to succeed in biology 102 on campus as compared to older students. Ethnicity was also a significant predictor of student success in biology 102 on campus, $Wald\ (1) = 8.401, p < .05$. Caucasian students were predicted to be more likely to succeed in biology 102 on campus as compared to students of other ethnicities. Finally, prior online course experience was a significant predictor of student success in biology 102 on campus, $Wald\ (1) = 8.517, p < .05$. The positive regression coefficient (B) illustrated a direct relationship where students who completed a prior online course were more likely to be successful in biology 102 on campus.

Findings as Related to the Professional Literature

Student Success in Online Biology

The findings of the current study support previous research showing no significant difference in student success between students who complete introductory biology online as compared to students who complete introductory biology on campus. The binary logistic regression analysis indicated that mode of instruction in biology 101 was not predictive of student success in biology 102 on campus for non-science major students within Virginia community colleges. Students were equally successful in biology 102 on campus regardless of whether they completed biology 101 online or on campus. Lunsford and Bolton (2006) and Johnson (2002) found no significant difference in community college student grades in introductory biology comparing online and on campus sections. The current research supports the previous findings by measuring student success in a different way and reaching the same conclusion. As a result the current research both adds to the literature and expands on previous ideas. The current

study further adds to the literature by sampling community colleges online biology students within Virginia for the first time. Researchers can now report similar trends in Virginia as compared to other regions in the United States. The current study had a larger sample size as compared to previous investigations and collected data over multiple semesters adding strong support to existing trends. The reinforcement of the trends already present within the literature adds weight to the conclusion that student success in introductory biology is not directly related to the mode of instruction.

The characteristics of students who completed online biology 101 and on campus biology 102 are similar to the general characteristics of online students within the VCCS. Jaggars and Xu (2010) tracked 24,000 VCCS students and determined women and Caucasian students were more likely to participate in an online course. The current study found students who completed online biology 101 and on campus biology 102 were mostly female and Caucasian. Jaggars and Xu also determined students older than 25 years old and students who previously completed an online course were more likely to enroll in an online course during their first year. Although the current research did not track when the student completed online biology 101 (first semester, second semester, etc.) the study did find that more students enrolled in biology 101 online and biology 102 on campus had previously completed an online course. However, most students who completed online biology 101 were younger than 25 years old, a difference from the general characteristics of VCCS online students. Perhaps older students were intimidated by completing a course with a laboratory component in the virtual environment. The fact that overall this study mirrors the trends previously reported in Virginia community college online students (Jaggars & Xu, 2010) supports the validity of the results.

Student Demographic Characteristics

Previous studies have investigated potential relationships between student success in online courses and student demographic characteristics. The current study is the first to investigate this specific relationship in community college online biology focusing on five different demographic characteristics.

Age

Most of the literature discusses differences in student participation in relationship to age as older students spend more time logged in and actively participating in the online environment (Dibiase & Kidwai, 2010; Hoskins & van Hooff, 2005; Ransdell et al., 2011). The trends in the literature regarding the relationship between student age and student success in terms of grades or course completion have not been thoroughly investigated and therefore the results of the current study are important to community college leaders. Mode of instruction did not moderate the predictive relationship between age and student success in biology 102 on campus within Virginia community colleges. This conclusion supports previous research reported by Dibiase and Kidwai (2010) finding no difference in average geography student project scores comparing older and younger students. Coldwell et al. (2008) also reported no significant difference in student performance between older and younger students in the online environment. Aragon and Johnson (2008) measured student success through online course completion (a different measure of student success) and concluded that there was no difference in age of community college students who completed or did not complete online courses. Overall, the results of this study support the trends previously reported within the literature regarding student age.

Gender

The results of the current study showed that mode of instruction in biology 101 had a moderator effect on the relationship between student gender and student success in biology 102 on campus. Therefore, the relationship between student success and student gender would depend on the instruction mode of the previous biology 101 course. The regression model suggested male students who completed biology 101 online are less likely to succeed in biology 102 on campus. The model predicted that 68.8% of male students who completed biology 101 online passed biology 102 on campus as compared to 90.3% of female students. These findings support previous studies by Price (2006), Doherty (2006), and Lin and Kim (2003) reporting female online students had a higher level of perceived learning and earned higher assessment grades. Aragon and Johnson (2008) and Packham et al. (2004) used course completion as a measure of student success and determined females had a significantly higher completion rate in online courses as compared to male students. The literature points to high levels of female engagement in the online classroom and a pronounced ability to develop a sense of community as reasons why female students may be more successful in online courses (Coldwell et al., 2008; Lin & Kim, 2003; Rovai, & Baker, 2005). Although the results of this study support previously reported findings, other researchers have found no difference in online student success in relationship to gender (Kemp 2002; Park & Choi; 2009; Sullivan 2001). This discrepancy indicates that the relationship between student gender and online course success is complex and requires further research.

Ethnicity

Ethnicity refers to a shared genealogy and cultural traits. The results of the current investigation support other published studies in the literature as mode of instruction in biology 101 did not moderate the predictive relationship between student ethnicity and student success in biology 102 on campus. Sullivan (2001) and Aragon and Johnson (2008) both found no significant difference in student performance or course completion in the online environment as related to ethnicity. The findings of the current study further confirm the idea that the ethnicity of the student does not directly impact success in the online environment. Although not directly measured within the current research, the literature reports that African American students have lower completion rates in online courses due to lack of access to technology (Moore et al., 2003). Since the current study differentiated ethnicity dichotomously, it was not possible to see if similar trends are found within Virginia Community Colleges in relationship to African American students and success in the online environment.

Prior Online Course Experience

The current literature indicates that students with prior online course experience are more likely to successfully complete future online courses (Aragon & Johnson, 2008; Hachey et al., 2012). This trend was not apparent within Virginia community college online biology students as the binary logistic regression showed mode of instruction in biology 101 did not moderate the relationship between prior online course experience and student success in biology 102 on campus. In a previous study, Hachey et al. (2012) found there was not a clear statistical relationship between previous online course experience and general success in online courses for community college students. The

authors suggested that specific kinds of online course exposure might benefit students in future online courses but the general number of online courses was not predictive of student success. The current study, which measured only if a student had completed at least one online course before enrolling in biology 101, supports the idea that certain types of online experiences might prove more significant in impacting student success rather than the number of online courses. Since the current study did not differentiate between the quantities of previous online courses before the community college student enrolled in biology 101, it is possible other relationships exist but were impossible to analyze with the current data set.

Enrollment Status

Previous research indicated part time students, or students who are taking fewer than 12 credits during the semester of the online course, were more likely to succeed and complete the online course as compared to students with a full time course load (Doherty, 2006, Moore et al., 2003). Within Virginia community colleges, mode of instruction did not moderate the predictive relationship between student enrollment status and student success in biology 102 on campus. Therefore the results of the current study are different than what has been previously reported in the literature. As this is the first study to investigate the relationship between student enrollment status and student success in a biology course it is unclear if similar patterns will be found in other science disciplines.

Unexpected Findings

One unanticipated finding from the current study was that few students completed biology 101 online and biology 102 on campus resulting in very different sample sizes for the analyses (96 verses 4863). It is unclear why this group of students was so small.

Perhaps the students who completed biology 101 online decided to continue in the virtual environment and complete biology 102 online as well. As the study did not request data for students who completed both semesters of introductory biology online it is unknown if this event occurred. Another possibility is that students completed biology 102 after more than one year had elapsed since biology 101 and therefore were not included in the sample. The one-year time frame between biology 101 and biology 102 was established in the participant criteria to ensure uniformity of content retention (Custers, 2010).

Most associate degrees require students to complete two science courses with laboratories. Students, however, do not have to complete both courses within the same discipline. Students may have completed biology 101 online and then taken another science instead of biology 102 such as a chemistry class or a geology course. Switching sciences could explain the low sample size of students who completed online biology 101 and on campus biology 102. Finally, students may have left the institution after completing biology 101 online. The student may have transferred or had to drop out due to poor grades, family commitments, or a change in employment. Jaggars and Xu (2010) found VCCS students who participated in an online course within the first semester or the first year were significantly less likely to persist to the following semester. A similar pattern may be present within online introductory biology. Although it is impossible to know which factors related to the small number of students who completed biology 101 online and biology 102 the most likely reasons include students remaining in the online environment, students switching science courses, or students leaving the institution.

Conclusions

Implications for Practitioners

The current research gives practitioners new knowledge as to what types of students are completing both online and on campus biology courses within Virginia. This information can help biology professors target the student population and know, even before the first day of class, the general characteristics of the students most likely to appear in their face-to-face or virtual classroom. If professors have an idea in advance of the demographic characteristics of the students they can prepare activities or alter their teaching style to better address the students within the classroom. Based on the current research, professors teaching online biology can assume that most of the students enrolled have completed a previous online course. These students should be familiar with the time commitment required to be successful but the participants may not be as comfortable with completing laboratory activities in the virtual world, a characteristic unique to online science courses. As a result, the professor can plan to spend more time instructing students on the laboratory aspects of the online course and less time discussing how to complete online quizzes or how to post to an online discussion board. By focusing on the differences of an online biology course and assuming the majority of the students are familiar with taking courses in the online environment the instructor can increase efficiency of course delivery.

The current research found more female students enrolled in biology as compared to male students within Virginia community colleges. Steinmann, Miller, and Pope (2004) surveyed female community college students and found female students typically studied at home and alone. Female students also reported it challenging to balance

academic and personal life but were unlikely to decrease their course load (Steinmann et al., 2004). Knowing these characteristics of female students and applying them to the biology classroom will help instructors effectively teach, advise, and support the majority of the biology student population within Virginia community colleges. Finally, the current study found that male students were less likely to succeed in biology 102 on campus after completing biology 101 online. Sullivan (2001) surveyed male and female students enrolled in online courses and found only 2% of male participants enjoyed interacting in the online environment as compared to 5% of female students. Therefore, biology instructors should work to integrate male students in the online classroom and help them develop a sense of community in an effort to increase their academic success.

The demographic information of Virginia community college biology students in relationship to student success will also benefit counselors in advising students in course selection. Although the VCCS investigated the success of online students in first semester college level English and math courses (Xu & Jaggars, 2011), the current study is the first focused on the success of Virginia community college students enrolled in online introductory biology courses. As many community college students complete introductory biology to fulfill associate degree requirements the findings of this study will help counselors better advise students regarding course delivery options as students try to fulfill degree requirements. Overall, mode of instruction in biology 101 was not predictive of student success in biology 102 and mode of instruction did not moderate the predictive relationship between student success in biology 102 and the demographic characteristics of age, ethnicity, prior online course experience, or enrollment status. Therefore, online introductory biology is a viable option for many Virginia community

college students. Students may be reluctant to register for online courses thinking the virtual environment is not a good match but the current study indicates that many different groups of students can be well served through biology 101 online. The one group of community college students not well served by online biology according to the current study appears to be male students. Therefore, counselors will want to spend more time advising and informing male students of course delivery options for introductory biology.

Within the VCCS's Rethink: Reengineering Virginia's Community Colleges, one area of focus is fostering a culture of high performance including innovation through technology (Reengineering Virginia's Community Colleges, 2012). Online courses fall within this topic and therefore findings from this study directly impact and help Virginia community colleges with online course structure and implementation. The interim report from the Innovation and Technology Task Force (2013) determined there were no consistent measures in place to evaluate programs and determine if programs should continue or be terminated. The current research helps the VCCS by identifying online introductory biology as a successful course for many groups of students and therefore a course that should be continued. The VCCS report also noted the need to create a culture that embraced innovation in an effort to serve more students at less cost and increase student success (Innovation and Technology Task Force, 2013). As higher education institutions reported that laboratory based science courses are challenging to teach in the online environment (Instructional Technology Council, 2011) online biology courses can be considered an innovative teaching method. Since the current research showed that mode of instruction in biology 101 was not predictive of student success in biology 102

on campus, the VCCS should embrace this innovation and use online biology offerings to meet the goals of the Rethink project including cost effectiveness, increased student access, and improved student success.

Although the current research sampled only community college students within Virginia, practitioners in other states can utilize these findings to make curriculum decisions at their institutions. The Virginia Community College System is diverse in institution sizes, locations, and students making the results useful to community colleges in many states. It is impossible to guarantee identical trends in other locations but practitioners can use the current findings as a baseline or comparison. The results will help administrators predict what might occur at their institutions in terms of student enrollment patterns in online and on campus introductory biology, student success in introductory biology independent of mode of instruction, and student demographic characteristics in relationship to mode of instruction in introductory biology.

Implications for Action

Jaggars and Xu (2010) found that fewer VCCS students completed online courses in the natural sciences, which includes biology. It was unclear from the research if there were few online course options within natural sciences or if VCCS students were being advised not to participate in online science courses. The current study found very different sample sizes between students who completed online biology 101 and on campus biology 102 as compared to students who completed both courses on campus, supporting Jaggars and Xu's conclusion. With the knowledge that mode of instruction in biology 101 is not predictive of student success in biology 102 administrators should add more sections of online biology. Online courses can be more cost effective for both the

student and the institution. The student does not have to invest gas money to travel to and from campus or pay for childcare (Sander, 2008). The community college may have higher instructional technology costs, but money spent to maintain classrooms decreases (Diamond, 2013). One of the goals of the VCCS's six-year strategic plan *Achieve 2015* (Wood, 2010) is to increase access to higher education. The findings of the current research point to online biology courses as a viable option for Virginia community colleges to effectively serve students while reaching strategic goals of increased student educational access.

Based on the results of the current study, community colleges should promote online introductory biology to students. Most associate degrees require students to complete two laboratory based science courses. Students deserve to be well informed of not only course options but also course delivery options. There are many different methods available to contact students including counselors, new student orientation sessions, the institutional website, Facebook pages, and student emails (Neibling, 2010; Zastrow, 2007). A combined communication effort incorporating all of these tools will effectively reach the largest student population informing them of the potential to complete introductory biology in the online environment.

Recommendations for Further Study

The current study is considered to be emerging research. The goal was to present overall trends of online introductory biology within Virginia community colleges. The results indicate that mode of instruction in biology 101 is not predictive of student success in biology 102 on campus. With this baseline, one of the next steps is to conduct focused investigations to learn more detailed information. Future studies should aim to

standardize more variables, for example, instructor or teaching methods, to help educators and administrators gain further knowledge about online biology within Virginia community colleges.

The current study determined male students who completed biology 101 online were significantly less likely to succeed in biology 102 on campus. It is unclear from the current research if male students were not well served in biology 101 online, or, if they were not supported in biology 102 on campus. This topic should be investigated in future studies in an effort to increase male student success in biology 102 on campus after completion of biology 101 online. The literature shows that female students are better able to develop a sense of community in the online classroom (Coldwell et al., 2008; Lin & Kim, 2003; Rovai, & Baker, 2005). Future research should investigate if a similar pattern of female community building is present in online biology 101 and if this factor impacts student success in biology 102 on campus in relationship to gender. Biology 102 covers a wider range of topics than biology 101. Perhaps male students feel overwhelmed by the speed of the course or the amount of material in biology 102 leading to decreased success. Future studies should investigate all potential factors that may impact male student success in both online biology 101 and on campus biology 102.

One interesting and unexpected finding of the current study was that many Virginia community college students who complete biology 101 online do not take biology 102 on campus. There could be many reasons for this choice, as discussed previously, but future research should investigate this question in more detail. Are students taking another science course? Are students staying in the online environment to complete biology 102? Are students not retained at the institution? The current study

indicated that students who do complete biology 101 online and biology 102 on campus are mostly female, college aged students who are Caucasian, full time students, and have previously completed an online course. Are more male students or more part time students who complete biology 101 online then exploring different options for their second science course at the community college? Answering this question will help administrators make informed course offering decisions and help counselors advise students in creating their course schedules.

As previously discussed, there are many different definitions of student success. The current study measured student success by final course grade in a subsequent biology course. Future studies should investigate student success in online biology with alternative measures, for example retention, withdrawal rates, or time to graduation. Measures such as retention and time to graduation are used to track institutional success (McLeod & Young, 2005) so learning about these measures in relationship to biology courses will also help community college leaders discover how effectively the institution is serving students. Johnson (2002) found no significant difference between student withdrawal rates in online and on campus introductory biology. Online VCCS courses in general had lower completion and student persistence as compared to on campus classes (Jaggars & Xu, 2010) but it is unknown if these trends are present in online biology. Using different measures of student success will broaden the understanding of online biology effectiveness within community colleges.

As the current study was the first to investigate student demographic characteristics in relationship to online biology more research is needed in this area. Will the same online biology trends be seen at community colleges in other states? The only

demographic characteristic that impacted student success within Virginia Community Colleges was student gender. However, all of the demographic characteristics were investigated dichotomously. It is possible that other relationships exist but were not found in the analysis due to the division of the data into two groups. Future studies should investigate student demographic characteristics in a non-dichotomous fashion for variables like age and ethnicity. Ethnicity, in particular, is an important characteristic to examine because grouping students into Caucasian and Non Caucasian does not differentiate between African American, Hispanic, and Asian students. African American and Hispanic students earn bachelors degrees in STEM (science, technology, engineering and math) fields at lower rates as compared to Caucasian and Asian students ("Increasing the Graduation Rates," 2006). A similar trend might be present in online introductory biology and future investigations should examine this possibility.

Future research investigating potential relationships between biology student success and student demographic characteristics should expand and examine other characteristics. Prior studies investigating online student characteristics tracked student GPA, time logged in, student participation, and student satisfaction (Aragon & Johnson, 2008; Coldwell et al., 2008; Dibiase & Kidwai, 2010; Lim, et al., 2008; Reeves & Osho, 2010; Rovai, & Baker, 2005). These concepts need to be investigated within online biology. It would also prove interesting to look at potential relationships between student access to technology and student success, student academic preparedness and student success, and student socioeconomic status and student success. Porchea, Allen, Robbins, and Phelps (2010) determined that community college students who were more academically prepared and students with a higher family income were more likely to

transfer to a four-year institution. These same factors may have a similar relationship to student success in on campus biology 102. Additionally, is there a relationship between student demographic characteristics and student success in other online sciences? The literature shows online chemistry students are equally successful to on campus students (Baron, et al., 2004; Cassanova et al., 2006; Kennepohl, 2007; Reeves & Kimbrough, 2004) but is this success related to student age, gender, or ethnicity? Future research should investigate this question.

The results of the current study indicated mode of instruction in biology 101 did not moderate the predictive relationship between previous online course experience and student success in biology 102 on campus. However, the researcher did not investigate the type of online courses previously completed. Hachey et al. (2012) found the type of online courses impacted student success rather than the number of online courses. It would prove interesting in future research to see if a similar relationship was found for online introductory biology.

Finally, qualitative research is needed to more fully understand the relationship between mode of instruction and student success in introductory biology. The literature is mixed with some online biology students stating they miss face-to-face interactions and immediate instructor feedback (Stuckey-Mickell & Stuckey-Danner, 2007) and other research showing no difference in attitudes between online and on campus biology students (Johnson, 2002). This discrepancy points to the need for more research. What trend is seen within Virginia community colleges? Administrators will be better able to serve online biology students if they can understand the student experiences and qualitative research will add to this knowledge base.

Concluding Remarks

The goal of the current research was to conduct a large-scale study of community college student success in online introductory biology. The research succeeded in this goal. Since the investigation included participants from multiple institutions over several semesters it not only adds to the existing literature but it increases support for online biology courses. This support can potentially changes practitioner's opinion that teaching online laboratory based science courses is challenging. The current study was the first investigating online biology within Virginia and measured student success in a different way by tracking student final grades in a subsequent course. As the VCCS is very invested in online education as illustrated by previous Virginia community college research focused on online courses the results of this study are valuable to the VCCS and have the potential to increase student access to online biology courses. The current study was also the first to investigate potential relationships between student demographic characteristics and student success in introductory biology. Community colleges serve a diverse student population so the results give practitioners new knowledge that mode of instruction in biology 101 only impacts student success in biology 102 on campus in terms of gender. As mode of instruction in biology 101 did not moderate the predictive relationship between student success in biology 102 and the other demographic characteristics online biology courses can effectively serve many different students within Virginia community colleges.

The current research is considered an emerging study and reported overall trends of mode of course delivery in introductory biology in relationship to student success. Therefore more research is needed to fully understand student success in introductory

biology and the potential influence of student demographic characteristics on student success. This study provides a baseline and offers suggestions as to gaps remaining within the literature that can be investigated in future research.

Community colleges continue to offer more online courses in an effort to cost effectively increase student access to higher education. Therefore, it is important for community college administrators to investigate the possibility of offering all subjects in the online environment. The findings of the current study indicate that online biology is a viable option for community colleges to effectively serve a diverse student population. The current investigation noted that one demographic group, male students, was significantly less successful in biology 102 on campus after completing biology 101 online. With this information, online biology instructors can investigate ways to better serve male students in online biology 101 and on campus biology 102. In addition, counselors should spend more time advising male students to make sure they are aware of different introductory biology course delivery options. As many students complete introductory biology to fulfill associate degree requirements the results of the current study provide community college leaders, administrators, biology professors, counselors, and students with valuable information about online biology course options.

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APPENDIX A

RESEARCY QUESTION VARIABLE TABLE

Research Question	Independent Variable	Dependent Variable	Moderator Variable
One	Mode of instruction in biology 101	Final course grade in biology 102	
Two	Mode of instruction in biology 101	Student demographic characteristics	
Three	Mode of instruction in biology 101	Student demographic characteristics	
Four	Student demographic characteristics	Final course grade in biology 102	Mode of instruction in biology 101

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Education

PhD	Community College Leadership, *Old Dominion University,* 2013
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BA	Biology, *Goucher College,* 2001

Professional Experience

2011-present	Assistant Professor of Biology, Tidewater Community College, Portsmouth, VA.
2005-2011	Biology Lab Manager and Biology Instructor, Piedmont Virginia Community College, Charlottesville, VA.
2004	Adjunct Biology Instructor, Piedmont Virginia Community College, Charlottesville, VA.

Presentations

"An examination of the predictive relationship between mode of instruction and student success in introductory biology"
VCCS New Horizons Conference, Roanoke, VA 2013

"Proposed research: A comparison between the effectiveness of online and on campus introductory biology as measured by student success in subsequent biology courses"
VCCS Science Peer Group Meeting, Virginia Beach, VA 2012

"Techniques for teaching BIO 101 laboratory online"
VCCS Distance Ed Peer Group Meeting, Richmond, VA 2010
VCCS Science Peer Group Meeting, Richmond, VA 2010

"Water supplementation and reproduction in bean beetles: An introductory biology lab activity"
VCCS Science Peer Group Meeting, Richmond, VA 2010

"Introducing phylogeny to general biology laboratory"
ABLE Conference, Newark, DE 2009
VCCS Science Peer Group Meeting, Wintergreen, VA 2008

Recent Awards

Old Dominion University Outstanding Doctoral Student in Community College Leadership, 2013
Old Dominion University Graduate Tuition Grant, 2012
Piedmont Virginia Community College Teaching and Learning Grant, 2008

Professional Affiliations

Phi Beta Kappa
Golden Key International Honour Society
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