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An Evaluation of Pathways to Community College Student Success in Anatomy and Physiology I

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AN EVALUATION OF PATHWAYS TO COMMUNITY COLLEGE STUDENT SUCCESS IN ANATOMY AND PHYSIOLOGY I

by

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ABSTRACT

The demand for healthcare workers is increasing nationwide. Higher education is responding by examining various interventions designed to increase completion (Abele, Penprase, & Ternes, 2011). Anatomy and Physiology is often identified as a gatekeeper course for students, since many withdraw or fail this course (Hopper, 2011). Within the VCCS, two colleges have implemented a prerequisite course, NAS 2, for Anatomy and Physiology. This study analyzed student data from before and after NAS 2 implementation, and examined General Biology to determine if it was a predictor of success in Anatomy and Physiology.

When NAS 2 was a significant predictor of grade in Anatomy and Physiology, students without NAS 2 were more likely to earn higher grades. At one college, NAS 2 was negatively associated with earning an A in Bio 141, Exp (B) = 1.405, χ^2 (1) = 4.058, p = .040. When compared to an outside college, NAS 2 was negatively associated with grades of F, D, C, and B. Here, the Exp (B)s ranged from 3.2 x 10^7, to 2.2 x 10^9, all with p values smaller than .0005.

At another institution, not having NAS 2 was associated with a 1.877 times increase in the likelihood of earning a higher grade in Anatomy and Physiology χ^2 (1) = 9.936, p = .002. When compared to an outside college, completing NAS 2 led to lower grades. In this comparison, students without NAS 2 were more likely to earn a higher grade in Anatomy and Physiology Exp (B) 1.941, χ^2 (1) = 13.362, p < .0005. Students who take the prerequisite course are not as well prepared for Anatomy and Physiology as the students who enter the course directly, holding constant other characteristics that often impact grades.

General Biology was a positive predictor of a grade of B when compared to NAS 2 completion, but only at the first college, Exp (B) of 1.533 ,χ^2 (1) = 6.815, p = .009. At the second institution, neither course was a significant predictor of final grade. Demographic variables of

age, ethnicity, and placing into a developmental course, were predictors in statistical models.

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Chapter I

Introduction

Coursework in Anatomy and Physiology is a common requirement for nursing and other allied health programs. These programs are at the forefront of many discussions in higher education today, since the United States and many other countries are experiencing a shortage of nurses (American Association of Colleges of Nursing [AACN], 2014) and other allied health workers (MacDowell, Glasser, Fitts, Fratzke, & Peters, 2009). The healthcare field, including nursing, is projected to grow 19% from 2014-2024 (Occupational Outlook Handbook, 2014).

The unmet national demand for nurses and other healthcare professionals is exacerbated by the attrition of students within these health care programs at colleges and universities (Hamshire, Willgoss & Wibberley, 2013). Attrition in general is an issue in higher education, as costs associated with programs increases (McGivney, 2003) and in healthcare programs can range from 30% (Fowler & Norrie, 2009 & O'Donnell, 2009) to 50% (Brown & Marshall, 2008; Newton & Moore, 2009). Two major solutions have been proposed: health care programs can increase the number of students they admit; or they can attempt to reduce attrition of students (Pritchard, 2010). Since nursing schools and allied health programs, especially within community colleges, are limited in the number of faculty members they employ and are limited in amount of space they have for classes, they cannot accommodate more students (AACN, 2014). Within the healthcare field, the National League for Nursing Accrediting Commission recommends that nursing programs should have a goal attrition rate of 20% or lower (Brown & Marshall, 2008). Many institutions that offer nursing and other allied health programs have been forced to examine curriculum and interventions that are offered to students in an attempt to increase the number of students who successfully complete health care programs (Abele,

Penprase & Ternes, 2011; Hamshire, Willgoss & Wibberley, 2013).

Studies have shown that success in "hard science" courses like Anatomy and Physiology are predictive of student success in nursing and allied health programs (Newton, Smith, Moore & Magnan, 2007). In many institutions, Anatomy and Physiology has been identified as a gatekeeper course, since this course must be completed prior to admission into a health program (Harris, Hannum, & Gupta, 2004). Additionally, Anatomy and Physiology typically has one of the highest withdrawal and failure rates on college campuses (Hopper, 2011). It is a difficult course that many students are unable to successfully complete. With a success rate (a final grade of C or better) of around 50%, many institutions, including institutions within the Virginia Community College System (VCCS), are attempting to increase student success within Anatomy and Physiology through various venues.

Studies on prerequisites have had mixed conclusions. Some studies on prerequisites have found them to be effective (Armstrong, 1998; Hoyt, 1999; McCoy & Pierce, 2004), while others report no impact, or even negative effects of requiring students to complete a prerequisite course (Arismendi-Pardi, 1997, Willett, 2000, Wilson, 1994). Research on prerequisites in biology courses has been limited. Very few studies have focused on prerequisites in Anatomy and Physiology, and most studies rely on qualitative research (Jameson, 2013; Nasr, 2012; Sturges & Maurer, 2013).

Two institutions, Community College B (Community College B) and Community College A (Community College A), have attempted to address success in Anatomy and Physiology by implementing a required prerequisite course. In both institutions, this course is designed to serve as a developmental-type course, to help prepare students for the rigors of Anatomy and Physiology. At Community College B, this course, Natural Science 2 (NAS 2), is

a three credit, 16-week course, while at Community College A, NAS 2 is an eight week, two credit course. Community College B requires students who enroll in Anatomy and Physiology I to have had prior course work in specific sciences, to complete NAS 2 with a grade of C or above, or allows students to complete a challenge examination that covers the content of NAS 2. Students who complete the challenge examination must complete the examination with a 70% or above. Community College B allows students with high school coursework in biology and chemistry to enroll in Anatomy and Physiology I. Students who have had these courses in college, or had a mix of high school and college courses in biology and chemistry are also allowed to enroll in the Anatomy and Physiology I course.

At Community College A, students have been permitted to take General Biology I in place of the NAS 2 course. With both prerequisites, students are required to complete with a C or better grade. Alternatively, students can choose to complete a challenge exam that covers General Biology I/NAS 2 content to be placed in Anatomy and Physiology. At Community College A, students must complete the challenge examination with a grade of 70% or better.

Problem Statement

As the demand for nurses and health care workers increases in the United States, institutions of higher education, including community colleges, are responding to this need. There has been research that examines whether certain prerequisites create successful students in their next course (Abou-Sayf, 2008; Abou-Sayf & Mariari, 2007; Arismendi-Pardi, 1997; Kaufmann & Gillman, 2002), but little research has been done with prerequisites courses in the sciences, particularly in Anatomy and Physiology prerequisites (Harris, Hannum & Gupta, 2004; Stickney, 2008). In the evaluation of prerequisites in the literature, there is much disagreement. Some prerequisites have demonstrated to be successful at producing students who perform better

in their subsequent course (Harris, Hannum & Gupta, 2004; McCoy & Pierce, 2004) while others have shown no difference or deleterious impacts to students who are required to complete them (Abou-Sayf, 2008; Rossi, 2003). Within the VCCS, it is important to evaluate these prerequisite courses and compare them to other prerequisites that are required to ensure that the required curriculum is better preparing students for the rigors of Anatomy and Physiology.

Purpose of Study

The purpose of this study was to assess four pathways to Anatomy and Physiology at two VCCS institutions, Community College A and Community College B, to determine which pathway leads to the greatest percentage of successful students. Further, this study investigated whether one or both of the required prerequisite science courses in these two institutions were correlated with producing students who were successful (final grade of C or better) in Anatomy and Physiology when compared with students who do not complete either of these two courses. This study also determined if General Biology I served as a better prerequisite than NAS 2 by producing a statistically significant number of successful students, identified as those who receive a C or better, in Anatomy and Physiology than students who completed either of the two NAS 2 courses.

Research Questions

This study was guided by the following research questions:

1. Does the existing NAS 2 prerequisite for Anatomy and Physiology lead to students who are more successful than students who did not complete the NAS 2 prerequisite?
    a. To what extent does completion of NAS 2 influence student success in Anatomy and Physiology when students who have completed NAS 2 at Community College A are

compared to students at Community College A who did not complete NAS 2 before it was a prerequisite when variables of age, gender, college level English/Math placement, and ethnicity are controlled?

b. To what extent does completion of NAS 2 influence student success in Anatomy and Physiology when students who have completed NAS 2 at Community College B are compared to students at Community College B who did not complete NAS 2 before it was a prerequisite when variables of age, gender, college level English/Math placement, and ethnicity are controlled?

c. To what extent does completion of NAS 2 influence student success when students at Community College A that completed NAS 2 are compared to students at another VCCS institution without NAS 2 with a similar success rate prior to NAS 2 implementation when variables of age, gender, ethnicity, college level English/Math placement, and prior institutional Anatomy and Physiology success rates are controlled?

d. To what extent does completion of NAS 2 influence student success when students at Community College B that completed NAS 2 are compared to students at another VCCS institution without NAS 2 with similar success rates prior to NAS 2 implementation when variables of age, gender, ethnicity, college level English/Math placement, and prior Anatomy and Physiology success rates are controlled?

2. Does General Biology I lead to students who are more successful than students who did not complete a prerequisite?

a. To what extent does General Biology influence student success in Anatomy and Physiology when students who took General Biology are compared to students who completed NAS 2 at Community College A when variables of age, gender, college level English/Math placement, and ethnicity are controlled?
b. To what extent does General Biology influence student success in Anatomy and Physiology when students who took General Biology are compared to students who completed NAS 2 at Community College B when variables of age, gender, college level English/Math placement, and ethnicity are controlled?

Scholarly Significance

Identifying whether one or both of the prerequisite courses is preparing students for study in Anatomy and Physiology will allow other institutions to determine whether they should implement one of these pathways if one course proves to be more effective for allied health students than current preparation methods. This project will provide other institutions within the Virginia Community College System with data to help them determine which pathway best prepares students for the academic rigors of Anatomy and Physiology. Beyond the VCCS, institutions that are examining allied health, nursing programs, and Anatomy and Physiology, can utilize these data to determine whether these requirements actually lead to better outcomes for students. To date, no significant analysis of these prerequisite programs has been completed, and information regarding the success of these courses can help institutions determine what interventions can increase student success.

Overview of Methodology

This quantitative study utilized ex post facto data on student success (defined as a C or better) from NAS 2 (the prerequisite course) and Anatomy and Physiology I at the two

community colleges where it is required: Community College A and Community College B. Additionally, temporal data from the two community colleges where NAS 2 is a requirement was compared to determine if student success changed since the prerequisite was implemented. For research questions dealing with comparisons within an institution, demographic variables of age, gender, and ethnicity, along with high school GPA, were controlled to assure that student populations that are being compared are similar. In comparisons where two different institutions were compared to determine if an institution with NAS 2 differs in success in Anatomy and Physiology success when compared to an institution without NAS 2, prior success rates for the previous three years before NAS 2 was implemented were used as a control to ensure that the institutions are similar. Data were collected from the Virginia Community College Systems office. Descriptive statistics were reported on these populations, ordered logistic regressions or multinomial logistic regressions were utilized to determine if the various comparisons are predictive of student grades in Anatomy and Physiology.

In research question one, parts a. and b., a temporal comparison was completed for both community colleges that have implemented NAS 2. Students from the two previous semesters of Anatomy and Physiology that were not required to complete NAS 2 were compared to students who were required to complete NAS 2 after implementation. In these research questions, the demographic variables of age, gender, and ethnicity, along with college level English/Math placement, were controlled to ensure comparison groups are similar. In these research questions, the independent variable is whether the student completed NAS 2 or not, and the dependent variable is the student grade in Anatomy and Physiology I.

To investigate research question one, parts c. and d., a comparison was done across institutions to determine if NAS 2 has impacted success rates. To do this comparison, Anatomy

and Physiology I success rates for the three years prior to NAS 2 implementation was compared across all VCCS institutions. Community College A's prior score was used to find another VCCS institution that has a similar success rate, and the Anatomy and Physiology I success was compared between the two institutions using an after implementation of NAS 2 success rate as a posttest comparison. The same methodology was utilized for Community College B: a pre-implementation Anatomy and Physiology I success rate was used to find a comparable VCCS institution, and a comparison was done using current post-NAS 2 implementation data. Again, an ordered logistic regression or multinomial logistic regression was utilized, and in these questions, demographic variables of age, gender, and ethnicity, along with college level English/Math placement, ensured comparable groups. The independent variable here is whether the student took NAS 2 or not, and the dependent variable is again student grade in Anatomy and Physiology I.

In research question two, the independent variable was whether a student took General Biology or NAS 2 prior to completing Anatomy and Physiology I. The dependent variable was again student grade in Anatomy and Physiology I. In these questions, the demographic variables of age, gender, and ethnicity, and college level English/Math placement, were controlled, and an ordered logistic regression or multinomial logistic regression was completed.

Delimitations

This study focused on students within the VCCS who enroll in Anatomy and Physiology. While all allied health students are required to complete Anatomy and Physiology I, nursing students are required to complete the course prior to admission into the nursing program. Many students who were included in this study may not have the goal of nursing school admission, or may not continue on to study an allied health field. This study included all students to ensure

there was an adequate sample size to detect significant differences between groups.

This study relied on ex post facto analysis of data and utilized data that is temporally different to compare before the prerequisite was required, to after the prerequisite was required. Although students may differ in some characteristics, demographic data and college level English/Math placement was reported and considered to create groups that are equivalent. Additionally, the prerequisite NAS 2 is new to Community College A. The prerequisite was added to the curriculum in 2013, so there is limited temporal data available from Community College A.

Definition of Terms

Age is discussed in this study as being traditional age (22 or younger) or non-traditional age (23 or older) (VCCS, 2012)

Anatomy and Physiology in this study refers to the first 16 week course in the anatomy and physiology series. Within the VCCS, this course is Bio 141.

Attrition is the cessation of individual membership in an institution of higher education (Bean, 1980 p. 157).

College level English/Math placement refers to whether a student placed into college level English and/or college level Math, or placed into developmental English and/or developmental Math upon completion of the placement examination. This study spanned a wide range of dates, so two different placement exams were in place. The COMPASS exam was originally used, then VCCS switched to the Virginia Placement Test.

Ethnicity is discussed in this study as a study identifying as white or non-white when they applied for admission into the VCCS (Wolfle, 2012).

General Biology I is the first semester of general biology. This course is taken over 16

weeks and has a lab requirement.

NAS 2 or Natural Science 2 is the prerequisite course that is required at both Community College A and at Community College B. Community College A offers the course as an eight week, two credit class with hands on activities, while NAS 2 is a 16 week course worth three credits at Community College B.

Prerequisite is a required course that must be completed successfully before enrolling in the next course in the sequence

Student success is defined as a final course grade of C (70%) or better. The VCCS considers this grade to be successful since it will transfer to a four-year institution upon graduation.

Organization of the Study

A brief background of the current nursing student retention crisis, and of the current research regarding prerequisite courses in higher education was presented in Chapter 1. Also presented in Chapter 1 is an overview of the methodology that was used for this study, the definitions of important terms utilized throughout the study, as well as the delimitations of the study. Chapter 2 will provide a more in depth analysis of research related to nursing student success and attrition, the impact of prerequisites in programs where they have been implemented, and on student success in Anatomy and Physiology. Methods for this study are outlined in Chapter 3, while the results of the study are discussed in Chapter 4. Chapter 5 presents the analysis of findings, and suggests future directions for Anatomy and Physiology prerequisite research.

Chapter II

Review of the Literature

This section presents a review of the literature on previous studies that examined issues related to student success and attrition related to students in higher education, students in community colleges, nursing, and allied health students. An overview of issues related to the focus on funding based on completion, factors that influence whether a student will complete higher education, and unique factors to health care students is provided.

A general overview of student success and student attrition is provided, then community college student success is explored. Within community colleges, various external societal and political pressures related to student success are discussed. Next, allied health and nursing as a field are explored in terms of students and issues related to nursing student success. Anatomy and Physiology is explored as one individual course that is required for allied health (including nursing). Next, associated prerequisites to Anatomy and Physiology are explored, including how they influence student success is discussed. Finally, a summary of issues is provided. Figure 1 demonstrates the context of the literature review from the broad topic of student success, down to Anatomy and Physiology student success.

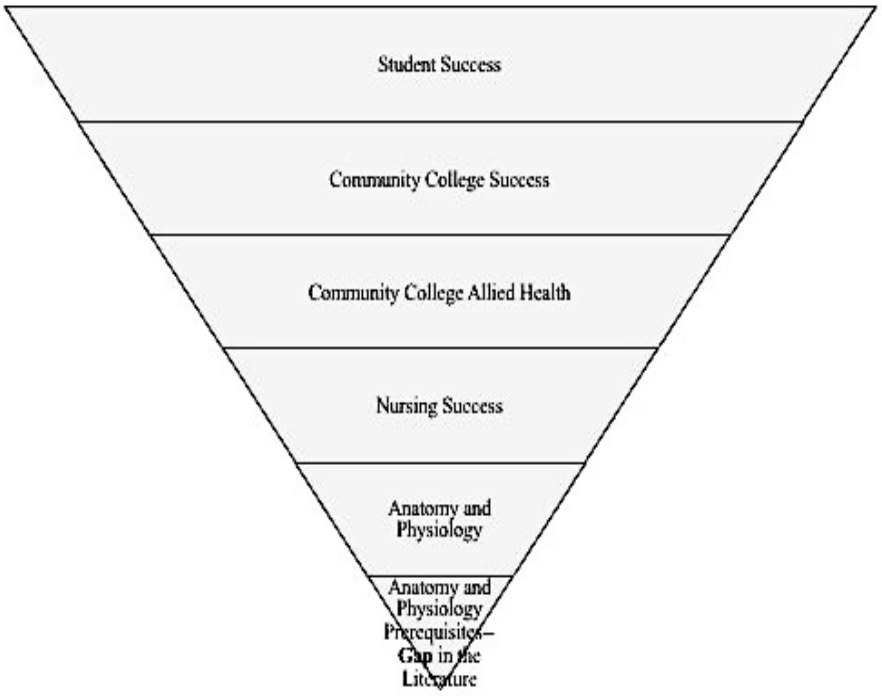

Figure 1. Outline of Literature Review Topics.

Methodology for Collecting and Analyzing Literature

Research was conducted using Old Dominion University library databases Education Research Complete, Education Full Text, Education: A SAGE Full-Text Collection, and ERIC. The databases at Old Dominion contain full text peer reviewed journal articles. Additionally, the Old Dominion and Virginia Community College Systems libraries' catalogs were utilized to locate related books, and Old Dominion's thesis/dissertation search tool, Dissertation and Theses Global was used to identify any similar topics. Search terms included: student success, student attrition, retention, persistence, community college, prerequisite, nursing, allied health, age, gender, ethnicity, science, theory, and developmental education. Search terms were also combined to form searches for community college success, community college prerequisites,

nursing student success, and allied health student success. Searches were conducted in 20014 and 2015.

Overview of Student Success

Student success, commonly defined in terms of grades, persistence, retention, credits earned, graduation, and/or length of time to graduation, has traditionally been at the forefront of higher education research. Institutions in higher education focus on course grades and other examination results as a mechanism for assessing success (Definitions and Conceptual Framework, 2007). As many as four-fifths of high school graduates require some type of post-secondary education to become economically and socially productive members of society (Kuhn, Kenzie, Buckley, Bridges & Hayek, 2006). College graduates earn on average a million dollars more over the course of their lives than non-college graduates with just a high school diploma (Pennington, 2004).

While college is important, the reality is that many students do not complete higher education. Enrollment and persistence rates are low for many student groups. African American, Latino, Native American students, students with disabilities, and low income students often do not persist (Gonzales & Szecsy, 2002; Harvey, 2001; Swail, 2003). In 2004, the National Center for Public Policy and Higher Education estimated that out of 100 ninth grade students, only 40 immediately enter college when they graduate, only 27 are still enrolled in their sophomore year of college, and only 18 actually complete post-secondary education within six years of graduating high school. This estimate is alarming. Far too many students do not complete higher education.

Students must face many challenges to become successful in college. Students often come into higher education without proper preparation and background to perform well. For

example, 60% of students in public two year institutions require at least one year of remedial coursework to bring them up to college level (Adelman, 2005; Horn & Berger, 2004; U.S. Department of Education, 2004). Kuh, Kinzie, Buckley, Bridges and Hayek (2006) found that students must have proper pre-college preparation to increase their odds of completing college.

Academic Preparation

Academic preparation in the K-12 system is important, along with family background, enrollment choices (since part time students often perform poorly when compared to full time students), and financial aid and assistance available to them (Kuh et al., 2006). Generally speaking, students need to be prepared for higher education, they need support from their family and understanding of why college is important, and have to have a way of financing their college education.

Adjustment Issues

Once enrolled in college, a student must go through several transitions to perform well. In general, students have to navigate various processes and obligations to persist within higher education. Students must navigate developmental education, financial aid, and outside work obligations, which can prevent engagement (Kuh et al., 2006). 45% of college students fail to complete their degree, less than a quarter are dismissed due to poor grades (Kuh et al., 2006). For many students, outside factors that influence social adjustment and academic performance are important.

Student Adjustment and Success Theory

There are many theories related to student success in higher education, many of which have been shown to apply in a variety of contexts. The theories that were discussed are sociological adjustment, institutional structures and their influence on success, student

characteristics, cultural characteristics, and economic background. Each of the following theories has utility in understanding why students succeed, but not can be applied universally. For example, Tinto's (1975, 1987 & 1993) theories of student adjustment has been supported in many studies (Braxton, Sullivan & Johnson, 1997; Pascarella &Terenzini, 2005). However, it should also be noted that Tinto's theory does not apply universally and that the definitions for academic and social integration given by Tinto are flawed (Braxton and Lien, 2000).

Sociological Adjustment. Tinto's (1975, 1987 & 1993) theory of student adjustment is the most prevalent theory regarding how college students socially adapt to college environments. Tinto (1993) suggested that students must separate from their former social or family group, then they transition into a new group, then incorporate those new group values and behaviors into their own values and behaviors. Further, Tinto described how academic integration acts in a manner similar to social integration. Students integrate into the academic environment by earning passing grades, and embracing the institutional or discipline academic norms. Social integration encompasses peer to peer interaction, along with faculty to student interaction. Academic integration is related to the choice of major (Kuh, Lund & Ramin-Gyurnek, 1994). Bean (1983) described how increased levels of adjustment academically and socially leads to gains in persistence and completion. Additionally, Tinto asserted that the social position of a student's family allows the student advantages in adjusting and that student background characteristics, such as race, gender, family, and financial situation all influence student's commitment and likelihood to persist in higher education (Tinto, 1993). Demographic background variables in Tinto's model (1993) accounted for 24% of the variance between the two groups: students who persist and students who do not persist (Halpin, 1990).

Tinto's work has been criticized for various reasons. One common issue is that Tinto's

theory doesn't apply to many student populations. Berger (2000) indicated that academic integration is not applicable to all students. Longwell-Grice and Longwell-Grice (2014) discovered that first generation students may be intimidated by faculty, and are less likely to seek out the faculty-student relationships essential to success in Tinto's model.

Additionally, many researchers have expressed that the operational definitions for academic and social integration are inadequate (Braxton & Lien, 2000; Braxton, Sullivan & Johnson, 1997; Hurtado & Carter, 1997). Others have discovered that the links between the stages of separation, transition and incorporation are not supported (Nora, 2002). Kuh & Love, (2000) suggested that the survey items used by Tinto may not be appropriate.

Institutional Characteristics. Institutional characteristics have been identified as a factor that can increase or decrease student success. In Bean's (1983) model of student attrition, the importance of beliefs was explored. In this model, Bean asserted that beliefs, shape attitudes, attitudes shape behaviors, and behaviors influence intents. Students have perceptions about an institution. For example, students interact with faculty and staff. These interactions can influence how the student perceives the institution. If a faculty member is not responsive or appears to the student to be unfair, this negatively affects how the student views the institution. That student may develop negative behaviors and may not persist at that institution. This is also true with institutional policies. If students view policies to be unjust, that student may develop negative beliefs, attitudes, and behaviors and can ultimately not persist at that institution (Bean, 1983).

In the same way, leaders and other institutional characteristics can influence retention and success. Leadership and decision-making at an institution can impact student success. If a senior leader cannot gain student support, students may develop a negative view of the institution

(Berger & Braxton, 1998). Pike & Kuh (2005) identified that negative perceptions of the campus size, control, mission, and location can all influence student perceptions.

Student Characteristics. Similar to institutional characteristics, a student's characteristics can influence success. Student characteristics such as self-efficacy can influence whether a student is successful or not. Bean & Eaton (2000) demonstrated that if a student feels able to succeed when they are faced with the academic and social challenges in higher education, they are more likely to succeed. Dweck (2000) also developed a theory around students' perceptions of themselves. In this theory, the self-theories of intelligence, some students believe intelligence is fixed, while others believe intelligence to be incremental, or able to be expanded on my learning. Students who view intelligence as an incremental entity are more likely to take on challenges and utilize services that institutions offer. Students who believe intelligence to be fixed are not as likely to utilize services, and face the risk of dropping out of higher education when they cannot deal with challenges.

Psychological contract theory indicates that students develop certain beliefs about their relationships with other students, faculty and staff. These relationships are based on implicit agreements between the student and the institution or student about how one should respond to the other. If a student feels like the institution has not responded appropriately and that contract has been violated, that student may lose trust in the institution (Rosseau, 1995).

Cultural Characteristics. In terms of cultural characteristics, minority student groups face additional challenges that may make accessing various campus services difficult. Minority student groups can experience difficulty feeling like they are a part of the academic community at any particular institution. Minority groups report feeling isolated and may not believe that faculty and staff are interested in their success (Turner, 1994).

Many theories, such as Tinto's model, may not fit well for minority student groups, since these theories are couched in culturally based assumptions. Minority groups may deal with different issues related to student success. Much of this discord can stem from minority groups' perceptions of what is valued and what the institutional norms are. It can be difficult for students to participate in an institution if that student group cannot reconcile their cultural beliefs and values with what they perceive to be the acceptable values and behaviors at the institution (Astin, 1977, Kuh & Whitt, 1988; Pascarella & Terenzini, 1991, 1995).

Tierney (1992) explored if students should conform to institutional norms if those norms conflict with the student's cultural norms. Jalomo (1995) studied Latino community college students and reported that this group of students was able to conform to the norms of the college, but that students struggled to do so. Gonzalez (2000), Ortiz (2004), and Torres (2003) also described Latino students experiencing tension between their lives within higher education, and their home lives, especially for first generation students who often lack support from parents when navigating higher education, and Latinas who often experience pressure to remain at home. First generation students may feel as if they are standing over two worlds: their home culture, and institutional culture (London, 1989). Rendon, Jalomo & Nora (2000) proposed that institutions have a responsibility to help these groups navigate the college or university norms, especially when the groups' cultural norms are different.

Economic Factors. Another factor that influences student success is whether the student perceives that higher education is giving them a benefit. Kuh et al., (2006) assert that student perform cost benefit analyses while deciding to enroll and/or persist in higher education. If a student determines that staying enrolled or completing an activity provides a good return on investment, students will stay. If a student determines that there is not a good return on

investment, the student will not persist (Braxton, 2003). Students perceive costs to be both tuition and fees, along with lost income while they are taking classes. In terms of benefits, students consider future learning, knowledge and skills, and higher qualifications (Goblin, Katz & Kuziemko, 2006). Higher education can help students realize all of the benefits of persistence--gains in knowledge, gaining important skills like problem solving and critical thinking, or obtaining a job after graduation to ensure students are weighing cost and benefit appropriately (Kuh et al., 2006).

Student Success in Community Colleges

Community colleges face many of the same barriers to student success that four year institutions do. Some factors can be unique to community colleges, and many outside influences have placed a pressure on community colleges in particular. Political pressures such as the American Graduation Initiative and performance based funding models work against community colleges and are forcing community colleges to examine student success models carefully.

Student Persistence and Completion in Community Colleges. Within community colleges, student persistence, completion, and transfer rates are also low. These rates have been particularly low among minority student groups. In 2004, American College Testing reported that two-year institutions had 8% higher dropout rate than four-year institutions (American College Testing [ACT], 2004).

Similar to students in higher education more generally, community college students who have parents with a college education are more likely to persist, low-income students are less likely to complete (Engstrom & Tinto, 2008). Older students are more likely to drop out of community college than similar students who are younger in age (Feldman, 1993). Minority groups such as African-American students have lower completion rates than white students

(Cofer & Somers, 2001).

The trend of decreased persistence, completion, and transfer has impacted and will continue to influence community colleges in several ways. The completion concern has led to many initiatives and policies to help increase the success and retention of students in community colleges. Among these efforts, three issues have large impacts for community colleges. These three issues are the federal pressure to increase the number of college graduates, the pressure to partner with K-12 education to promote college readiness, and the pressure to provide funding based on performance.

American Graduation Initiative and Community Colleges. The pressure to increase the number of college graduates has been stemming from an initiative introduced on the federal level. In 2009, President Barack Obama outlined the American Graduation Initiative (AGI), which challenged the nation to produce five million students who have completed degrees and certificates by 2020 (Obama, 2009). In order to meet this goal, institutions of higher education are seeking innovative ways to increase student completion and persistence. The American Graduation Initiative (AGI) that was outlined by President Obama is an attempt to meet workforce demands, and to create employment opportunities in the United States (Obama, 2009). The AGI focuses on completion, but has created a sense of urgency to examine persistence of students and to create new models of persistence and retention (Bahr, 2013).

Community colleges enroll 44% of undergraduates in the United States' Higher education system (Williams, 2013). Within community colleges, it is important to note that not all students plan to receive a degree or certificate and that many students are seeking to transfer to four-year institutions, for personal enrichment, or to enhance their work related skills (Tinto, 2012). Two-year institutions serve a variety of students, are open access institutions, and thus,

have lower graduation rates (Bahr, 2013). With the new focus on completion, the community college mission is being challenged. Community colleges work to provide upward transfer, workforce development and community education within the communities they serve through various pathways. Community colleges also serve minority groups. To illustrate the mission of community colleges, Bahr stated, "the community college is the primary door through which non-traditional, underrepresented, low-income, and first generations students enter post-secondary education" (Bahr, 2013, p. 139). In order to meet this goal, institutions have had to focus on student completion and persistence and have focused on new models of persistence and retention (Bahr, 2013). Under this initiative, community colleges should have an annual increase of 250,000 degrees awarded (Kotamraju & Blackman, 2011). If the number of degrees conferred by other post-secondary institutions remains the same, the bulk of the initiative's graduate increase could fall on community colleges (Kotamraju & Blackman, 2011). As many as 50% of new degrees would need to come from community colleges under this initiative (Kotamraju & Blackman, 2011).

Performance Based Funding and Community Colleges. Along with college readiness and developmental education reform, funding has played a large role in driving the focus on completion. The amount of funding that community colleges and other higher education institutions rely on from the state legislature has been decreasing (Hermes, 2012). Traditionally, funding was based on the number of full-time equivalent students enrolled in the college (Hermes, 2012). Many have argued that funding based on full time equivalent students is biased against community colleges, since community colleges are comprised of mainly part time students (Zarkesh & Beas, 2004).

With the increased focus on completion and tighter state budgets, state governments have

been pressuring institutions, including community colleges, to provide justification for expenditures (Alexander, 2000). As of February 2013, this had resulted in 12 states in the United States allocating some state money to institutions based on the performance of the institution (Abdul-Alim, 2013; Alexander, 2000). More states are considering transitioning to various levels of performance based funding (Abdul-Alim, 2013; Alexander, 2000).

Community Colleges and Developmental Education. As institutions of higher education identify measures that can increase the number of graduates and successful students, developmental education has been identified as an area where many colleges can work to increase attainment. Many institutions, such as Virginia have identified developmental education as an area where redesign could result in better attainment. Cohen and Brawer (2008) stated that one in three community college courses is a remedial course. The redesign of developmental education models has occurred to increase completion of developmental education and college (Top 10, 2015).

In 2012, developmental education created much discussion among lawmakers and higher education officials. Legislatures and administrators recognized that 21 states prohibit or discourage remedial education from being taught at four-year institutions, and many states are refusing to fund developmental education at four-year institutions (Top 10, 2013). The lack of developmental courses at four-year institutions has resulted in the responsibility of developmental education being pushed on to community colleges, which struggle to create successful students in developmental education courses (Ariovich & Walker, 2014). Many students report feeling discouraged with the time and cost of developmental classes and often drop out of college as a result (Williams, 2013).

College Readiness and Developmental Education in Community Colleges. College readiness has become a concern. Institutions, including community colleges, have looked to the K-12 public education system to better prepare students to come into a higher education setting. The push for high school graduates that are college ready has resulted in more rigorous academic standards in the K-12 arena in the last two years (Top 10, 2013). These increased standards illustrate the effort to bridge the gap between high school and college (Top 10, 2013). Policy makers have developed policies and initiatives designed to make transitioning from high school to college easier for students. Initiatives such as High Schools that Work, career academies, and technical preparation programs help to bridge the gap between post-secondary education and higher education (Kim & Bragg, 2008).

Developmental education is a large issue that community colleges face. Students who require remedial coursework often do not complete it, and when students do complete the developmental coursework, graduation rates are still low for these groups (Amos, 2011; Yates, 2010). Though developmentally placed students may not perform as well academically as students who come to community college at a college level, some studies have found that developmental students who do complete their developmental coursework do as well as non-developmental students in their college level courses (Bahr, 2008; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009).

Prerequisites and Community Colleges. Prerequisite courses in community colleges have been studied in a multitude of contexts. Most of these studies have been done in English and Mathematics courses. There has been disparity in the literature where prerequisites have been examined, with some researchers finding that prerequisite coursework can lead to students who perform better in the target class (Harris, Hannum & Gupta, 2004; McCoy & Pierce, 2004),

while others have shown no difference or deleterious impacts to students who are required to complete them (Abou-Sayf, 2008; Rossi, 2003).

Abou-Sayf (2008) explored the effectiveness of an English and a math prerequisite course. The researcher pointed out that prerequisites are only implemented for two reasons: to increase student success in a target course, or to ensure students' safety in the target course. Abou-Sayf (2008) explained that many faculty conduct an informal qualitative survey of courses to identify which preexisting course has outcomes that match the skills and competencies needed for the target course and that there has been an increase in the number of prerequisites students are forced to complete.

Additionally, Abou-Sayf indicates that quantitative studies allow for the analysis of a prerequisite to determine if one group who takes the prerequisite is different from a group that did not complete the prerequisite. The comparison group may be from a different semester, or may be from the same semester. In this study, students enrolled in the same semester at a community college were given the option of enrolling in the target English course or enrolling in a prerequisite course first. Interestingly, when the math prerequisite was waived, enrollment in the target math increased, while eliminating a prerequisite for English did not result in increased enrollment.

Abou-Sayf and Miari (2007) described the "persistence effect" with regard to prerequisite courses. This effect describes how prerequisites often increase student success in a target course, but not in the desired way. Their idea is that prerequisite courses require students to enroll longer at the institution, increasing the likelihood that students will drop out along the way. Only students who persist are able to access the target course, so they are generally better students who were likely to succeed in the target course from the beginning. In this way, prerequisite

courses increase the time to degree, and may not work in the way administrators and faculty intend them to.

Other studies have utilized qualitative approaches (Manokore, 2014, Simpson & Eddy, 1991), but quantitative approaches dominated the literature (Arismendi-Pardi, 1997; Armstrong, 1998; Hoyt, 1999; McCoy & Pierce, 2004; Wilson, 1994), and many have contradictory statements regarding prerequisites. For example, Wilson (1994) found that mathematics prerequisites were not a significant predictor of success in college chemistry, but Hoyt (1998) indicated that prerequisites are not only necessary, but that high performance in prerequisites is necessary for success in various courses.

Community College Response to Completion Agenda. One way community colleges have responded to the focus on completion is by implementing measures that have been shown to be effective at increasing student retention in college and within programs (Hermes, 2012). These measures are meant to increase student success and decrease attrition. There are many broad changes institutions undertake to attempt to increase completion. Institutions increase completion through mentoring, bridge programs, by establishing cohorts of students, and by examining developmental education programs, to name a few (Cohen & Brawer, 2008; Drennan, Meehan, Kemple, Johnson, Treacy & Butler, 2007). Beyond these broad measures, it can be effective to examine one specific area and address the issues within that program to determine interventions are successful at increasing completion. In the short term, colleges can identify an intervention that is successful for a smaller program, and can apply that intervention in the long term to other disciplines and areas.

Allied Health and Nursing Student Success

Nursing and allied health students are another unique population (Bosher & Pharris, 2009; Jeffreys, 2010). Students within these programs face additional hurdles to success, and since nurses are in large demand world-wide, nursing programs, especially in community colleges, have been drawing attention (Harvath, 2008). Students enrolled in these healthcare programs often leave college for reasons similar to college students in general: they often leave due to personal, financial, and academic stresses (Glossop, 2001). Additionally, nursing and allied health students often are dealing with limited social capital: they are often full or part time workers, tend to be from lower socioeconomic backgrounds, and may have lower school entry scores (Lizzio, Wilson, & Simmons, 2002). Nursing students are often older students who are changing careers, and thus have families (Birks, Chapman, Ralph, McPherson, Eliot, & Coyle, 2013). Many programs are reporting these shifting student demographics and are introducing various interventions to help support students (Andrew, Salamonson, & Holcomb, 2008).

Allied Health and Nursing. Nursing and allied health fields have been largely impacted by the focus on completion. This is because the demographics of the nursing student population has shifted, as many students are now classified as "nontraditional," the workforce has become restructured and many students attend health programs as a second degree program, and students who apply for nursing and allied health programs are less prepared (Bosher & Pharris, 2009; Harvath, 2008; Hegge & Hallman, 2008; Jeffreys, 2010). As in community colleges in general, health care student success is influenced by demographics, including race, age, socioeconomic status, and gender (Andrew, Salamonson & Holcomb, 2008; McLaughlin, Muldoon & Moutray, 2010).

Nursing Retention Crisis. Nursing programs, especially Registered Nursing programs, are a staple of community colleges. Nurses are critical to society, to the communities they serve and to the medical field. In the United States, as well as in other countries worldwide, there is a shortage of nurses (Occupational Outlook Handbook, 2015). In addition, the current workforce of nurses is aging. As many nurses retire in upcoming years, the shortage is expected to continue into 2020 (Blais, Hayes, Kozier, & Erb, 2006).

To help reduce the projected workforce shortage and to increase the numbers of graduates, institutions are attempting to identify which support interventions are the most successful for nursing students and help to attract and retain more nursing students (Drennan et al., 2007). More nursing students and better retention leads to more selective programs, which also helps increase completion (Drennan et al., 2007). When institutions implement policies that are effective for nursing students, they stand to gain and maintain enrollment, which leads to more funding for the nursing program when resources are allocated based on completion rates (Drennan et al., 2007).

Nursing student attrition has been identified as a major contributor to the nursing shortage (McLaughlin et al., 2010). It has also been difficult for programs to attract nursing students who are academically prepared. This has been referred to as a "recruitment and retention crisis in nursing" (McLaughlin et al., 2010, p. 303). Institutional programs that have been shown to be effective for retaining students are tutoring programs and mentoring programs (Beauvais et al., 2014). Social constructs, such as gender roles and gender identity have been shown to be influential in determining student attrition (McLaughlin et al., 2010). Other researchers have identified the ability of a nursing student to manage stress, to spend time on the tasks they are presented, to deal with financial hardships, along with perceived stress and support

as being influential for success (Brown & Edelmann, 2000; Horstmanshof & Zimitar, 2007; Jameson, 2014).

Creating a Supportive Environment

Emotional and belonging support is important in creating an environment in which students can be successful (Cech, Metz, Babcock & Smith, 2011; Shelton, 2012). As described by Cech et al. (2011), the emotional support is important to all students, including minority students. Shelton (2012) identified that perceived support is crucial to nursing student success. Yoder (1990) proposed a model where mentorship increases psychosocial support. In this model, mentor ship improves encouragement and also creates an environment supportive of personal counseling for the student being mentored (Yoder, 1990).

Additionally, nurse mentorships have been shown to be successful in programs where they are implemented. Nelson, Godfrey and Purdy (2004) found that when student nurses were assigned a mentor, there was less turnover of nursing students, and higher licensure examination success rates. Students also reported easier transitions into the workforce that nursing students who did not have experience with a nurse mentor (Nelson, Godfrey, & Purdy, 2004). Other research has illustrated that nurse mentorship not only creates an environment of support in terms of acceptance and role modeling, but also helps to creating a coaching environment. In this coaching environment, students receive challenging assignments and are exposed to various aspects of nursing they might not experience until later (Byrne & Keefe, 2002). This is especially true with regard to minority student groups. Minority students within nursing programs have been shown to have greater rates of completion when provided with a nurse mentor (Andrew et al., 2008; Beauvais et al., 2014).

Nursing Programs

Nursing programs, especially Registered Nursing programs are a staple of community colleges, since nurses are critical to society, the communities they serve, and to the medical field. In the United States and other countries around the world, there is a serious shortage of nurses (Gould & Fontenia, 2006). In the United States, as the current workforce of nurses ages and many nurses leave their positions in upcoming years, the shortage of nurses is projected to continue into 2020 (Blais, Hayes, Kozier & Erb, 2006). Because of this shortage, many countries, including the United States are now examining nurse education critically and have made nursing research a priority (Drennan et al., 2007).

Institutions are attempting to determine the most effective support and interventions for nursing students to ensure that they are successful and can fill this need in the workforce (Drennan et al., 2007). The best nursing programs in higher education are able to attract and retain nursing students, keeping enrollment. Keeping high enrollment means that institutions can be more selective of students who are admitted, which increases completion (Drennan et al., 2007). Institutions, therefore, stand to gain and maintain enrollment through implementation of policies that are effective for nursing students, which ultimately leads to more funding for nursing programs at institutions as more funding is being allocated based on completion (Drennan et al., 2007).

Factors Influencing Attrition of Nursing Students. Among the topics of concern, the attrition of student nurses is often identified as the most influential on the nursing shortage (McLaughlin, Muldoon, & Moutray, 2010). Some researchers have described this issue as the recruitment and retention crisis in nursing (McLaughlin et al., 2010). Many institutions face such large issues with retention that they are focusing on understanding what factors influence

retention and success of nursing students specifically (Fontaine, 2014; Shelton, 2012; Starck, Love, & McPherson, 2008).

Many factors can play a role in nursing student retention. Students may face personal issues, such as balancing schoolwork with their family obligations, deal with learning issues and support issues as they struggle to deal with course loads, and can face problems with clinical placements (Hamshire et al., 2013). Two studies have identified various institutional programs that help students deal with these issues and are effective at retaining students. Tutoring and mentoring programs have been shown to be effective, while other studies have shown that student demographics are the most influential factors in determining nursing student success (Beauvais, Stewart, DeNisco, & Beauvais, 2014). Social constructs, like gender roles and gender identity are also important for success, since nursing tends to be a female dominated field (McLaughlin et al., 2010). Additionally, hardiness of the nursing student along with perceived stress and support from family and from the institution have been shown to be influential to nursing student retention (Jameson, 2014). In terms of prerequisites, Abele, Penprase, & Ternes (2013) researched which prior coursework serves as a predictor of success in a baccalaureate nursing program

One study by Jameson (2014) examined what effect educational interventions have on baccalaureate nursing students and what effect did that same intervention have on perceived stress of the student. Other research questions examined the differences in demographic data and gender roles on success and completion (Andrew et al., 2008; McLaughlin et al., 2010).

Shelton (2012) developed a theoretical framework for a model of nursing student retention in higher education. Using the self-efficacy work of Bandura (1997) and Tinto's (1993) theory of retention, a model was developed. This model combined the ideas of Bandura's

work (1997) that self-efficacy (the belief in one's abilities) when planning and carrying out courses of action is required to produce desired results. Shelton (2012) applied Bandura's model to education and asserted that efficacy determines if academic behavior is initiated, how long the behavior is sustained, and therefore influences whether or not a student will persist. This model also applies Tinto's (1993) theory of retention in that the feeling of community is important in order for students to persist. A feeling of community and a belief that an individual's abilities, goals and values are similar to other individuals in the institution is necessary to help a student feel that they belong (Tinto, 1993).

Shelton (2012) combined these ideas and suggested that student background variables of age, gender, previous coursework, past GPA, standardized test scores, financial resources, family educational level, family responsibilities, marital status, and employment all influence retention of nursing students. Shelton (2012) also described that internal psychological processes of self-efficacy, academic and career goals and goal commitment all are influential in retention of nursing students, along with psychological and functional support. Psychological support is described as encouragement, caring, and promotion of self-worth, while functional support is the activities that help students perform specific tasks and achieve goals. In this model, both types of goals promote integration as described by Tinto (1993) and a sense that success is possible, as described by Bandura (1997).

Institutional Support. Shelton's framework (2012) described the importance of support, combining Tinto's (1993) ideas on retention with Bandura's (1997) ideas of sociological support within a system. Most studies that have been done on nursing student success have focused on the effectiveness of institutional interventions designed to assist nursing students and increase retention and success of these students. This is an important issue since each institution has

different demographics of students, and unique characteristics that make that institution different from other institutions of higher education. For example, Andrew, Salamonson, and Halcomb (2008), utilized a Likert-type scale for rating the utility of certain institutional services at one particular university. This particular study also used some qualitative data to gain information on what students found to be effective. The study identified that social support is vital to student success, whether through instructors, tutors, financial assistance, from family, or from other students within the program, which places value on institutional services that help students feel socially supported during their time at this particular institution (Andrew et al., 2008).

Other studies focus on one particular group of students at individual institutions to identify factors important in a more localized area. For example, one study examined a program that was designed for Native American students at an institution in California (Cech, Metz, Babcock, & Smith, 2011). In this study, the effectiveness of various support services were investigated to determine which are most effective for the Native American nursing students. The study concluded that institutional support is important in terms of stipends, emotional, and a sense of belonging. The study also illustrated that tangible support such as stipends was less important that emotional and belonging support. The study also discussed how motivational support is important to student success and retention (Cech et al., 2011).

Social Perceptions and Student Retention and Success. As described by Bandura (1997) and Shelton (2012), social perceptions are powerful when related to student retention. Social constructs such as perceptions of support, gender roles and identity, stress and perceived hardiness have been identified as factors that influence retention and success of nursing students (Jameson, 2014, McLaughlin et al., 2009, Shelton, 2012). Perception and gender roles have been identified as a predictor of success in nursing programs, since there is a preconception that

women are better nurses, and men are less likely to persist in nursing programs (McLaughlin et al., 2009). Perception of nursing careers is important, since nursing is a female dominated field (McLaughlin et al., 2009).

Shelton found that perceived support, whether actual or not, is related to both persistence and academic performance, since students with higher perceived support were more likely to persist and perform well academically within a community college nursing program (Shelton, 2012). The perceived hardiness and stress of students was also found to be correlational with student success. In a study completed in 2014, Jameson found that in a baccalaureate program, hardiness interventions are effective at reducing perceived stress among students (Jameson, 2014). Hamshire et al., (2013), also described that of students who thought about leaving their healthcare program, 11% decided to stay because of the support they received from family, friends, or staff at their institution.

Spiritual well-being emotional intelligence, psychological empowerment, and resilience have been shown to correlate with student success at a four-year private catholic college (Beauvais et al., 2014). In this study, a psychological empowerment scale, a resilience scale, and a spiritual well-being scale were used to collect information from nursing students. The study concluded that all of these variables are associated with academic success at their particular institution. It should be noted that this institution was a religious school, and conclusions are only generalizable to that particular population.

Student Demographics and Nursing Student Success. Several studies have focused on student demographic characteristics and student success. Race has been correlated with success in several studies, with minority groups less likely to complete a nursing program (Starck, Love, & McPherson, 2008; Stickney, 2006). Age has been implicated in several studies, with older

students being more at risk (Beauvais et al., 2014; Starck, Love, & McPherson, 2008; Stickney, 2006). Gender has also been identified as correlational, since male students are less likely to persist in a nursing program (McLaughlin et al., 2009; Starck et al., 2008).

Clinical Placements. Hamshire et al., (2013), identified that clinical placements can be a significant issue for students in the healthcare fields. Students within these programs have difficulty completing their academic work while completing clinical rotations simultaneously. Placements can also be a negative experience. For example, in the Hamshire et al., study (2013), students reported that they struggled to deal with ill patients, or felt like they were not valued in their clinical setting. These negative feelings can lead to attrition of healthcare students (Hamshire et al., 2013).

Prerequisites and Student Success in Nursing. In many institutions, prerequisites are being implemented in an attempt to increase student success through better preparation, even within nursing programs and preadmission requirements. Some research has been done at individual institutions where courses that best predict successful completion are identified and often implemented as prerequisite courses. In one study of a college's nursing program, introductory biology and chemistry were thought to be the only necessary prerequisites for student success in the nursing program (Abele, Penprase & Ternes, 2011). In this study, a psychology course was also identified as a course that predicts success in the nursing program. The researchers indicated that since a correlation existed between the psychology course and nursing program completion, a psychology could also serve as a prerequisite to the nursing program (Abele et al., 2011).

Summary of Factors Influencing Student Success

It is clear that student success is correlated to many issues. Certainly, student demographics, and experiences within healthcare programs play a role in student success, and various institutions have had varied success utilizing certain interventions to help nursing students successfully complete their program of study. However, it is the contradictory information that suggests a large need for future research. In this case, prerequisites have been shown to increase success and hinder success (Abou-Sayf, 2008; Harris, Hannum & Gupta, 2004; McCoy & Pierce, 2004; Rossi, 2003).

It is important that individual institutions complete their own research examining their own, individual prerequisite requirements and determine if those requirements help or harm student completion and retention.

Anatomy and Physiology and Prerequisites

Anatomy and Physiology is a difficult course that is a requirement for admission into nursing programs and is required for allied health students. This course is essential to allied health students since it provides a foundation for skills and clinical application of knowledge (Jordan & Reed, 1997; McKee, 2002). Feder (2005) and Sefton (2005) all described how faculty indicate Anatomy and Physiology is a difficult course because it requires students to synthesize information across disciplines, quickly increases in knowledge and complexity, and does not have clear boundaries. Additionally, many students have had negative prior experiences with bioscience courses, so they come into the Anatomy and Physiology course with aversions to science, and little confidence in their abilities to do well (Craft, Hudson, Plenderleith, Wirihana, & Gordon, 2013; McKee, 2002). Studies in the literature that assess particular issues to student success and retention related to Anatomy and Physiology courses are hard to find.

The content of Anatomy and Physiology courses is notoriously challenging. Davis (2010) described how these courses are typically content heavy, so they tend to be conceptually difficult. Sturges & Maurer (2013) described how students agree the first Anatomy and Physiology course is the most difficult, and how students are overwhelmed with the terminology used in Anatomy and Physiology courses. This study also identified that 89% of students intend to continue in their intended allied health major, but 30%-50% of students failed Anatomy and Physiology (Sturges & Maurer, 2013).

The Sturges and Maurer (2013) study identified the importance of assisting students with vital study skills to ensure success. This study indicated that skills such as reading, and note taking are essential for student success. Additionally, this study indicated that previous coursework in chemistry and biology were correlated with student success in Anatomy and Physiology I, highlighting the importance of previous science coursework in success (Sturges & Maurer, 2013).

Individual instructors can have a large impact on student success in Anatomy and Physiology. Clancy, McVicar, and Bird (2000) report that there is large variation in instructors teaching skills and background experience in Anatomy and Physiology. Encouraging active learning was suggested as one tactic institutions might undertake to increase success in Anatomy and Physiology (Nasr, 2012; Sturges & Maurer, 2013), however, many studies have found that Anatomy and Physiology courses often have few hands on activities in lectures (Eom, Wen, & Ashill, 2006; McKinney & Page, 2009; Koch, Salamonson, Everett, & Davidson, 2010). Nasr (2012) and Johnston, Hamill, Barton, Baldwin, Percival, Williams-Pritchard, Salvage-Jones & Todorvic (2015) both demonstrated that these active learning techniques, such as case studies,

are essential to student learning in Anatomy and Physiology, and increase student success in courses where it is utilized.

Conclusion: Gaps in the Literature

In conclusion, many of the studies on nursing attrition and completion are similar. Largely, they are non-experiments that are correlational. Most non-experimental studies had similar hypotheses and similar survey type instruments using Likert-type scales. Only a few were quasi-experiments, and no true experiments were done. Within the quasi-experimental study, logistic regression studies with an appropriate instrument would strengthen the validity of the results and can reduce biases in evaluation of the prerequisite course (Field, 2000).

To evaluate the need for prerequisites, experimental quantitative studies are frequently done where a group that took a prerequisite is statistically compared to a group of students who did not take the course. Many of these studies are uncontrolled and a variety of factors, including preexisting difference between groups, and various biases may influence the outcome, indicating a need for controlled studies (Bettinger & Long, 2005).

Along with a need for quasi-experimental studies, there is a need for individual institutions to complete similar smaller scale studies to ensure their nursing program/allied health programs and interventions are as effective as possible. Institutions are facing external pressures to increase the number of students who complete. Pressures such as the AGI and performance based funding models are forcing institutions to focus on student success. Rather than instituting a variety of supports and investing money in these programs, institutions should evaluate the measures they implement to determine what interventions lead to more improved student success. This is especially important in nursing programs. A nursing program with a high completion rate is better at attracting potential student nurses and can be more selective in

admitting students. Better nursing programs also mean more nurses will be able to meet the workforce needs throughout the country and the world. In order to create these nurses, Anatomy and Physiology I, which is a mandatory course for allied health professions, is under scrutiny. Determining how to best prepare students for this difficult course is important for the nursing program, the institution, and society.

Chapter III

Methodology

This study utilized post facto data and a quantitative design that allowed for the collection of numerical data that helped to assess the relationship between type of prerequisite/prior coursework before NAS 2, and student success in Anatomy and Physiology I, the subsequent course of study.

Purpose Statement

The purpose of this study was to assess four pathways to Anatomy and Physiology at two VCCS institutions, Community College A and Community College B, to determine which pathway leads to the greatest percentage of successful students. Further, this study investigated whether one or both of the required prerequisite science courses at these two institutions were correlated with producing students who are successful (final grade of C or better) in Anatomy and Physiology when compared with students who do not complete either of these two courses. This study also determined if General Biology I serves as a better prerequisite than NAS 2 by producing a statistically significant number of successful students, identified as those who receive a C or better, in Anatomy and Physiology than students who complete either of the two NAS 2 courses.

This study utilized a quasi-experimental approach with a quantitative method to analyze statistically significant differences between prior prerequisite coursework and success in Anatomy and Physiology. Students were not randomly selected or randomly assigned to groups. Rather, this study used this method since data on these prerequisites already exists within the Virginia Community College System (VCCS) Office of Institutional Effectiveness.

Research Questions

This study was guided by the following research questions:

1. Does the existing NAS 2 prerequisite for Anatomy and Physiology lead to students who are more successful when compared to students who did not complete a prerequisite?
    a. To what extent does completion of NAS 2 influence student success in Anatomy and Physiology when students who have completed NAS 2 at Community College A are compared to students at Community College A who did not complete NAS 2 before it was a prerequisite when variables of age, gender, college level English/Math placement, and ethnicity are controlled?
    b. To what extent does completion of NAS 2 influence student success in Anatomy and Physiology when students who have completed NAS 2 at Community College B are compared to students at Community College B who did not complete NAS 2 before it was a prerequisite when variables of age, gender, college level English/Math placement, and ethnicity are controlled?
    c. To what extent does completion of NAS 2 influence student success when students at Community College B that completed NAS 2 are compared to students at another VCCS institution without NAS 2 with a similar success rate prior to NAS 2 implementation when variables of age, gender, ethnicity, college level English/Math placement, and prior institutional Anatomy and Physiology success rates are controlled?
    d. To what extent does completion of NAS 2 influence student success when students at

Community College A that completed NAS 2 are compared to students at another VCCS institution without NAS 2 with similar success rates prior to NAS 2 implementation when variables of age, gender, ethnicity, college level English/Math placement, and prior Anatomy and Physiology success rates are controlled?

2. Does General Biology I lead to students who are more successful than students who did not complete a prerequisite?
    a. To what extent does General Biology influence student success in Anatomy and Physiology when students who took General Biology are compared to students who completed NAS 2 at Community College A when variables of age, gender, college level English/Math placement, and ethnicity are controlled?
    b. To what extent does General Biology influence student success in Anatomy and Physiology when students who took General Biology are compared to students who completed NAS 2 at Community College B when variables of age, gender, college level English/Math placement, and ethnicity are controlled?

Research Design

This study employed a quantitative method that helped to determine if there were any significant differences between different types of prerequisites or not having any prerequisite to Anatomy and Physiology. This quantitative method was quasi-experimental, since it relied on ex post facto data and independent variables that already existed, and involved using a comparison group design using a treated and untreated comparison group (Wholey, Hatry & Newcomer, 2010). Since the dependent variable was categorical, ordered logistic regression was attempted to

identify the probability that students will earn a C or better based on their prior completion of a prerequisite course. If data did not meet the assumptions necessary for ordered logistic regression, multinomial logistic regressions were done instead. Additionally, this study utilized students who did not take a prerequisite course as a pre-existing control group for comparison since a truly randomized study cannot be completed in this case. Within a comparison group design, both naive designs and matched designs were utilized. Both types of design allowed for an estimation of the impact of the prerequisite since the treated and untreated groups have occurred naturally in the comparison of students who were not required to take a prerequisite to students who were, and a matched design allowed for the comparison of students who completed a prerequisite to students at a similar institution who were not (Wholey, Hatry & Newcomer, 2010).

Study Context

The Virginia Community College System (VCCS) is made up of 23 different community colleges and 40 campuses across the state of Virginia. These campuses are found in a variety of locations: in urban; suburban; and rural areas across the state. Each of these colleges are responsible for following the degree requirements, course offerings, and other curricular policies set forth by the VCCS. After pressure to increase student success in various courses within the VCCS, Human Anatomy and Physiology (BIO 141) was identified as a problematic course for students. In response to the pressure to increase success in BIO 141, NAS 2, or Foundations of Life Science 2, is a course listed in the VCCS Master Course File as a course that "presents

elementary biological and chemical principles for allied health students whose high school preparation is deficient in the biological sciences" (Foundations of Life Sciences, n.d.). This course varies in number of credits and length between the two institutions that offer it.

Community College A is one of the larger community college in the VCCS system. Serving around 47,000 students per academic year, with 62% of those students being part time, this college has taken a different approach to adding a prerequisite to the curriculum. As demonstrated in Figure 2, at Community College A, NAS 2 was introduced later, with a pilot completed in summer of 2013. NAS 2 was scaled up in fall of 2013, when all students who did not meet other criteria for exemption were required to take the course. Community College A does not allow for exemption based on high school coursework, but does allow students to complete a challenge examination that they must earn 70% or better on, or allows students to receive a waiver if the student successfully completed BIO 1, BIO 100, BIO 101 (General Biology I) as long as the student earned a C or better, and the student completed the course within the last three years. At this institution, NAS 2 is a two credit, eight-week course. This course covers the scientific method, characteristics of life, basic chemistry, cell energy, enzymes and transport, cell reproduction, DNA structure and transcription/translation, medical and anatomical terminology, and homeostatic control of the body.

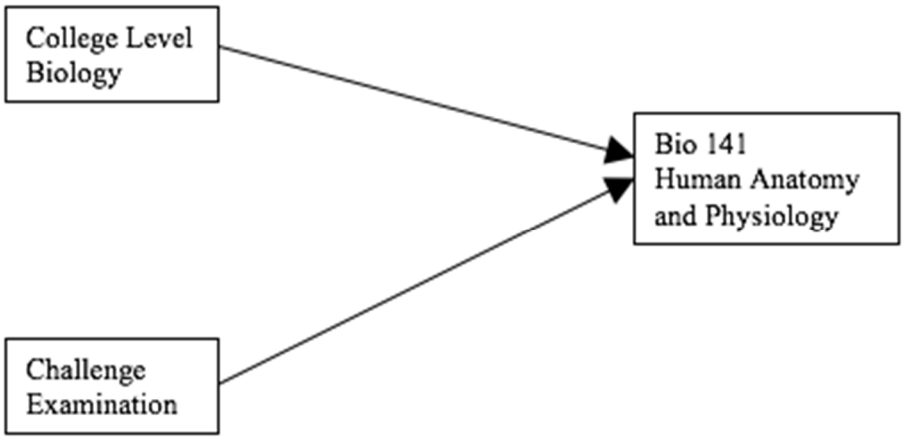

Figure 2. Pathways to Anatomy and Physiology at Community College A.

Community College B is a community college in a metropolitan area of Virginia that serves around 5,000 students per academic year. Of these students, 79% are part time students. This college offers several pathways of preparation that have to be completed prior to taking BIO 141 as outlined in Figure 1, with NAS being implemented as one of the acceptable pathways to BIO 141 in the spring of 2006 semester. Students at Community College B who have successfully completed one high school biology course, and one high school chemistry course are not required to take NAS 2 before enrolling in BIO 141. Students who have previously successfully completed one semester of college level biology and chemistry, or a combination of college level biology or chemistry in combination with a high school credit for one and completed with a C or better are not required to complete NAS 2. Students may also opt to complete a NAS 2 challenge examination. If they score a 70% or better on the exam, they are

not required to take NAS 2. NAS 2 at Community College B is a 16 week, three credit course that covers basic chemistry, cell structure, cell division, protein synthesis, membrane transport, metabolism, cell respiration, water-salt balance, acid-base balance, cancer and metastasis, histology of body tissues, directional and anatomical position of the body, the body systems, and infectious microorganisms.

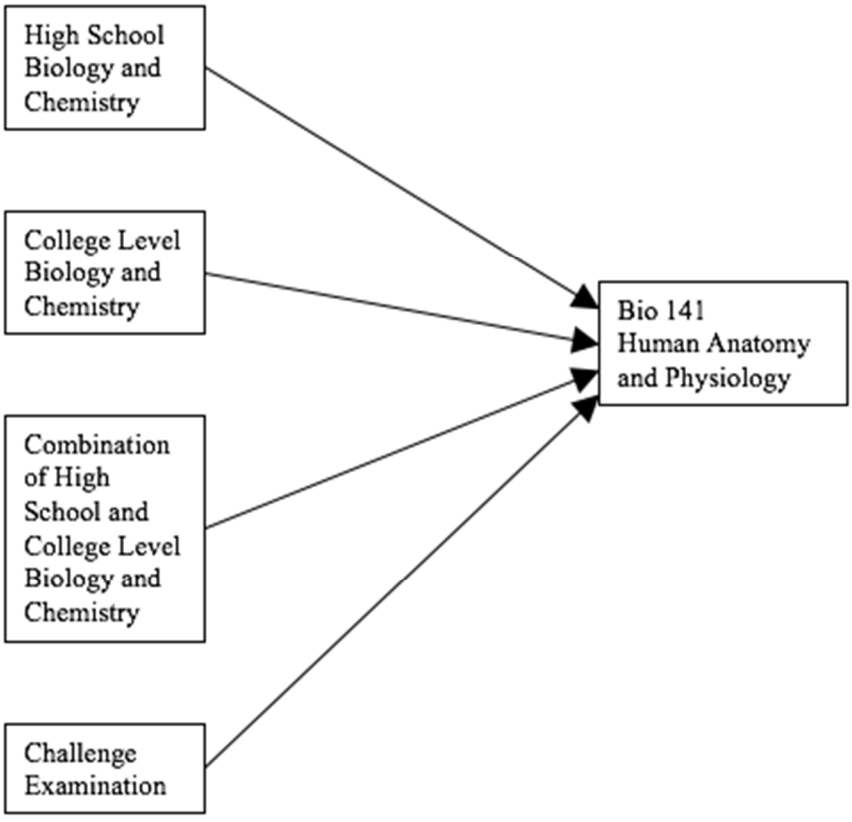

Figure 3. Pathways to Anatomy and Physiology at Community College B

This study was completed with data from four institutions within the Virginia Community College System. Ex post facto was collected from the VCCS systems office from academic years 2010/2011, and 2014/2015 for Community College A, and from academic year 2006/2007 and 2014/2015 for comparisons involving Community College B. Students from Community College B was compared to students from Community College A, and students from each of those institutions was compared to students at two institutions within the VCCS that had similar Anatomy and Physiology I success rates prior to the prerequisite being implemented. In each comparison, demographic information on age, gender, ethnicity, and college level placement in English/Math was controlled to ensure similar groups. In each comparison, 100 individuals was the goal for each group to ensure statistical power in each comparison. One group had a sample size of 80, and all others were above 100.

To gain access to these data, permission was secured through the Old Dominion University Institutional Review Board, and through the Virginia Community College Systems Office. Both organizations reviewed the methodology to ensure student data were protected.

Operationalization of Variables

This study examined whether prerequisites for Anatomy and Physiology led to greater student success when compared to other groups of students who have not had a prerequisite. This study identified what type of prerequisite (General Biology I or NAS 2) leads to the most successful students in Anatomy and Physiology. The variables of completing General Biology I (Bio 101), completing NAS 2, and completing other Biology or Chemistry coursework were

recorded dichotomously. English and Math placement was also used dichotomously—either a student placed into college level English and Math, or they were placed into one or more developmental courses. Age was left as a scale variable, while race was recorded as being one of three categories: white, African American/black, and other. Grade for Anatomy and Physiology I (Bio 141) was recorded as A, B, C, D, F, or W.

Student Success. Student success was defined as a final course grade of C (70%) or better (Xu & Jaggars, 2011). A grade of C or better allows a community college student to transfer the credit to a four-year institution. Student success is the dependent variable for all six research questions.

Demographic Characteristics. The demographic characteristics that were utilized for this study are age, gender, and ethnicity. These demographic data were used as a control to ensure that comparison groups are equivalent. These demographic variables, along with college level placement in English/Math, were chosen based on the influence they generally have in other studies (Stickney, 2008; Wolfle, 2012; Wolfle & Williams, 2014) and the availability of these data from the Virginia Community College Systems office.

Research Question Evaluation. In research questions one, parts A and B, a temporal comparison was completed for both community colleges that have implemented NAS 2. Students from the three previous semesters of Anatomy and Physiology that were not required to complete NAS 2 was compared to students who were required to complete NAS 2 after implementation. In these research questions, the demographic variables of age, gender, and

ethnicity, along with college level placement in English/Math, were controlled to ensure comparison groups are similar. In these research questions, the independent variable is whether the student completed NAS 2 or not, and the dependent variable is whether the student was successful in Anatomy and Physiology (final grade of C or better) or not.

To investigate research question one, parts C and D, a comparison was done across institutions to determine if NAS 2 has impacted success rates. This comparison is outlined in Table 1. To do this comparison, Anatomy and Physiology I success rates for the three years prior to NAS 2 implementation were compared across all VCCS institutions. Community College A's prior score were used to find another VCCS institution that has a similar success rate, and the Anatomy and Physiology I success were compared between the two institutions using an after implementation of NAS 2 success rate as a post-test comparison. The same methodology was utilized for Community College B: A pre-implementation Anatomy and Physiology I success rate was used to find a comparable VCCS institution, and a comparison was done using current post-NAS 2 implementation data. Again, a logistic regression was utilized, and in these questions, demographic variables of age, gender, and ethnicity, along with college level placement in English/Math, will ensure comparable groups. The independent variable here is whether the student took NAS 2 or not, and the dependent variable is again student success in Anatomy and Physiology I.

In research question two, the independent variable is whether a student took General Biology or NAS 2 prior to completing Anatomy and Physiology I. This comparison is outlined

in Table 1. The dependent variable is again student success in Anatomy and Physiology I, as defined by earning a final grade of C or better. In these questions, the demographic variables of age, gender, and ethnicity, along with college level placement in English/Math, were controlled.

Table 1.

Student Success in Anatomy and Physiology I Comparisons.

Research Question	Setting	Course and Duration	Comparison
1. a.	Community College A	NAS 2 8 weeks	Compare student success in Anatomy and Physiology with students who complete the NAS 2 course to students with no prerequisite prior to implementation
1. b.	Community College B	NAS 2 16 weeks	Compare student success in Anatomy and Physiology with students who complete the NAS 2 course to students with no prerequisite prior to implementation
1. c.	Community College A Community College C (similar pre NAS 2 Anatomy and Physiology success rate)	Community College A--NAS 2 8 weeks Community College C--No prerequisite requirement	Compare students success in Anatomy and Physiology from Community College A to students at Community College C
1. d.	Community College B Community College D (similar pre NAS 2 Anatomy and Physiology success rate)	Community College B—NAS 2 16 weeks Community College D—No prerequisite requirement	Compare student success in Anatomy and Physiology at Community College B to student success at Community College D
2. a.	Community College A	General Biology I 16 weeks NAS 2 8 weeks	Compare student success in Anatomy and Physiology for students who completed General Biology to students who completed NAS 2
2. b.	Community College B	General Biology I 16 weeks NAS 2 16 weeks	Compare student success in Anatomy and Physiology for students who completed General Biology to students who completed NAS 2

Data Collection Procedures

Data were collected ex post facto from the VCCS Systems Office after the researcher obtained permission from the Academic Services and Research Department at the VCCS, the Darden College of Education Human Subjects Review Committee at Old Dominion University, and through the Virginia Community Systems office. Upon approval, accompanying forms were submitted to the VCCS Systems office to obtain data for analysis. Data did not have any identifying information for students. Students were identified by a randomly created number only, referred to as a pseudo identification number. After the data were obtained, the researcher kept data in a password protected file on a password protected external hard drive.

Data Coding and Analysis

Data were coded using the categories outlined in Table 2. Age was left as a continuous variable to include as much detail as possible. Gender, college level placement in English and Math, completion of NAS 2, completion of Bio 101, and success were coded dichotomously. In addition to success, grades for Bio 141 were utilized to complete an ordinal or multinomial regression. Treating grades as an ordinal variable allowed for a more detailed comparison between groups in ordinal regression. In multinomial regressions, grade in Anatomy and Physiology I was treated as a categorical variable with withdrawals compared to grades of F, D, C, B, and A.

Table 2.

Coding of Variables

Variable	Type of Variable	Categories	Code
Gender	Dichotomous	Male	0
		Female	1
Ethnicity	Categorical	White	0
		Black	1
		Other	2
Age	Continuous	Range: 16-65	
College/Developmental English and/or Math Placement	Dichotomous	Developmental placement for at least one course	0
		College Level Placement for both Math and English	1
Completion of NAS 2	Dichotomous	No	0
		Yes	1
Completion of Bio 101	Dichotomous	No	0
		Yes	1

After data were collected, data were organized into tables and/or figures that display the independent variables and the number and percent of students experiencing success within that group. This allowed for comparison between the type of prerequisite and student success. Data on the demographics of the two comparison groups for each research questions was identified. Number of students and percentage of students within each category was displayed to illustrate that comparison groups were similar. Figures were produced to illustrate the information. Ordered logistic regression or multinomial logistic regression was performed to identify if there was a relationship between the type of prerequisite and student success. Additionally, an ordered logistic regression or multinomial logistic regression allowed for the identification of any

demographic variables that act as predictors of student success in Anatomy and Physiology (Peng, Lee & Ingersoll, 2002).

Limitations

This study focused on students within the VCCS who enroll in Anatomy and Physiology in the context of nursing programs. While it would be preferable to only include nursing students since this target student population is of interest to many researchers, it is important to note that many students who were included in this study may not have had the goal of nursing school admission or other allied health program admission. This study included all students, not just nursing or allied health students, to ensure there was an adequate sample size to detect significant differences between groups.

Internal validity in this study was also threatened by a non-experimental design. While an experimental design with random selection of students and random assignment to treatment groups would allow for a causal inference, propensity score matching of groups should control common confounding factors in educational research (Wholey, Hatry, & Newcomer, 2010).

Another limitation of this study was that it relied on ex post facto analysis of data. Since data already exist, the researcher could only perform analysis based on existing data. Other variables (such as employment status) may be important to success in Anatomy and Physiology, but were not included since data were not available. Additionally, this study utilized data that was temporally different to compare before the prerequisite was required, to after the prerequisite was required. Although students may differ in some characteristics, the demographic data that was reported and controlled in an attempt to create groups that are largely equivalent. Since no

data on high school GPA was available, placement in college level or developmental English or Math was used as an academic measure to control groups. Obviously, this is not the most accurate measure of prior academic achievement, but was the only similar data available through the VCCS office. Additionally, no data on socioeconomic status was available for students in the study. Ethnicity, then, acted as a proxy for socioeconomic status. The combination of college/developmental Math and English placement as an indicator of prior academic achievement, and ethnicity as a proxy for socioeconomic status resulted in an under specific model.

The prerequisite NAS 2 is new to Community College A, which is also a limitation of this study. The prerequisite was added to the curriculum in 2013, so there is limited data available from Community College A, with a sample size of around 300 students. Ideally, this study would be repeated when more consecutive semesters of data are available.

In terms of external validity, this study was largely limited to the VCCS institutions that are utilized in the study. Overall, two institutions have NAS 2, and these institutions were compared to two other institutions within the VCCS. While this study can provide useful information to other VCCS institutions, it is important to note that findings may not apply to other contexts.

Conclusion

In conclusion, this study utilized ex post facto data that allowed the researcher to draw conclusions regarding the effectiveness of the two types of prerequisites on student success. The design allowed for the control of student characteristics of age, gender, ethnicity, along with college level placement in English/Math, to determine how pathways to Anatomy and Physiology potentially influence student success.

Chapter IV

Findings

The purpose of this study was to explore course outcomes in Anatomy and Physiology I for students at four different community colleges in the Virginia Community College System. Two community colleges included in this study require a prerequisite course or prior science coursework before Anatomy and Physiology I. Two other comparison colleges were included had similar prior success rates in Anatomy and Physiology I to the two that now require prerequisites. The two comparison colleges do not require any prior coursework before Anatomy and Physiology I. The regressions that were done helped to determine if prior coursework is correlated with success. For all four colleges, data for these students included information on gender, age, ethnicity, developmental math or English placement, and whether they completed General Biology I (Bio 101) or not. The outcome of grade in Anatomy and Physiology I was recorded for all students. In the two colleges where prerequisite course work is required, student level data on completion of Natural Science 2 (NAS 2) was also collected. Each of these descriptors were used as independent variables, while final grade (and success as defined by a final grade of C or better) in Anatomy and Physiology I was used as the dependent variable.

The findings of this study are presented within this chapter in the form of descriptive statistics, and the results of multinomial logistic regression and ordinal logistic regression. Multinomial logistic regression was used when data violated one or more of the statistical assumptions needed to run an ordinal logistic regression. All findings are described within the text, and are represented in tables.

Data Screening

The data were provided in six spreadsheets by the VCCS Academic Services and Research Department. The data received included student data from fall and spring semesters, only, since summer data sets were so small, and protection of student data was a concern. Upon receipt of these data, students included were assigned a pseudo ID number. Each student had information for age, gender, community college, grade in Anatomy and Physiology, whether the student took NAS 2, Bio 101, or other Biology/Chemistry coursework. Data for ethnicity and college/developmental English/Math was incomplete.

Ethnicity data were missing for some students who choose to not specify their ethnicity, and college/developmental English and/or Math placement was incomplete as not all students take placement exams in the VCCS. The percentage of students from a sample not identifying ethnicity ranged from 0% in two samples, to 0.9% and 1% in two others, to 2.4% and 2.5% in the last two datasets. Students who did not identify ethnicity were excluded from the data. For students who did identify as a particular ethnicity, three categories were used. The categories of White, African American/Black, or Other. The category of "Other" included students who identified as Hispanic/Latino, Asian, American Indian or Alaskan Native, Pacific Islander or Native Hawaiian, and any student who identified as being two or more races.

After a discussion with the VCCS Academic Services and Research Division about the missing information on college or developmental English/Math placement, it was determined that students without placement data from taking either the Virginia Placement Test or the

COMPASS placement exam were likely considered to be college ready by counselors at their college. This happens when a counselor identifies that the student successfully completed advance placement classes in high school, or scored high on the SAT/ACT exam. Based on this, students were identified as developmental if they placed in to one or more developmental English or Math courses. Students who had placement data that put them in college level English and Math were counted as college level students. Students who did not have any placement data entered in the data set were assumed to not have taken the placement exam. These students were assumed to be college level, since the VCCS Office of Institutional Effectiveness indicated that these students were likely placed in college level English and Math based on a counselor/college employee's evaluation.

Descriptive Data of Students from All Community Colleges Used in the Study

Table 3 presents the descriptive data for the whole sample at each of the four community colleges. Mean age was 23 at Community College C in 2014-2015, 26 at Community College D, 27 at Community College B in 2006-2007, 26 at Community College B in 2014-2015, 27 at Community College A in 2010-2011, and 26 at Community College A in the 2014-2015 academic year. Age ranged between 16-60, and varied slightly at all four community colleges. At all four institutions, students were predominantly female, with 78.68% (Community College B 2014-2015) to 93.75% (Community College C 2014-2015) being female. Community College A had a large number of African American/Black students, with 32.35% of students in 2010-2011, and 28.21% of the sample being in this category in 2014-2015. Community College C

was the least diverse sample, since 93.75% of students were identified as White in the 2014-2016 academic year.

College level placement was different across the pre and post academic years for Community College A and Community College B. At Community College A, in the 2010-2011 academic year 60.19% of students were placed in at least one developmental class, and for Community College B in the 2006-2007 academic year, 59.47% of students were developmentally placed in Math and/or English. In 2014-2015 data, developmental placement dropped to 21.32% at Community College B, and to 28.89% at Community College A. At Community College C, 37.50% of students were placed in at least one developmental course in 2014-2015, and Community College D had 24.60% of students in one developmental course. This disparity across the two timescales at Community College A and B is likely due to the change in placement tests. In the 2006-2007, and 2010-2011 academic years, the COMPASS placement test was used, and in the 2014-2015 academic year, the Virginia Placement Test was utilized for developmental Math placement.

Completion of NAS 2 varied as well. In Community College A 2010-2011, NAS 2 did not exist, so no students had completed the course. In Community College B in 2006-2007, the course did exist before it was redesigned to be a prerequisite for Anatomy and Physiology I, so 16.32% of students had taken NAS 2 before it was a prerequisite. These students were excluded from analyses. Community College D also had 0.48% of students who had taken a course with the NAS 2 prefix. These students were also excluded from analyses.

General Biology I completion dropped slightly for Community College A. In 2010-2011 19.05% of students had taken the course, and in 2014-2015, only 17.71% had taken General Biology I. At Community College B in 2006-2007, 13.33% of students took General Biology I, and by 2014-2015, only 6.60% of students completed General Biology I. Community College C in 2014-2015 was similar to the 2014-2015 Community College B data, with 6.25% of students completing General Biology I before taking Anatomy and Physiology. College D in 2014-2015 had the highest value for General Biology I completion, with 63.13% of students completing the course before taking Anatomy and Physiology I.

In terms of success, in the 2014-2015 academic year, Community College C had the highest success rate, with 93.75% of students finishing Anatomy and Physiology I with a grade of C or better. College D had a success rate of 62.62% in the 2014-2015 academic year. Other institutions had a success rate of around 50%. Community College A 2010-2011 had a success rate of 47.10% for students in Anatomy and Physiology I, which increased to 52.50% in 2014-2015. Community College B had a success rate of 57.89% for Anatomy and Physiology I in 2006-2007, which increased slightly to 58.63% in 2014-2015.

For grade level data, College A in 2010-2011 had the lowest percentage of A grades (17.42%), while College B in 2014-2015 had the highest percentage (30.96%) of A grades in Anatomy and Physiology I. College C had the greatest percentage of B grades when compared to the other colleges (28.75%), and Community College B in the 2006-2007 academic year had the lowest percentage of B grades (15.74%). College B in 2014-2015 had the lowest percentage

of C grades (11.93%), while College C in 2014-2015 had the highest percentage (48.75%). College A also had the lowest percentage for D grades (3.12%) in 2014-2015, while College B had the highest (9.64%) in 2014-2015. For a final grade of F, College A had the highest percentage with 20.37% of students earning a grade of F in the 2014-2015 academic year, while 1.25% of students earned a grade of F at Community College C in 2014-2015. For withdrawals from Anatomy and Physiology I, 28.14% of students withdrew from the course at Community College A in the 2010-2011 academic year, with no students withdrew at Community College C in the 2014-2015 academic year.

Table 3.

Overall Descriptors of Data

Descriptor		Community College A 2010/2011 N=2399	Community College A 2014/2015 N=1762	Community College B 2006/2007 N=190	Community College B 2014/2015 N=394	Community College C 2014/2015 N=80	Community College D 2014/2015 N=626
Age	Mean Age	27	26	27	26	23	26
	Traditional	40.27	41.09	42.63	44.16	68.75	48.89
	Non Traditional	59.73	58.91	57.37	55.84	31.25	51.11
	Age Range	16-60	17-62	16-59	16-52	18-42	17-57
Gender	Male	16.97	17.20	20.53	21.32	6.25	13.74
	Female	83.03	82.80	79.47	78.68	93.75	86.26
Ethnicity	White	55.61	52.50	79.47	69.80	95	57.67
	African American/Black	32.35	28.21	13.68	13.71	2.5	27.48
	Other	12.05	19.30	6.84	16.50	2.5	14.86
Developmental Placement*	Development in English and/or Math	60.19	28.89	59.47	21.32	37.5	24.60
	College Level English and Math	39.81	71.11	40.53	78.68	62.5	75.40
NAS 2**	No NAS 2	100.00	47.33	83.68	52.79	100	99.52
	NAS 2	0.00	52.67	16.32	47.21	0	0.48
General Biology	No Bio 101	80.95	82.29	86.32	93.40	93.75	36.90
	Bio 101	19.05	17.71	13.68	6.60	6.25	63.10
Success in Anatomy and Physiology	Successful (C or Better)	47.10	52.50	57.89	58.63	93.75	62.62
	Unsuccessful (W, F, or D)	52.90	47.50	42.11	41.37	6.25	37.38
Grade in Bio 141	Withdrawal	28.14	24.01	25.26	18.53	0	16.29
	F	19.05	20.37	10.00	13.20	1.25	12.62
	D	5.71	3.12	6.84	9.64	5	8.47
	C	12.84	12.15	12.63	11.93	48.75	18.37
	B	16.84	17.71	16.32	15.74	28.75	20.45
	A	17.42	22.64	28.95	30.96	16.25	23.80

* Placement tests changed during this timeframe from the Compass Placement Test to the Virginia Placement Test (VPT)
**In post implementation data, some students may have taken a challenge exam and placed directly in to Anatomy and Physiology I. Some students may have obtained a waiver due to completing Bio 101 or an equivalent. Some students were able to enroll in Anatomy and Physiology I without any prerequisites due to a system error in registration.

Pre and Post NAS 2 Comparisons

Research question 1a explored the completion of NAS 2, and investigated if completing NAS 2 influences student grade in Anatomy and Physiology when students who have completed NAS 2 at Community College A are compared to students at Community College A who did not complete NAS 2 before it was a prerequisite when variables of age, gender, college level English/Math placement, and ethnicity are controlled. In the 2014/2015 dataset, only 52.67% of students actually completed NAS 2 before taking Anatomy and Physiology I. The 834 students who did not complete the prerequisite in 2014/2015 were excluded from analysis, since a variety of factors may have allowed students to register for Anatomy and Physiology I. Data for students from the 2010/2011 academic year, and the students from the 2013/2014 academic year who were left in the analysis are shown in Table 4. The two groups are largely similar. Age was statistically similar between the two groups, with both groups having a mean age of 27 years. Developmental level Math placement was expected to vary between the two groups, since the placement tests changed from the COMPASS ACT placement test in 2010/2011 to the Virginia Placement Test (VPT) in 2014/2015 for math placement. Preliminary research reports fewer students placing into Developmental Math as a result of this change (Rodriguez, 2014), so fewer students placing into developmental courses was an expected result.

Table 4.

Percentages of Students in Each Classification, Community College A Pre and Post Prerequisite

Descriptor	Category	Percentage of Students, College A Pre Implementation 2010-2011 N=2399	Percentage of Students College A Post Implementation 2014-2015 N=928
Age	22 or younger	40.27	40.01
	23 or older	59.73	59.99
	Mean Age	27	27
	Age Range	16-60	17-62
Gender	Male	16.97	13.90
	Female	83.03	86.10
Ethnicity	White	55.61	50.75
	African American/Black	32.35	28.99
	Other	12.05	20.26
English/Math Placement	Developmental English or Math	60.19	40.95
	College Level English and Math*	39.81	59.05
Coursework Prior to Bio 141	No NAS 2	100.00	0.00
	NAS 2**	0.00	100.00
	No Biology 101	80.95	94.71
	Biology 101	19.05	5.29

* Placement tests changed during this timeframe from the Compass Placement Test to the Virginia Placement Test (VPT)

Grade in Anatomy and Physiology I was not statistically different between students who had completed NAS 2 and students who did not t (1646.909) = -.893, p = .372. Success in Anatomy and Physiology I went from 47.10% of students being successful in 2010-2011 to 48.28% in 2014-2015. A grades went from 17.42% of students to 20.80%, B grades went from 16.84% to 15.73%, and C grades went from 12.84% to 11.75%. Unsuccessful grades decreased. The percentage of students earning a final grade of D decreased from 5.71% to 3.34%, F grades

decreased from 19.05% to 21.34%, and Withdrawals decreased from 28.14% to 27.05%. These data are shown in Table 5.

Table 5.

Student Outcomes in Anatomy and Physiology For Students With and Without NAS 2 at Community College A Pre and Post Prerequisite

Descriptor	Category	Percentage of Students, College A Pre Implementation 2010-2011 N=2399	Percentage of Students College A Post Implementation 2014-2015 N=928
Success in Bio 141	Successful (A, B, or C final grade)	47.10	48.28
	Unsuccessful (D, F, or W final grade)	52.90	51.72
	Final Grade of A	17.42	20.80
	Final Grade of B	16.84	15.73
	Final Grade of C	12.84	11.75
	Final Grade of D	5.71	3.34
	Final Grade of F	19.05	21.34
	Withdrawal from Bio 141	28.14	27.05

*In post implementation data, some students may have taken a challenge exam and placed directly in to Anatomy and Physiology I. Some students may have obtained a waiver due to completing Bio 101 or an equivalent. Some students were able to enroll in Anatomy and Physiology I without any prerequisites. For this comparison, students who did not complete NAS 2 in the post implementation data set were excluded from the comparison.

The variable age was found to be skewed 1.276 (SE = 0.42), and exhibited kurtosis 1.295 (SE = .085), so a squared transformation was attempted. Squaring age did not improve the distribution, so age was left untransformed. An ordinal logistic regression was attempted, since the outcome variable of grade in Anatomy and Physiology I is of an ordinal nature. However, these data violated the assumption of proportional odds χ^2 (28) = 152.736, p < .0005, so a multinomial logistic regression was used instead. This sacrifices the ordinal nature of the

dependent variable, but was still useful in determining whether NAS 2 is influential with regard to Anatomy and Physiology I grade.

For the multinomial logistic regression, the category of 1 was used for reference. This meant that for the first comparisons, White was compared to Black/African American. Thus, a second comparison was done to rotate the ethnicity of Black/African American for the category of "Other." Significant results are shown in Table 6. The model generated using multinomial logistic fit data significantly better than the intercept only model χ^2 (35) = 457.041, p < .0005. The resulting model had a Nagelkerke pseudo R^2 value of .133, explaining around 13.3% of variation.

Age. Age was found to be a significant factor when a withdrawal was compared to the grades of F, B, or A. In the grade of F category, the Exp (B) statistic was .979, illustrating that the odds of staying in a course and earning a grade of F as opposed to withdrawing was .979 for students who were older χ^2 (1) =2.677, p = .003. In the category of B, the Exp (B) statistic was 1.016, again illustrating that older students were 1.016 times as likely to stay in the course and earn a grade of B χ^2 (1) = 5.231, p = .022. This is similar to the results were for the A category, with an Exp (B) of 1.051. In the A category, older students had a slight advantage, being 1.051 times more likely to earn a grade of A, χ^2 (1) = 7.196, p < .0005.

Ethnicity. Ethnicity was a factor in each of the successful outcomes for Bio 141. When compared to white students, Black/African American ethnicity was negatively associated with the successful outcomes of C, B, and A grades. The Exp (B) ranged from .262 in the A grade category, to .548 in the B grade category.

Developmental Placement. Developmental placement was negatively associated with

final grade of B and A. Therefore, students who did not place in to college level Math and English were .348-.505 times as likely to withdraw from Anatomy and Physiology I in the categories of B and A grade.

General Biology I. Not taking General Biology I was negatively associated with earning a final grade of A. Therefore, students who had completed General Biology I were .694 times as likely to earn a final grade of A when compared to students without General Biology I.

Table 6.

*Statistically Significant Results, Community College A Pre and Post Prerequisite As Indicated by Multinomial Regression**

Comparison	Factor	B	SE	Wald	Df	Sig	Exp (B)	95% CI for Exp (B)
W to F	Age	-0.21	.007	2.677	1	.003	.979	.966, .993
W to D	NAS 2	.450	.219	4.215	1	.040	1.568	1.021, 2.408
W to C	Ethnicity (African American/Black)	-.653	.184	12.579	1	.005	.521	.363, .747
W to B	Age	.016	.007	5.231	1	.022	1.016	.1.002, 1.030
	Developmental Placement	-.684	.113	36.796	1	.000	.505	.405, .629
	Ethnicity (Black/African American)	-.602	.177	11.557	1	.001	.548	.387, .775
W to A	Age	.050	.007	7.196	1	.000	1.051	1.038, 1.065
	Developmental Placement	-1.056	.114	85.530	1	.000	.348	.278, .435
	Ethnicity (Black/African American)	-1.341	.192	48.629	1	.000	.262	.179, .381
	General Biology (Bio 101)	-.365	.159	5.280	1	.022	.694	.509, .948

*Withdrawals compared to course grade for Anatomy and Physiology I

Another research question examined the extent NAS 2 influences student success in Bio 141 at Community College B, where the prerequisite course is 16 weeks long. In this dataset,

there were two groups that were excluded from the original sample. There were 31 students who took the NAS 2 course before it was a prerequisite for Anatomy and Physiology, and 208 students who did not take the prerequisite course for Anatomy and Physiology I after it was a requirement, presumably due to passing a challenge exam, or meeting the other prior coursework requirements.

The descriptive data from the students who were included in the analysis is indicated in Table 7. These student populations were statistically similar to each other for age and gender. Mean age was 27 for students without NAS 2, and was 26 for students with NAS 2. Age ranged from 16-59 for students without NAS 2, and ranged from 16-52 for students with NAS 2. Gender was 22.01% male for students without NAS 2, and was 19.89% male for students with NAS 2. The two comparison groups varied in college level English and Math placement ($t(329.724) = -3.738$, $p < .0005$). Since the placement tests administered to students changed during this timeframe from the COMPASS placement test, to the Virginia Placement Test, this difference was expected.

Table 7.

Percentages of Students in Each Classification, Community College B Pre and Post Prerequisite

Descriptor	Category	Percentage of Students, College B Pre Implementation 2006-2007 N=159	Percentage of Students College B Post Implementation 2014-2015 N=186
Age	22 or younger	44.03	47.31
	23 or older	55.97	52.69
	Mean Age	27	26
	Age Range	16-59	16-52
Gender	Male	22.01	19.89
	Female	77.99	80.11
Ethnicity	White	80.50	67.74
	African American/Black	12.58	16.13
	Other	6.92	16.13
English/Math Placement	Developmental English or Math	54.72	34.95
	College Level English and Math*	45.28	65.05
Coursework Prior to Bio 141	No NAS 2	100	0
	NAS 2**	0	100
	No Biology 101	84.28	99.46
	Biology 101	15.72	0.54

* Placement tests changed during this timeframe from the Compass Placement Test to the Virginia Placement Test (VPT)
**In pre implementation data for NAS 2, some students had taken the course prior to it being a formal prerequisite for Bio 141. These students were excluded from statistical analyses, since they had prior experience in NAS 2. In post implementation data, some students had entered into Bio 141 because of prior coursework. These students were excluded from statistical analyses.

Final grade in Anatomy and Physiology I was not statistically different when the two academic years were compared (t (317.770) = 1.801, p = .073). When these data were compared, the percentage of successful students in Anatomy and Physiology actually decreased from 55.97% in the 2006-2007 academic year, to 44.62% in 2014-2015. Students earning a final

grade of A decreased from 28.30% to 15.59%, and B grades declined from 16.35% to 15.59%. Final grade of C increased from 11.32% to 13.44%, D grades increased from 6.29% to 12.37%, and F grades increased from 9.43% to 19.89%. Withdrawals decreased from 28.30% to 23.12%. These data are shown in Table 8.

Table 8.

Student Outcomes in Anatomy and Physiology for Students with and without NAS 2 at Community College B Pre and Post Prerequisite

Descriptor	Category	Percentage of Students, College B Pre Implementation 2006-2007 N=159	Percentage of Students College B Post Implementation 2014-2015 N=186
Success in Bio 141	Successful (A, B, or C final grade)	55.97	44.62
	Unsuccessful (D, F, or W final grade)	44.03	55.38
	Final Grade of A	28.30	15.59
	Final Grade of B	16.35	15.59
	Final Grade of C	11.32	13.44
	Final Grade of D	6.29	12.37
	Final Grade of F	9.43	19.89
	Withdrawal from Bio 141	28.30	23.12

The variable of age was found to be skewed 1.11 (SE = .131), and had a kurtosis value of .253 (SE = .262). Transforming age did not improve these values, so age was left as the original value. An ordinal logistic regression was done, and data were found to not exhibit collinearity, and the assumption of proportional odds was met, as assessed by a full likelihood ratio test χ^2

(24) = 38.30, p = .052. The resulting model was a good fit to the observed data χ^2 (6) = 79.124, p < .0005. A pseudo R^2 Nagelkerke was .211. Significant results from this comparison are shown in Table 9. Students who completed NAS 2 were 1.877 times more likely to do well in Bio 141 than students who did not complete NAS 2, which was a significant difference χ^2 (1) = 9.936, p = 0.002. The odds of being successful in Anatomy and Physiology I were .315, 95% CI (-1.558, -.737) times higher for students who placed into college level Math and English when compared to students in developmental courses, which was statistically significant χ^2 (1) = 30.065, p < .005. Age was also a significant factor, with a positive increase of 1.065 more likely to be successful in NAS 2 CI (.044, .90), χ^2 (1) = 33.367, p < .005.

Table 9.

Statistically Significant Results, Community College B Pre and Post Implementation as Indicated by Ordinal Logistic Regression

Predictor	B	Wald Chi Square	Exp (B)	Sig.	95% CI for Exp (B)
Developmental Placement	-1.148	30.065	.315	.000	-1.558, -.737
NAS 2	.647	9.936	1.877	.002	.245, 1.049
Age	.067	33.367	1.065	.000	.044, .090

Comparisons of Colleges with NAS 2 to Colleges without NAS 2

The next set of research questions explored if there was a difference in Anatomy and Physiology I success when the community colleges with NAS 2 were compared to other VCCS colleges with similar prior Anatomy and Physiology I success rates. In the first comparison, Community College A was compared to another community college in the Virginia Community College System. This second community college was selected for comparison by the VCCS because it had a similar Anatomy and Physiology success rate for three years prior to the NAS 2 course being implemented as a prerequisite at Community College A.

Descriptive information for this data set is given in Table 10. Although the sample size from Community College C was small, the two institutions were statistically similar in developmental placement (t (1007) = .687, p = .492), and had similar numbers of students completing General Biology I (t (1007) = .342, p = .732), and had prior success rates for Anatomy and Physiology of 50 and 58% in the 2010-2011 academic year for Community College A and C, respectively.

In this analysis, 833 students from Community College A were found to have not completed NAS 2. These 833 students were excluded from statistical analyses for this comparison.

Table 10.

Percentages of Students in Each Classification, Community Colleges A and C Post Prerequisite

Descriptor	Category	Percentage of Students College A Post Implementation 2014-2015 N=928	Percentage of Students College C Post Implementation 2014-2015 N=81
Age	22 or younger	40.09	68.75
	23 or older	59.91	31.25
	Mean Age	27	23
	Age Range	17-62	18-42
Gender	Male	13.90	6.25
	Female	86.10	93.75
Ethnicity	White	50.75	95.24
	African American/Black	28.99	2.38
	Other	20.26	2.38
English/Math Placement	Developmental English or Math	40.95	35.00
	College Level English and Math	59.05	65.00
Coursework Prior to Bio 141	No NAS 2	0.00	100.00
	NAS 2	100.00	0.00
	No Biology 101	94.72	93.75
	Biology 101	5.28	6.25

As Table 11 illustrates, success rates for Community College A and Community College C were different in the 2014-2015 academic year. Community College A had 48.27% of students passing Anatomy and Physiology with a C or better grade, while Community College C had 93.75% of students passing Anatomy and Physiology with a final grade of C or better. Final grades in Anatomy and Physiology varied between the two institutions. Community College A had 20.80% of final grades being A, while Community College had 17.50%. For final grade of B, Community College A had 15. 73%, while Community College C had 28.75%. Community

College C had higher percentages of C grades, with 47.50% of students earning a C, while Community College A only had 11.75% of students earning a C. At community College C, 5% of students earned a D, and at Community College A, 3.34% of students earned a final grade of D in Anatomy and Physiology. Community College A had much higher percentages of F grades and withdrawals, with 27.04% of students failing the course, and 20.58% of students withdrawing. Community College C only had 1.25% of students fail Anatomy and Physiology, and no students withdrew from Anatomy and Physiology in the 2014-2015 academic year. The difference in final grade for Anatomy and Physiology I was found to be statistically different between the two colleges (t (1164.157) = 10.725, $p < .0005$).

Table 11.

Student Outcomes in Anatomy and Physiology for Students with and without NAS 2 at Community College A and Community College C

Descriptor	Category	Percentage of Students College A Post Implementation 2014-2015 N=928	Percentage of Students College C Post Implementation 2014-2015 N=81
Success in Bio 141	Successful (A, B, or C final grade)	48.27	93.75
	Unsuccessful (D, F, or W final grade)	51.73	6.25
	Final Grade of A	20.80	17.50
	Final Grade of B	15.73	28.75
	Final Grade of C	11.75	47.50
	Final Grade of D	3.34	5.00
	Final Grade of F	27.04	1.25
	Withdrawal from Bio 141	20.58	0.00

The variable of age had a skewness of 1.344 (*SE* = .077) and kurtosis of 1.528 (*SE* = .154). Squaring the variable of age did not improve the skewness or kurtosis, so age was used untransformed in the model. These data were found to not exhibit collinearity, but violated the assumption of proportional odds necessary to complete an ordinal logistic regression $\chi^2(28)=107.783$, $p<.0005$. Based on this violation, a multinomial regression was completed to compare the impact of the independent variables on the outcome in Bio 141.

Results from the multinomial logistic regression are shown in Table 12. The resulting model that was used was found to be a better fitting model than the intercept only model $\chi^2(35)=222.654$, $p < .0005$. The Nagelkerke pseudo R^2 for this model was .205, indicating that the model explained 20.5% of these data.

In this comparison, withdrawals were compared to final grades for each of the grade categories. Since Community College C had no withdrawals in the 2014/2015 academic year, NAS 2 data for the category of A is not available. In all other categories, NAS 2 was a significant factor, with not having NAS resulting in large positive B values. Based on this, students at Community College C did better in Anatomy and Physiology than students at Community College A with the NAS 2 course. Developmental placement was negatively significant in the model, indicating that developmental students are less likely to earn the final grades of B or A. Ethnicity of African American/Black was also significant for the B and A final grade categories.

Table 12.

Statistically Significant Results, Community College A and C Post Prerequisite as Indicated by Multinomial Regression When Withdrawals Are Compared to Grades in Biology 141

Comparison	Factor	B	SE	Wald	Df	Sig	Exp (B)	95% CI for Exp (B)
W to F	NAS 2	17.285	1.049	271.616	1	.000	3.2×10^7	4.1×10^6, 2.5×10^8
W to D	NAS 2	20.723	.651	1012.75	1	.000	9.9×10^8	2.7×10^8, 3.6×10^9
W to C	NAS 2	21.517	.363	3515.753	1	.000	2.2×10^9	1.08×10^9 , 4.5×10^9
W to B	NAS 2	20.750	.376	3048.08	1	.000	1.0×10^9	4.9×10^8, 2.1×10^9
	Developmental Placement	-.568	.213	7.114	1	.008	.567	.373, .860
	Ethnicity (Black/African American)	-.606	.302	4.021	1	.045	.546	.302, .986
W to A	Age	.048	.011	17.426	1	.000	1.049	1.026, 1.073
	Developmental Placement	-.783	.208	14.164	1	.000	.457	.304, .687
	Ethnicity (Black/African American)	-1.274	.326	15.279	1	.000	.280	.148, .530

Community College B post implementation data were compared to an outside VCCS institution as well. Here, success data in Anatomy and Physiology was examined for three years prior to Community College A's implementation of NAS 2 as a prerequisite course. Community College D was identified by the VCCS Academic Research and Services department as the VCCS institution with prior implementation success rates in Anatomy and Physiology most similar to Community College B's prior success rates. A comparison between Community College B and Community College D was completed. Community College B was found to have 208 students in the 2014/2015 academic year who did not take NAS 2, and Community College D was found to have 3 students who did take a NAS 2 course. In both cases, these students were

excluded from analysis to ensure that the two groups either took the NAS 2 course structured to be a prerequisite to Anatomy and Physiology, or did not take such a course.

These two institutions did not vary significantly in age (t (277.876) = -1.396, p = .164), gender (t (272.301) = 1.877, p = .062), or ethnicity (t (807) = 1.427, p = .151). Mean age was 26 for Community College B, and 25 for Community College D. Community College B had 47.31% of students being traditional age, and Community College D had 48.96% traditional age. Both populations were mostly female, ranging from 80.11% female at Community College B, to 86.20% female and Community College D. Ethnicity breakdown was similar at the two institutions, with both institutions being predominately White. These data are shown in Table 13.

Table 13.

Percentages of Students in Each Classification, Community Colleges B and D Post Prerequisite

Descriptor	Category	Percentage of Students College B Post Implementation 2014-2015 N=186	Percentage of Students College D Post Implementation 2014-2015 N=623
Age	22 or younger	47.31	48.96
	23 or older	52.69	51.04
	Mean Age	26	25
	Age Range	16-52	17-57
Gender	Male	19.89	13.80
	Female	80.11	86.20
Ethnicity	White	67.74	57.62
	African American/Black	16.13	27.45
	Other	16.13	14.93
English/Math Placement	Developmental English or Math	34.95	24.56
	College Level English and Math	65.05	75.44
Coursework Prior to Bio 141	No NAS 2	0.00	100.00
	NAS 2	100.00	0.00
	No Biology 101	99.46	37.18
	Biology 101	0.54	62.82

Grade in Anatomy and Physiology I was statistically different between the two institutions (t (807) = 4.050, $p < .0005$). Community College D does not use the NAS 2 course as a prerequisite to Anatomy and Physiology I, however, despite having similar prior Anatomy and Physiology success rates, Community College D had a success rate for Anatomy and Physiology of 62.82%. Community College B only had 44.62% of students earn a grade of C or better in the 2014-2015 academic year. Community College D had more students earning grades

of A, B, and C, but also had fewer D grades, fewer failing grades, and had fewer withdrawals than Community College B. These data are shown in Table 14.

Table 14.

Student Outcomes in Anatomy and Physiology for Students with and without NAS 2 at Community College B and Community College D

Descriptor	Category	Percentage of Students College B Post Implementation 2014-2015 N=186	Percentage of Students College D Post Implementation 2014-2015 N=623
Success in Bio 141	Successful (A, B, or C final grade)	44.62	62.76
	Unsuccessful (D, F, or W final grade)	55.38	37.24
	Final Grade of A	15.59	23.92
	Final Grade of B	15.59	20.39
	Final Grade of C	13.44	18.46
	Final Grade of D	12.37	8.51
	Final Grade of F	19.89	12.36
	Withdrawal from Bio 141	23.12	16.37

Age was again examined, since it did exhibit a skewness value of 1.347 (*SE* = .086) and a kurtosis value of 1.256 (*SE* = .172), but was left untransformed, since transformations did not improve these values A logistic regression revealed that these data did not exhibit multicollinearity, and did not violate the assumption of proportional odds necessary to use ordinal logistic regression $\chi^2(24) = 46.277$, $p = .052$. A Generalized Linear Models approach revealed a deviance of 1498.007, $p = .831$. The Pearson chi square for the resulting model was

1850.694 (1803), p= 1.026, indicating that the resulting model was a good fit for these data. Statistically significant results are shown in Table 15.

Completing NAS 2 was a significant predictor of grade in Anatomy and Physiology I, with students completing the course being 1.941 times as likely to earn a higher grade than students without the course. Age was associated with higher grade in a positive way, with an Exp (B) value of 1.041. Ethnicity of Other had a negative relationship with increased grade in Anatomy and Physiology I, along with developmental placement for English and/or Math.

Table 15.

Statistically Significant Results, Community College B and Community College D Post Implementation as Indicated by Ordinal Logistic Regression.

Predictor	B	Wald Chi Square	Exp (B)	Sig.	95% CI for Exp (B)
NAS 2	.663	13.362	1.941	.000	1.360, 2.770
Age	.040	25.243	1.041	.000	1.025, 1.058
Ethnicity (Other)	-.407	5.123	1.502	.024	1.056, 2.137
Developmental Math and/or English Placement	-.650	19.277	.522	.000	.391, .698

Findings NAS 2 Compared to General Biology I

Another set of research questions examined comparisons between students who took the NAS 2 prerequisite and students who took General Biology I before Anatomy and Physiology I. These comparisons were done for both Community College A and Community College B, where

the NAS 2 prerequisite is used. In the first comparison, students at Community College A that took the NAS 2 prerequisite and students at Community College A that took General Biology I before completing Anatomy and Physiology I were included. In this dataset, 2,513 students at Community College A had taken neither the Bio 101 or NAS 2 course prior to completing Anatomy and Physiology I. Additionally, 48 students at Community College A had taken both the Bio 101 and NAS 2 courses. All students who had taken neither course, or that took both courses were excluded from analyses.

Descriptive data for this comparison is shown in Table 16. The two comparison groups were statistically similar in ethnicity (t (1597) = -1.275, p = .202). For students who took NAS 2, 54.04% were White, 26.17% were African American/Black, and 19.80% of students were in the ethnicity of Other. For General Biology I students, 52.36% were White, 30.14% were African American/Black, and 17.50% were in the category of Other ethnicity.

Table 16.

Percentages of Students in Each Classification, Community College A General Biology and NAS 2

Descriptor	Category	Percentage of Students College A with NAS 2 2010-2011, 2014-2015 N=879	Percentage of Students College A with General Biology 2010-2011, 2014-2015 N=720
Age	22 or younger	31.06	50.83
	23 or older	68.94	49.17
	Mean Age	27	25
	Age Range	17-62	17-55
Gender	Male	19.91	19.44
	Female	80.09	80.56
Ethnicity	White	54.04	52.36
	African American/Black	26.17	30.14
	Other	19.80	17.50
English/Math Placement	Developmental English or Math	0.00	68.06
	College Level English and Math	100.00	31.94
Coursework Prior to Bio 141	No NAS 2	0.00	100.00
	NAS 2*	100.00	0.00
	No Biology 101*	100.00	0.00
	Biology 101	0.00	100.00

*48 students took both Bio 101 and NAS 2 and were excluded from the statistical analyses, and 2513 students had neither Bio 101 or NAS 2, and were excluded from analyses.

Final grade in Anatomy and Physiology was not statistically different between the two comparison groups (t (1556.185) = 1.282, p = .200). Success varied between the two groups, with 59.61% of NAS 2 students being successful in Anatomy and Physiology, and 46.94% of students with General Biology I being successful in Anatomy and Physiology. Students with NAS 2 earned more A grades, with 28.56% of students who took NAS 2 earning an A in

Anatomy and Physiology. A greater percentage of students with NAS 2 earned B grades in Anatomy and Physiology than General Biology students. Final grades of D and F in Anatomy and Physiology was a higher percentage for students with General Biology than students with NAS 2, and a higher percentage of General Biology students withdrew from Anatomy and Physiology than students with NAS 2. These data are shown in Table 17.

Table 17.

Student Outcomes in Anatomy and Physiology for Students with NAS 2 and for Students with General Biology at Community College A

Descriptor	Category	Percentage of Students College A with NAS 2 2010-2011, 2014-2015 N=879	Percentage of Students College A with General Biology 2010-2011, 2014-2015 N=720
Success in Bio 141	Successful (A, B, or C final grade)	59.61	46.94
	Unsuccessful (D, F, or W final grade)	40.39	53.06
	Final Grade of A	28.56	15.83
	Final Grade of B	18.54	17.78
	Final Grade of C	12.51	13.33
	Final Grade of D	2.16	6.11
	Final Grade of F	17.97	21.53
	Withdrawal from Bio 141	20.25	25.42

*48 students took both Bio 101 and NAS 2 and were excluded from the statistical analyses, and 2513 students had neither Bio 101 or NAS 2, and were excluded from analyses.

A logistic regression revealed that these data did not exhibit multicollinearity, but these data violated the assumption of proportional odds necessary to use ordinal logistic regression χ^2 (24) = 85.689, $p < .0005$. For this reason, a multinomial logistic regression was used. Age was found to exhibit a skewness of 1.426 (*SE* = .061), and a kurtosis value of 1.883 (*SE* = .122), but

all transformations attempted, including squaring age, did not improve skewness or kurtosis. For this reason, age was left untransformed. Age still violated the assumption of linearity of the logit of the dependent variable, but age was treated as a continuous variable to avoid collapsing data into categories any further. The resulting model significantly predicted data (χ^2 (30) = 172.084, p < .0005). The Nagelkerke pseudo R^2 was .106 for this data set. Significant results from this comparison are shown in Table 18.

The statistical results from this multinomial regression show that General Biology (not having NAS 2, but General Biology instead), was a significant predictor of earning a D or B grade when compared with withdrawals. In these two categories, the Exp (B) values were 2.113, and 1.533, respectively, indicating that General Biology students were 1.533 and 2.113 times as likely to earn those grades than students with NAS 2. Developmental placement for English or Math was negatively associated with the likelihood of earning a final grade of B or A in Anatomy and Physiology, with Exp (B) values ranging from .469 to .502. Students who were initially placed into college level courses were .469 and .502 times as likely to earn a grade of B or A when compared to students who were developmentally placed. Ethnicity was also a significant predictor, with African American/Black students exhibiting a lesser likelihood of earning a B or A grade when compared with White students. Age was positively associated with a final grade of A, indicating that older students were more likely to earn the A final grade.

Table 18.

Statistically Significant Results, Community College A Students Completing General Biology vs. NAS 2 As Indicated by Multinomial Regression When Withdrawals Are Compared to Grades in Bio 141

Comparison	Factor	B	SE	Wald	Df	Sig	Exp (B)	95% CI for Exp (B)
W to D	No NAS 2 (Bio 101)	.748	.268	7.765	1	.005	2.113	1.248, 3.577
W to B	No NAS 2 (Bio 101)	.427	.164	6.815	1	.009	1.533	1.112, 2.113
	Developmental Placement	-.689	1.165	17.375	1	.000	.502	.363, .694
W to A	Ethnicity (Black/African American)	-1.281	.259	24.563	1	.000	.278	.167, .461
	Age	.043	.010	20.365	1	.000	1.044	1.025, 1.064
	Developmental Placement	-.756	.163	21.519	1	.000	.469	.341, .646

The next dataset addressed whether or not there is a statistically significant difference for students who take General Biology I when compared to students who took NAS 2 at Community College B. In this research question, age, gender, ethnicity, English/Math placement, and other Biology/Chemistry coursework were included as independent variables.

Findings for descriptive information for these groups of students are shown in Table 19 below. Two students were removed from the initial data set, as they had completed both Biology 101, and NAS 2. Some students took neither course, so 317 students were also excluded from analyses. When these two group means were compared using a t test to see if they were significantly different from each other, the demographic variables of ethnicity and developmental placement were statistically similar (t (80.549) = -1.181, p = .241, and t (263) = .758, p = .449). Both samples were predominately White, with NAS 2 students being 68.37% White, and General

Biology students being 76% white. Developmental placement was slightly higher for NAS 2 students, with 41.86% of NAS 2 students placing into developmental English or Math. For General Biology students, 36% were placed into developmental English and/or Math.

Table 19.

Percentages of Students in Each Classification Community College B General Biology and NAS 2

Descriptor	Category	Percentage of Students College B with NAS 2 2014-2015 N=215	Percentage of Students College B with General Biology 2010-2011, 2014-2015 N=50
Age	22 or younger	45.12	72.00
	23 or older	54.88	28.00
	Mean Age	27	22
	Age Range	17-59	18-46
Gender	Male	18.60	42.00
	Female	81.40	58.00
Ethnicity	White	68.37	76.00
	African American/Black	16.74	14.00
	Other	14.88	10.00
English/Math Placement	Developmental English or Math	41.86	36.00
	College Level English and Math	58.14	64.00
Coursework Prior to Bio 141	No NAS 2	0.00	100.00
	NAS 2*	100.00	0.00
	No Biology 101	100.00	0.00
	Biology 101	0.00	100.00

*2 students took both Bio 101 and NAS 2 and were excluded from the statistical analyses. 317 students took neither course, and were excluded from analyses.

Grade was not statistically significant when students who took General Biology were compared to students who took NAS 2 (t (263) = 1.490, p = .137). Students with NAS 2 mostly withdrew or failed Anatomy and Physiology, with 20.93% of students withdrawing from the course, and 19.07% of students failing. For students with General Biology, 22% earned As in Anatomy and Physiology, 22% earned Bs in Anatomy and Physiology, and 20% earned Cs in Anatomy and Physiology. Of students with General Biology, 18% withdrew from Anatomy and Physiology, and only 12% failed the course. Only 6% of students with General Biology earned a final grade of D in Anatomy and Physiology. Table 20 illustrates these data.

Table 20.

Student Outcomes in Anatomy and Physiology for Students with General Biology and NAS 2 at Community College B

Descriptor	Category	Percentage of Students College B with NAS 2 2014-2015 N=215	Percentage of Students College B with General Biology 2010-2011, 2014-2015 N=50
Success in Bio 141	Successful (A, B, or C final grade)	48.37	64.00
	Unsuccessful (D, F, or W final grade)	51.63	36.00
	Final Grade of A	18.14	22.00
	Final Grade of B	15.81	22.00
	Final Grade of C	14.42	20.00
	Final Grade of D	11.63	6.00
	Final Grade of F	19.07	12.00
	Withdrawal from Bio 141	20.93	18.00

*2 students took both Bio 101 and NAS 2 and were excluded from the statistical analyses. 317 students took neither course, and were excluded from analyses.

Age was found to have a skewness value of 1.299 (*SE* = .150), and a kurtosis value of .810 (SE = .298). Transforming age did not improve these values, so age was left as the original

variable. A multinomial logistic regression was completed, since data violated the assumption of proportional odds $\chi^2(24) = 37.077$, $p = .043$. The model that resulted was a good fit $\chi^2(30) = 91.916$, $p < .0005$, with a Nagelkerke value of .302.

Table 21 illustrates the statistically significant findings for this research question. In this comparison, college/developmental level placement was a significant factor that influenced success in Anatomy and Physiology for the categories of D, C, B, and A. This indicates that students who come to college underprepared for English and Math were less likely to earn these grades than students who were placed into college level courses. Age was also significant for the categories of B and A grades, both having a positive B value of .066 and .098 respectively. This indicates that older students were again more likely to earn the grade of B or A than students who were younger.

Table 21.

Statistically Significant Results, Community College B Students Completing General Biology vs. NAS 2 As Indicated by Multinomial Logistic Regression

Comparison	Factor	B	SE	Wald	Df	Sig	Exp (B)	95% CI for Exp (B)
W to D	Developmental Placement	-1.042	.499	4.364	1	.037	.353	.133, .938
W to C	Developmental Placement	-.943	.442	4.539	1	.033	.39	.164, .927
W to B	Age	.066	.026	6.458	1	.011	1.069	1.015, 1.125
	Developmental Placement	-1.255	.445	7.961	1	.005	.285	.119, .682
W to A	Age	.098	.026	14.237	1	.000	1.103	1.048, 1.161
	Developmental Placement	-1.573	.473	11.047	1	.001	.207	.082, .524

Additional Analysis

Community College A's post implementation data indicated that a large group of students (571) were able to enroll in Anatomy and Physiology I despite the fact that they did not have the required prerequisite course(s). Although there is no way to know exactly how these students were able to enroll in the Anatomy and Physiology I course, a comparison was done to see if there was a difference between students who took the prerequisite and the students who did not complete the prerequisite course. In this data set, students who had taken Bio 101 were eliminated from analysis, leaving only students who did not have NAS 2 and students who had taken the NAS 2 course.

To ensure that groups similar, descriptive data were recorded. The two groups were statistically similar in age (t (1322.173) = -.455, p = .649), and gender (t (1145.443) = -1.562, p = .119), Table 22 indicates the breakdown of demographics for these two groups.

Table 22.

Percentages of Students in Each Classification, Community College A Students with and Without NAS 2 Academic Year 2014/2015

Descriptor	Category	Percentage of Students Community College A Without NAS 2 2014/2015 N=571	Percentage of Students Community College A With NAS 2 2014/2015 N=879
Age	22 or younger	36.25	39.48
	23 or older	63.75	60.52
	Mean Age	25	27
	Age Range	17-60	17-62
Gender	Male	16.81	13.77
	Female	83.19	86.23
Ethnicity	White	56.22	51.08
	African American/Black	28.02	29.24
	Other	15.76	19.68
English/Math Placement	Developmental English or Math	13.31	40.73
	College Level English and Math	86.69	59.27
Coursework Prior to Bio 141	No NAS 2	100.00	0.00
	NAS 2	0.00	100.00
	No Biology 101	100.00	100.00
	Biology 101	0.00	0.00

Success in Anatomy and Physiology was 58.84% for students without the NAS 2 prerequisite, and was 48.35% for students with the prerequisite, and grade was statistically different for the two groups (t (1448) = 3.983, $p < .0005$). Withdrawal rates were lower for the group of students who did not take NAS 2, with 20.67% of students withdrawing, as compared to 26.85% of students withdrawing from Anatomy and Physiology who took NAS 2. 26.44% of students who did not take NAS 2 earned final grades of A in Anatomy and Physiology, while 19.44% earned Bs. 12.96% of students without NAS 2 earned final grades of C, and 2.28% earned a final grade of D. 18.21% of students without the prerequisite course failed the target

course. For students who took NAS 2, 20.48% earned a final grade of A in Anatomy and Physiology, and 15.81% earned Bs. For students that took NAS 2, 12.06% earned a final grade of C and 3.30% earned a final grade of D. For students who completed NAS 2, 21.50% failed Anatomy and Physiology, and 26.85% withdrew. These data are shown in Table 23.

Table 23.

Student Outcomes in Anatomy and Physiology for Community College A Students with and without NAS 2 in the 2014/2015 Academic Year

Descriptor	Category	Percentage of Students Community College A Without NAS 2 2014/2015 N=571	Percentage of Students Community College A With NAS 2 2014/2015 N=879
Success in Bio 141	Successful (A, B, or C final grade)	58.84	48.35
	Unsuccessful (D, F, or W final grade)	41.16	51.65
	Final Grade of A	26.44	20.48
	Final Grade of B	19.44	15.81
	Final Grade of C	12.96	12.06
	Final Grade of D	2.28	3.30
	Final Grade of F	18.21	21.50
	Withdrawal from Bio 141	20.67	26.85

Age was again left untransformed, since transformations did not improve the skewness value of 1.276 (SE = .042) or kurtosis value of 1.295 (SE = .085). The data violated the assumption of proportional odds necessary to complete an ordinal regression χ^2 (28) =152.736, p < .0005, so a multinomial logistic regression was used. The resulting model was significant χ^2 (30) = 175.510, p < .0005. The Nagelkerke pseudo R^2 value for this data was .118.

In terms of statistical findings, completing NAS 2 was only significant at the A grade level. Students who did not complete NAS 2 were 1.405 times as likely to earn a grade of A when compared with students who did complete NAS 2. Developmental placement was significant for the categories of A and B final grades, and ethnicity of African American/Black and having an ethnicity of Other were significant in the categories of B and A grades when compared with White students. Age was positively associated with final grade of A in Anatomy and Physiology I. Statistically significant findings are shown in Table 24.

Table 24.

Statistically Significant Results, Community College A 2014/2015 from Multinomial Regression When Withdrawals Were Compared to Grades in Anatomy and Physiology I for Students with and Without NAS 2

Comparison	Factor	B	SE	Wald	Df	Sig	Exp (B)	95% CI for Exp (B)
W to F	Gender	.557	.288	5.999	1	.014	1.746	1.118, 2.727
W to D	Ethnicity (Other)	-.993	.452	4.822	1	.028	.371	.153, .899
W to B	Ethnicity (Other)	-.457	.229	3.983	1	.046	.633	.404, .992
	Ethnicity (African American/Black)	-.832	.253	10.827	1	.001	.435	.265, .714
	Developmental Placement	-.624	.199	9.806	1	.002	.536	.363, .792
W to A	Age	.050	.010	25.284	1	.000	1.051	1.031, 1.071
	Ethnicity (African American/Black)	-1.375	.269	26.209	1	.000	.253	.149, .428
	Developmental Placement	-.857	.195	19.262	1	.000	.425	.290, .622
	NAS 2	.340	.169	4.058	1	.044	1.405	1.009, 1.957

College Level Students. Since developmental placement differed between the two groups in Community College A's 2014-2015 data, and developmental placement was a factor influencing final grade in Anatomy and Physiology in many of the previous models, a regression was done using only college level English and Math students to see if NAS 2 was a significant predictor of grade in Anatomy and Physiology. In this comparison, 256 college level students had not taken NAS 2 or General Biology I, and 879 college level students had taken the NAS 2 prerequisite course, but not General Biology I. Of the students without the required prerequisite, 54.70% were successful in Anatomy and Physiology. Of the college level students who had the prerequisite course, 55.07% were successful in Anatomy and Physiology after taking the NAS 2 prerequisite. The two groups were statistically similar in age t (1008.671) = -.378, p = .705, gender t (1002.050) = -1.036, p = .300, and ethnicity t (1014) = -.745, p = .456. The percentages of students in various demographic categories is shown in Table 25. Mean age was 26 for students without NAS 2, and was 27 for students with NAS 2. Ages ranged from 17-54 for students without NAS 2, and was 17-62 for students who did take the NAS 2 course prior to completing Anatomy and Physiology. Gender was 17.98% male for students without NAS 2, and 15.55% male for students with NAS 2. Ethnicity was similar in the two comparison groups. Students without NAS 2 were 57.58% White, 26.06% African American/Black, and 16.16% Other races. For students with NAS 2, 57.39% of students were in the White category, 23.22 were African American/Black, and 19.39% were in the Other category for ethnicity.

Table 25.

Percentages of College Level Students in Each Classification, Community College A 2014/2015 With and Without NAS 2 with and without NAS 2

Descriptor	Category	Percentage of College Level Students Community College A Without NAS 2 2014/2015 N=495	Percentage of College Level Students Community College A With NAS 2 2014/2015 N=521
Age	22 or younger	36.36	38.20
	23 or older	63.64	61.80
	Mean Age	26	27
	Age Range	17-54	17-62
Gender	Male	17.98	15.55
	Female	82.02	84.45
Ethnicity	White	57.58	57.39
	African American/Black	26.06	23.22
	Other	16.16	19.39
English/Math Placement	Developmental English or Math	0.00	0.00
	College Level English and Math	100.00	100.00
Coursework Prior to Bio 141	No NAS 2	100.00	0.00
	NAS 2	0.00	100.00
	No Biology 101	100.00	100.00
	Biology 101	0.00	0.00

Final grades in Anatomy and Physiology were significantly different for the two comparison groups t (1014) = 2.190, p = .029. For students without NAS 2, 62.02% were successful in Anatomy and Physiology. 29.09% of students without NAS 2 earned a final grade of A, 19.80% earned a final grade of B, 13.13% earned a final grade of C, 2.02% earned a grade of D, while 15.96% failed Anatomy and Physiology, and 20% withdrew. For students with NAS 2, 54.70% were successful in Anatomy and Physiology. For this group, 24.95% earned a final grade of A, 18.81% earned a final grade of B, 10.94% earned a C, 2.69% earned a final grade of

D, and 18.81% earned a final grade of F, and 23.80% withdrew from Anatomy and Physiology. These data are illustrated in Table 26.

Table 26.

Student Outcomes in Anatomy and Physiology for College Level Community College A Students with and without NAS 2 in the 2014/2015 Academic Year

Descriptor	Category	Percentage of College Level Students Community College A Without NAS 2 2014/2015 N=495	Percentage of College Level Students Community College A With NAS 2 2014/2015 N=521
Success in Bio 141	Successful (A, B, or C final grade)	62.02	54.70
	Unsuccessful (D, F, or W final grade)	37.98	45.30
	Final Grade of A	29.09	24.95
	Final Grade of B	19.80	18.81
	Final Grade of C	13.13	10.94
	Final Grade of D	2.02	2.69
	Final Grade of F	15.96	18.81
	Withdrawal from Bio 141	20.00	23.80

To statistically model what factors are important for grades in Anatomy and Physiology for college level English and Math students, a multinomial regression was completed, since data violated the assumption of proportional odds necessary to complete an ordinal logistic regression χ^2 (20) = 40.868, p = .004. Age was found to has a skewness of 1.479 (SE = .077), and a kurtosis value of 2.134 (SE = .153), but all transformations attempting, including squaring age, did not improve skewness or kurtosis. Age was therefore left untransformed. An ordinal logistic regression was attempted, but data violated the assumption of proportional odds necessary to complete an ordinal logistic regression χ^2 (20) = 37.599, p = .010, so a multinomial logistic

regression was completed. The resulting model from the multinomial logistic regression significantly improved the model over the intercept only model χ^2 (25) = 96.265, $p < .0005$, and had a Nagelkerke pseudo R^2 value of .094.

The statistical results from this comparison show a difference in gender for the category of F. Males were 1.868 times more likely to earn an F grade that females when F final grades were compared to withdrawals. Ethnicity was significant in the D, B, and A categories. In the D grade category, the ethnicity of Other had a positive B value, indicating that when compared to White identifying students, the students in the Other category were more likely to earn a grade of D. African American/Black ethnicity corresponded to a negative B in B and A final grades. NAS 2 was a significant factor in the final grade of A category, but in a positive way. This indicates that students without the NAS 2 prerequisite were 1.472 times more likely to earn a grade of A than students with it. These data are shown in Table 27.

Table 27.

Statistically Significant Results, College Level Students Community College A 2014-2015 as Indicated by Multinomial Logistic Regression When Withdrawals Are Compared to Grades in Anatomy and Physiology I.

Comparison	Factor	B	SE	Wald	Df	Sig	Exp (B)	95% CI for Exp (B)
W to F	Gender	.625	.267	5.463	1	.019	1.868	1.106, 3.156
W to D	Ethnicity (Other)	1.284	.538	5.690	1	.017	.277	.096, .795
W to B	Ethnicity (African American/Black)	-.697	.303	5.289	1	.021	.498	.275, .902
W to A	Age	.046	.012	14.940	1	.000	1.047	1.023, 1.072
	Ethnicity (African American/Black)	-1.454	.323	20.241	1	.000	.234	.124, .440
	NAS 2	.387	.186	4.316	1	.038	1.472	1.022, 2.121

Developmental Students. To explore what prerequisites are significant for students who are developmentally placed, Community College A data from 2014/2015 academic year was divided so that just developmentally placed students were included. Students who had taken General Biology I were excluded from this analysis. For these data, the two groups were statistically similar in all demographic variables. Table 28 shows the percentages of students in each of the demographic variable categories for the two comparison groups.

Table 28.

Percentages of Developmental Students in Each Classification, Community College A 2014/2015 With and Without NAS 2

Descriptor	Category	Percentage of Developmental Students College A without NAS 2 N=76	Percentage of Developmental Students College A Students with NAS 2 N=358
Age	Under 23	35.53	41.34
	23 or older	64.47	58.66
	Mean Age	28	27
	Age Range	18-59	17-60
Gender	Male	9.21	11.17
	Female	90.79	88.83
Ethnicity	White	46.05	41.90
	Black/African American	40.79	37.99
	Other	13.16	20.11
English/Math Placement	Developmental English or Math	100.00	100.00
	College Level English and Math	0.00	0.00
Coursework Prior to Bio 141	No NAS 2	100.00	0.00
	NAS 2	0.00	100.00
	No Biology 101	100.00	100.00
	Biology 101	0.00	0.00

In terms of success in Anatomy and Physiology, only 38.16% of developmentally placed students who did not take NAS 2 were successful in the target course. Of the students who did complete the NAS 2 course, 39.19% were successful in Anatomy and Physiology. Final grade in Anatomy and Physiology I was not significantly different for developmental students who had taken General Biology I vs. those who did not t (432) = .013, p = .990. These data are shown in Table 29.

Table 29.

Student Outcomes in Anatomy and Physiology for Developmental Level Community College A Students with and without NAS 2 in the 2014/2015 Academic Year

Descriptor	Category	Percentage of Developmental Students College A without NAS 2 N=76	Percentage of Developmental Students College A Students with NAS 2 N=358
Success in Bio 141	Successful (A, B, or C final grade)	38.16	39.11
	Unsuccessful (D, F, or W final grade)	61.84	60.89
	Final Grade of A	9.21	13.97
	Final Grade of B	17.11	11.45
	Final Grade of C	11.84	13.69
	Final Grade of D	3.95	4.19
	Final Grade of F	32.89	25.42
	Withdrawal from Bio 141	25.00	31.28

Age was again left untransformed with a skewness value of 1.193 (*SE* = .117), and a kurtosis value of .961 (*SE* = .234). Age squared did not make these data more normally distributed, and did not improve skewness or kurtosis. An ordinal regression was completed. These data did not violate the assumption of multicollinearity, or the assumption of proportional odds χ^2 (16) = 10.411, *p*= .844. The model that was produced from these data was significant χ^2 (5) = 16.138, *p*= .006, as assessed by a Likelihood Ratio Chi-Square.

In the statistical model that resulted, only age and ethnicity (Black/African American) were statistically significant. For ethnicity of African American/Black, the B value was -.591, the Exp (B) was .554, with *p* = .015. Age was associated with a B of .026, and an Exp(B) of 1.027. NAS 2 was not significant in this model. Table 21 highlights the statistically significant factors in the ordinal regression.

Table 30.

Statistically Significant Results, Developmental Students Community College A 2014/2015 as Indicated by Ordinal Logistic Regression

Predictor	B	Wald Chi Square	Sig.	Exp (B)	95% CI for Wald Exp (B)
Ethnicity (Black/African American)	-.591	5.916	.015	.554	.344, .892
Age	.026	7.166	.007	1.027	1.007, 1.047

Traditional Age Students. Students who were 22 years of age or younger who had not completed General Biology I were pulled from the larger 2014/2015 Community College A dataset for an additional analysis. These students were compared in two groups: students without the NAS 2 prerequisite to Anatomy and Physiology, and students with the prerequisite.

When the two groups (students without NAS 2 and students with NAS 2) were compared, the two groups were statistically similar in gender χ^2 (401.657) = -.996, p= .320, and in ethnicity χ^2 (552) = -1.603, p= .109. For gender, students without the NAS 2 course were 15.46% male, and students with the prerequisite were 12.39% male. Ethnicity was statistically similar, 60.87% of the sample of students without NAS 2 were in the White ethnicity category, and 53.89% were White for students with NAS 2. 22.22% of students without NAS 2 were African American/Black, while 25.07% were African American/Black for students with NAS 2. The "Other" category was 16.91% for students without NAS 2, and 21.04% for students with NAS 2. These data are shown in Table 31.

Table 31.

Percentages of Traditional Age Students in Each Classification, Community College A 2014/2015 With and Without NAS 2

Descriptor	Category	Percentage of College A Students without NAS 2 or Bio 101 N=207	Percentage of College A Students with NAS 2 N=347
Age	Under 23	100	100
	23 or older	0	0
	Mean Age	20	19
	Age Range	18-22	19-22
Gender	Male	15.46	12.39
	Female	84.54	87.61
Ethnicity	White	60.87	53.89
	Black/African American	22.22	25.07
	Other	16.91	21.04
English/Math Placement	Developmental English or Math	13.04	42.65
	College Level English and Math	86.96	57.35
Coursework Prior to Bio 141	No NAS 2	100.00	0.00
	NAS 2	0.00	100.00
	No Biology 101	100.00	100.00
	Biology 101	0.00	0.00

Students without the prerequisite were more likely to be successful that students without it (t (552) = 4.063, p< .0005), with 56.04% of students without the prerequisite being successful in Anatomy and Physiology, and 38.33% of students with it were successful. For students without NAS 2, the highest percentages for outcomes in Anatomy and Physiology were withdrawal (21.64%), final grade of B (21.26%), final grade of F (19.81%), final grade of A (18.36%), or final grade of C (16.43%). Only 2.42% of students without NAS 2 earned a grade of D in Anatomy and Physiology. For students with the NAS 2 course, the highest percentages were for withdrawing (33.14%), a final grade of F (24.21%), or a final grade of B (15.56%). The

percentage of students earning a final grade of C was 11.82%, and 10.95% of students earned A grades. The percentage of students who took NAS 2 that earned a final grade of D in Anatomy and Physiology was 4.32%. These data are highlighted in Table 32.

Table 32.

Student Outcomes in Anatomy and Physiology for Traditional Age Students at Community College A in the 2014/2015 Academic Year

Descriptor	Category	Percentage of College A Students without NAS 2 or Bio 101 N=207	Percentage of College A Students with NAS 2 N=347
Success in Bio 141	Successful (A, B, or C final grade)	56.04	38.33
	Unsuccessful (D, F, or W final grade)	43.96	61.67
	Final Grade of A	18.36	10.95
	Final Grade of B	21.26	15.56
	Final Grade of C	16.43	11.82
	Final Grade of D	2.42	4.32
	Final Grade of F	19.81	24.21
	Withdrawal from Bio 141	21.74	33.14

An ordinal regression was done with the control variables included. Age was left untransformed, with a skewness value of .166 (*SE* = .104), and kurtosis value of -.922 (*SE* = .207). These data were found to not violate assumptions of multicollinearity, or proportional odds χ^2 (24) = 26.926, *p*=.308. The resulting model was statistically significant χ^2 (6) = 44.953, p<.0005, and the Nagelkerke pseudo R^2 value was .081.

Three of the independent variables were significant in this model. Developmental placement was found to be a significant predictor of grade, with a negative B, and a Exp (B) of .591. Ethnicity of African American/Black also had a negative Exp (B) when compared to white

students, with an Exp (B) of .436. NAS 2 was a significant predictor of grade, with a positive B value of .379, indicating that student without NAS 2 were 1.461 times more likely to earn a higher grade in Anatomy and Physiology than students with NAS 2. Table 33 shows the statistical results from this analysis.

Table 33.

Statistically Significant Results, Community College A Traditional Age Students 2014-2015 as Indicated by Ordinal Logistic Regression

Predictor	B	Wald Chi Square	Sig.	Exp (B)	95% CI for Wald Exp (B)
Ethnicity (African American/Black)	-.831	12.568	.000	.436	.275, .690
Developmental Placement	-.526	9.037	.003	.591	.419, .833
NAS 2	.379	1.663	.031	1.461	1.036, 2.061

Non-Traditional Age Students. An analysis of non-traditional age students (23 or older) was completed for Community College A students in the 2014-2015 academic year. Gender was not significantly different when the two groups means were compared t (741.412) = -1.159, p = .247, along with ethnicity t (894) = -1.561, p = .119. When students without NAS 2 were compared to students with NAS 2, it was clear that 86.76% of students who did not take NAS 2 were college level for English and Math, which was a significant difference between the two groups (t (1120.475) = -5.560, p < .0005). This may indicate that these students were somehow allowed to enroll in Anatomy and Physiology without the prerequisite. Since many are

college ready, it may be that these students were informed they did not need the prerequisite. Table 34 shows demographic data and Anatomy and Physiology grade for these two groups of students.

Table 34.

Percentages of Non-Traditional Age Students in Each Classification, Community College A 2014/2015 With and Without NAS 2

Descriptor	Category	Percentage of College A Students without NAS 2 or Bio 101 N=364	Percentage of College A Students with NAS 2 N=532
Age	Under 23	0	0
	23 or older	100	100
	Mean Age	30	32
Gender	Male	17.58	14.66
	Female	82.42	85.34
Ethnicity	White	53.57	49.25
	Black/African American	31.32	31.95
	Other	15.11	18.80
English/Math Placement	Developmental English or Math	13.46	39.47
	College Level English and Math	86.54	60.53
Coursework Prior to Bio 141	No NAS 2	100.00	0.00
	NAS 2	0.00	100.00
	No Biology 101	100.00	100.00
	Biology 101	0.00	0.00

When comparing the two group outcomes for Anatomy and Physiology, 60.27% of students were successful in Anatomy and Physiology without having completed the NAS 2 course, as compared to 54.73% of students who took the prerequisite. Final grade in Anatomy and Physiology I was not significantly different when the two groups were compared t (894) =

1.817, $p = .070$. When comparing the breakdown of final grades, 31.04% of students who did not take NAS 2 earned a final grade of A, as compared to 26.69% for students who did complete NAS 2. Final grades of B were different as well, with 18.41% of students without the prerequisite earning a B in Anatomy and Physiology, and 15.98% of students with the prerequisite earning a B. 12.22% of students with NAS 2 earned a final grade of C in Anatomy and Physiology, while 10.99% earned a C for students without the prerequisite. Final grade of D in Anatomy and Physiology was similar for students without and with the NAS 2 course, with percentages of 2.20% and 2.63%, respectively. A higher percentage of students with the NAS 2 course earned final grades of F (19.74%), than students without the NAS 2 course (17.31%). 20.05% of students without the prerequisite withdrew from Anatomy and Physiology, while 22.74% of students with the prerequisite course withdrew. Table 35 demonstrates these data.

Table 35.

Student Outcomes in Anatomy and Physiology for Non Traditional Age Students at Community College A in the 2014/2015 Academic Year

Descriptor	Category	Percentage of College A Students without NAS 2 or Bio 101 N=364	Percentage of College A Students with NAS 2 N=532
Success in Bio 141	Successful (A, B, or C final grade)	60.44	54.89
	Unsuccessful (D, F, or W final grade)	39.56	45.11
	Final Grade of A	31.04	26.69
	Final Grade of B	18.41	15.98
	Final Grade of C	10.99	12.22
	Final Grade of D	2.20	2.63
	Final Grade of F	17.31	19.74
	Withdrawal from Bio 141	20.05	22.74

Age was tested for normality, and found to have a skewness value of 1.301 (*SE* = .082) and a kurtosis value of 1.245 (*SE* = .163). These data were left untransformed, since all transformations attempted did not improve these values. An ordinal regression was done for these data since these data did not violate either assumption of multicollinearity or the assumption of proportional odds χ^2 (24)=7.003, p=1.000. The resulting model was a good fit for data χ^2 (6)=61.636, p<.0005, as assessed by a Likelihood Ratio Chi-Square analysis.

Ethnicity (Black/African American) was found to be a significant factor when predicting course grade in Anatomy and Physiology, as well as developmental placement for English and/or Math. The prerequisite course, NAS 2, was not a significant factor for Anatomy and Physiology grade for non-traditional age students. Table 36 shows the statistical results for this test.

Table 36.

Statistically Significant Results, Community College A Non Traditional Age Students 2014-2015 as Indicated by Ordinal Logistic Regression.

Predictor	B	Wald Chi Square	Sig.	Exp (B)	95% CI for Exp (B)
Ethnicity (Black/African American)	-.620	11.806	.001	.538	.377. .766
Developmental Placement	-.546	15.193	.000	.579	.440, .762

Chapter V

Conclusions

The goal of this study was to evaluate the relationship between various prior science coursework, including a newly implemented prerequisite course, and final grade in Anatomy and Physiology I. This was done by examining data sets from four community colleges within the Virginia Community College System that included demographic information about the student, as well as if they took particular classes before attempting to complete Anatomy and Physiology I. The demographic variables that were included in this study allowed for an examination of what variables influence success in Anatomy and Physiology I at these four community colleges. This chapter will address a summary of the study completed, discuss the major findings of the study, and present conclusions that can be drawn from the research questions. Finally, the implications of these conclusions were examined.

Summary of the Study

This study examined prior coursework before students complete Anatomy and Physiology I, since this course has been identified as a "gate keeper" course to other Allied Health programs (Harris, Hannum, & Gupta, 2004). Anatomy and Physiology typically has one of the highest withdrawal and failure rates on college campuses (Hopper, 2011). Because of these low success rates, pathways to success in Anatomy and Physiology are of interest to a variety of institutions of higher education.

Prerequisites have been studied in a variety of disciplines. These studies examine the effectiveness of the prerequisite in the target course following the prerequisite. Some studies on prerequisites have found them to be effective at improving grades in the subsequent course (Armstrong, 1998; Hoyt, 1999; McCoy & Pierce, 2004), while others report no impact, or even

report negative effects of requiring students to complete a prerequisite course, since the prerequisite can add additional time to a student's program (Arismendi-Pardi, 1997, Willett, 2000, Wilson, 1994). Within the biological sciences, there are not many studies on prerequisites, and few studies have focused on prerequisites in Anatomy and Physiology. Of the work that has been completed, most of these studies rely on qualitative research (Jameson, 2013; Nasr, 2012; Sturges & Maurer, 2013).

Two institutions, Community College B (Community College B) and Community College A (Community College A), have attempted to address success in Anatomy and Physiology by implementing a required prerequisite course. In both institutions, this course is designed to serve as a developmental-type course, to help prepare students for the rigors of Anatomy and Physiology. The length of the course varies at the two colleges, as does the number of credits. Community College A offers an 8 week two credit course, while Community College B offers the prerequisite as a 16 week three credit course. Community College B requires students who enroll in Anatomy and Physiology I to have had prior course work in specific sciences, to complete NAS 2 with a grade of C or above, or allows students to complete a challenge examination that covers the content of NAS 2. Students who complete the challenge examination must complete the examination with a 70% or above. Community College B allows students with high school coursework in biology and chemistry to enroll in Anatomy and Physiology I. Students who have had these courses in college, or had a mix of high school and college courses in biology and chemistry are also allowed to enroll in the Anatomy and Physiology I course.

At Community College A, students have been permitted to take General Biology I in place of the NAS 2 course. With both prerequisites, students are required to complete with a C

or better grade. Alternatively, students can choose to complete a challenge exam that covers General Biology I/NAS 2 content to be placed in Anatomy and Physiology. At Community College A, students must complete the challenge examination with a grade of 70% or better.

Problem Statement

As the demand for nurses and health care workers increases in the United States, institutions of higher education, including community colleges, are responding to this need. Institutions have examined what support programs can be offered to assist students with the rigors of allied health curricula. Some research has examined whether certain prerequisites create successful students in their next course (Abou-Sayf, 2008; Abou-Sayf & Mariari, 2007; Arismendi-Pardi, 1997; Kaufmann & Gillman, 2002), but little research has been done with prerequisites courses in the sciences, particularly in Anatomy and Physiology prerequisites (Harris, Hannum & Gupta, 2004; Stickney, 2008), which is an important course in allied health programs.

In the evaluation of prerequisites in the literature, there is much disagreement. Some prerequisites have demonstrated to be successful at producing students who perform better in their subsequent course (Harris, Hannum & Gupta, 2004; McCoy & Pierce, 2004) while others have shown no difference or deleterious impacts to students who are required to complete them (Abou-Sayf, 2008; Rossi, 2003). Within the VCCS, it is important to evaluate these prerequisite courses and compare them to other prerequisites that are required to ensure that the required curriculum is better preparing students for the rigors of Anatomy and Physiology.

Purpose of Study

The purpose of this study was to assess four pathways to Anatomy and Physiology at two VCCS institutions, Community College A and Community College B, to determine which

pathway leads to the greatest percentage of successful students. Further, this study will investigate whether one or both of the required prerequisite science courses in these two institutions are correlated with producing students who are successful (final grade of C or better) in Anatomy and Physiology when compared with students who do not complete either of these two courses. This study also helped to determine if General Biology I serves as a better prerequisite than NAS 2 by producing a statistically significant number of successful students, identified as those who receive a C or better, in Anatomy and Physiology than students who complete either of the two NAS 2 courses.

Research Questions

This study was guided by the following research questions:

1. Does the existing NAS 2 prerequisite for Anatomy and Physiology lead to students who are more successful than students who did not complete the NAS 2 prerequisite?
    a. To what extent does completion of NAS 2 influence student success in Anatomy and Physiology when students who have completed NAS 2 at Community College A are compared to students at Community College A who did not complete NAS 2 before it was a prerequisite when variables of age, gender, college level English/Math placement, and ethnicity are controlled?
    b. To what extent does completion of NAS 2 influence student success in Anatomy and Physiology when students who have completed NAS 2 at Community College B are compared to students at Community College B who did not complete NAS 2 before it was a prerequisite when variables of age, gender, college level English/Math placement,

and ethnicity are controlled?

c. To what extent does completion of NAS 2 influence student success when students at Community College A that completed NAS 2 are compared to students at another VCCS institution without NAS 2 with a similar success rate prior to NAS 2 implementation when variables of age, gender, ethnicity, college level English/Math placement, and prior institutional Anatomy and Physiology success rates are controlled?

d. To what extent does completion of NAS 2 influence student success when students at Community College B that completed NAS 2 are compared to students at another VCCS institution without NAS 2 with similar success rates prior to NAS 2 implementation when variables of age, gender, ethnicity, college level English/Math placement, and prior Anatomy and Physiology success rates are controlled?

2. Does General Biology I lead to students who are more successful than students who did not complete a prerequisite?

a. To what extent does General Biology influence student success in Anatomy and Physiology when students who took General Biology are compared to students who completed NAS 2 at Community College A when variables of age, gender, college level English/Math placement, and ethnicity are controlled?

b. To what extent does General Biology influence student success in Anatomy and Physiology when students who took General Biology are compared to students who completed NAS 2 at Community College B when variables of age, gender, college level English/Math placement, and ethnicity are controlled?

Overview of Methodology

This was a quantitative study that utilized ex post facto data on student success (defined as a C or better) and student grades in Human Anatomy and Physiology I, based on whether the student completed NAS 2, General Biology I, or had none of these courses. These data were from two community colleges where NAS 2 is required: Community College A and Community College B. Additionally, temporal data from the two community colleges where NAS 2 is a requirement was compared to determine if student success changed since the prerequisite was implemented. For research questions dealing with comparisons within an institution, demographic variables of age, gender, and ethnicity, along with college placement in English and Math, were included to assure that student populations that are being compared are similar. In comparisons where two different institutions are being compared to determine if an institution with NAS 2 differs in success in Anatomy and Physiology success when compared to an institution without NAS 2, prior success rates for the previous three years before NAS 2 was implemented were used as a control to ensure that the institutions are similar. To analyze these data that were collected from the Virginia Community College Systems office. Descriptive statistics were reported on these populations, and ordinal logistic regressions were utilized where assumptions were not violated to determine if the various comparisons are predictive of student grades in Anatomy and Physiology. In research questions where statistical violation of assumptions occurred, multinomial logistic regressions were used to examine the relationship between independent variables and the dependent variable of final grade in Anatomy and Physiology I.

In research question one, parts a. and b, a temporal comparison was completed for both community colleges that have implemented NAS 2. Students from the two previous semesters of

Anatomy and Physiology that were not required to complete NAS 2 were compared to students who were required to complete NAS 2 after implementation. In these research questions, the demographic variables of age, gender, and ethnicity, along with college level English and Math placement, were controlled to ensure comparison groups are similar. In these research questions, the independent variable is whether the student completed NAS 2 or not, and the dependent variable is the student grade in Anatomy and Physiology I.

Summary of Major Findings

The major findings of this study included analyses of the prerequisite course. Several datasets showed a negative relationship between having completed the prerequisite course and higher grades in Anatomy and Physiology. At Community College A, when pre implementation data were compared to post implementation data, the NAS 2 course was a significant contributor to final grade in Anatomy and Physiology, but for students who did not take the NAS 2 course. This was true when withdrawals were compared to final grades of D, with an Exp (B) of .521, χ^2 (1) = 12.579, p = .044. In the post implementation data at Community College A, NAS 2 was negatively associated with earning an A over a W in Bio 141, with an Exp (B) value of 1.405 , χ^2 (1) = 4.058, p = .040. When Community College A was compared to Community College D, NAS 2 was again negatively associated with grades of F, D, C, and B, when withdrawals were compared to final grades in Bio 141. Here, the Exp (B)s were very large, ranging from 3.2×10^7, to 2.2×10^9, and all significance values were smaller than .0005. At Community College B, not having completed NAS 2 was associated with a 1.877 times increase in the likelihood of earning a higher final grade in Bio 141 , χ^2 (1) = 9.936, p = .002. When Community College B was compared to Community College D, again, completing NAS 2 led to lower grades. In this comparison, Exp (B) was 1.941, indicating students without NAS 2 were 1.941 times more likely

to earn a higher grade in Anatomy and Physiology χ^2 (1) = 13.362, $p < .0005$. Biology 101, which is accepted as a prerequisite for Anatomy and Physiology at Community College B, was a significant factor influencing grade for final grade of A in Anatomy and Physiology I and when compared to NAS 2, but only at Community College A.

General Biology was a better predictor of earning a final grade of D or B at Community College A than NAS 2 completion was. This data had an Exp (B) value of 2.113 ,χ^2 (1) = 7.765, $p < .0005$ for the final grade of D, and an Exp (B) of 1.533 ,χ^2 (1) = 6.815, $p = .009$, for final grade of A. At Community College B, taking NAS 2 or General Biology I was not a significant predictor of final grade. Other demographic variables, such as age, and ethnicity were found to be important predictors to the various statistical models produced. Developmental placement was also statistically significant in many comparisons, indicating that prior academic achievement is a significant contributor to success in Anatomy and Physiology I.

NAS 2 as a Prerequisite Course

The first comparison involved the comparison of Community College A data from the 2010-2011 academic year to the 2014-2015 academic year. Interestingly, there were only 52.66% of students who completed the required prerequisite in the 2014-2015 academic year. This indicates that a large number (834) students did not take the course of interest, NAS 2. These data were omitted from analysis, since there was no way of knowing why these students did not take the prerequisite. They may have gotten approval from a counselor to bypass the course, may have completed the challenge exam successfully, or may have had prior coursework that was approved as a substitute for the NAS 2 course. Students who did not take the required prerequisite may have been able to enroll directly in the target course. Since a large proportion of the sample did not take the required prerequisite, and the data available does not indicate why

they did not take the prerequisite, additional data are needed.

When using the pre-prerequisite data as compared to the post-prerequisite data at Community College A, success did increase from the 2010-2011 academic year to the 2014-2015 academic year. The increase in success was from 47.10% of students being successful in 2010-2011 to 51.72% in 2014-2015. The percentages of A grades went from 17.42% of students to 20.80%. But, in the categories of B final grade, percentages went from 16.84% in 2010-2011 to 15.73% in 2014-2015. C grades declined from 12.84% to 11.75%, and D grades declined from 5.71% to 3.34%. Failing grades actually increased from 19.05% to 21.34%, while the percentage of withdrawals decreased from 28.14% to 27.05%. This indicates that success generally increased after the prerequisite was implemented, but because of an increase in final grades of A in Anatomy and Physiology. The increase in the percentage of failing grades is also concerning, since all students in the 2014-2015 post comparison had taken the NAS 2 course.

The statistical findings from the Community College A pre and post-prerequisite data show NAS 2 being significant in the category of withdrawals compared to final grade of D. Surprisingly, not taking the course was associated with a 1.568 times increase in the likelihood of earning a D instead of the W. Based on this, further data on who passed a challenge exam prior to Anatomy and Physiology is needed. It may be that some students went in to Anatomy and Physiology better prepared, even without the required prerequisite course. Further exploration is needed.

Adding the prerequisite course to the curriculum may be responsible for the slight increase in success in the category of A final grades in Anatomy and Physiology at Community College A. It is likely any students who would not have passed Anatomy and Physiology I in the 2014-2015 academic year may not have passed the prerequisite course, NAS 2. If this is the

case, NAS 2 may be eliminating students before they can enroll in Anatomy and Physiology I. NAS 2, then, may be the real "gatekeeper" course at this institution.

The comparison that was performed using the 2014-2015 academic year's data from Community College A further complicates this story. In these data, due to an error in the registration system, some students were able to enroll in Anatomy and Physiology without the required prerequisite course. This served as a natural control group, and when students without NAS 2 were compared to students with the NAS 2 course, students without the prerequisite did as well as students with the prerequisite, and even performed better than students with the prerequisite, earning higher percentages of A and B final grades in Bio 141. These may be the students who were able to pass the challenge examination, but these data were not immediately available for analysis. The statistical analysis of these data indicated that students without NAS 2 were 1.405 times as likely to earn a grade of A in Anatomy and Physiology when compared to students with the NAS 2 course. This indicates that the NAS 2 course is leading to success in Anatomy and Physiology, and is not helping students catch up academically to students who enter Bio 141 directly.

The 2014-2015 data for Community College A was further broken down in to specific demographics of students to explore this issue of students without the prerequisite performing better than students who did complete NAS 2. In the sample of developmentally placed students, the prerequisite course did slightly increase success. In this comparison, 38.16% of students without NAS 2 were successful in the target course, while 39.11% of students with NAS 2 were successful. Final grade was not significantly different for students without and with NAS 2, and was not a significant factor included in the ordinal logistic regression model. Thus, for developmental students, NAS 2 appeared to not have an effect on Anatomy and Physiology

grade.

In college level students, there was a significant difference in final grade in Anatomy and Physiology, again with students who did not complete the prerequisite outperforming the students who had completed it. This indicates that students who did not complete the prerequisite may have had better preparation for the course than NAS 2. It may be that these students were somehow allowed to by-pass the prerequisite, though that is not an advertised policy. It may also be that the prerequisite is not preparing students for the rigors of Anatomy and Physiology, since generally, students without it did as well or better than students with the prerequisite. Students who were able to directly enroll in Anatomy and Physiology may have some other advantage outside of completing a prerequisite.

Age appeared to be an important factor for Community College A students in the 2014-2015 academic year as well. When traditional age students with and without the prerequisite course were compared, students without the prerequisite again performed better than students with the prerequisite. NAS 2 was not a significant factor included in the model for course grade in Anatomy and Physiology for non-traditional students. The difference in final grade for Anatomy and Physiology was statistically significant for traditional students without and with the NAS 2 course.

Another research question explored how the NAS prerequisite course impacted student grades in Anatomy and Physiology at Community College B. In this comparison, data from 2006-2007 academic year was used as pre-prerequisite data, and was compared to student grades from the 2014-2015 academic year. In this comparison, student success actually decreased, though the difference in final grade was not significant. In the 2006-2007 academic year, 54.72% of students were successful in Anatomy and Physiology in 2006-2007 as compared to

44.62% in 2014-2015. This was reflected in grades for Anatomy and Physiology. The percentage of A grades decreased from 28.30% to 15.59%, the percentage of B final grades decreased from 16.35% to 15.59%, while C grades increased from 11.32% to 13.44%, and final grades of D increased from 6.29% to 12.37%. The percentage of students failing Bio 141 also increased from 9.43% to 19.89%. The percentage of withdrawals did decrease from 28.30% to 23.12%.

Based on these data, it appears that the prerequisite has had mixed results at this community college. Statistically, not completing NAS 2 was found to be a significant factor influencing grade in Bio 141, with students without NAS 2 outperforming students with the prerequisite. While it is positive that the percentage of withdrawals declined, and the percentage of Cs increased from the pre to post timeframe, the decline in A and B final grades for Bio 141 is concerning. This may indicate that, based on this snapshot, the NAS 2 course may not be adequately preparing students for Anatomy and Physiology. Additionally, the percentage of failing grades actually increased, which may be due to the fact that the 2006-2007 academic year included a wide range of students, and the 2014-2015 data only includes students who had taken NAS 2. This means that students with some background in college level science were excluded from the post-prerequisite data. Regardless, the NAS 2 course does not appear to be leading to students who are better prepared for Anatomy and Physiology.

Outside community colleges who had similar prior success rates to Community College A and Community College B were also a part of this study. Community College A was compared to Community College C, and data indicate that Community College C had increased success rates from around 50% to 93.75%. Obviously, when compared to Community College A in 2014-2015, the difference in final grade was statistically significant. Not taking the NAS 2

course was a significant factor included in the multinomial logistic model for the categories of F, D, C and B final grades, with very large Exp (B) values. Community College C has likely implemented some other variety of intervention that is successful and has led to greater student success in Anatomy and Physiology.

This was also true for the Community College B to Community College D comparison. With similar success rates for three years prior to NAS 2 implementation, Community College D increased student success in Anatomy and Physiology to 62.76%. When compared to Community College B students with NAS 2, Community College D students were 1.941 times as likely to earn a higher grade in Anatomy and Physiology. Community College D has likely taken a different approach to increasing success in Anatomy and Physiology that is having an impact at their institution.

This study found that the NAS 2 prerequisite appears to have little impact on increasing student success in Anatomy and Physiology I, at least when a pre and post snapshot of student grades are compared. Students without the NAS 2 course are likely to have had some other academic preparation, either in outside courses, or the ability to pass a challenge exam, which appears to be a more important factor influencing student success in Anatomy and Physiology. Outside coursework generally has been found to increase student success. Abele, Penprase, and Ternes (2011), and Sturges & Maurer (2013) both indicate that prior coursework in biology and chemistry can help increase students' grades in Anatomy and Physiology. Harris, Hannum, and Gupta (2004) and McCoy and Pierce (2004) both supported using prerequisites as a way of increasing student success in a target course. This study does not support NAS 2 as a prerequisite, but indicates that some prior preparation may be important.

In assessing the effectiveness of a prerequisite course, it is important to consider that

adding a course to the curriculum may shift the "gatekeeping" function on to the prerequisite. It may be that, as Abou-Sayf and Miari (2007) suggested, only students who successfully complete NAS 2 are able to access the target course. If the latter is the case, NAS 2 may be acting as the new "gatekeeper" course for Anatomy and Physiology. Students who pass NAS 2 are allowed to continue on into Anatomy and Physiology I. Students in the post implementation data who were not prepared to pass Anatomy and Physiology I would likely fail the prerequisite course first.

It is worthwhile to note that adding a pass/fail type course may have a negative impact on student retention and persistence. Adding additional coursework adds time to completion for students, adds cost to their program, and increases the chances that students will withdraw at some point (Abou Sayf & Miari, 2007; Williams, 2013). Though this study did not examine persistence or completion of students, these variables should be examined to help community college leaders determine if prerequisite course leads to other unintended outcomes. This is especially important as institutions look to increase the number of students completing their course of study, and work towards providing local communities with skilled allied health workers.

Age

Expectedly, age turned out to be a significant predictor of grade in Anatomy and Physiology in many of the comparisons. In the first comparison of Community College A in 2010-2011 to 2014-2015, age was found to be a significant factor when a withdrawal was compared to the grades of F, B, or A. In the grade of F category, the Exp (B) statistic was .979, illustrating that the odds of staying in a course and earning a grade of F as opposed to withdrawing were .979 for students who were older χ^2 (1) =2.677, p <.0005. This contrasts what the results were for the B and A categories, with an Exp (B) of 1.016 and 1.051, respectively. In

the A and B category, as age increased, so did chances of earning an A or a B instead of a W, χ^2 (1) = 53.016, $p < .0005$, and χ^2 (1) = 5.231, $p = .022$. Based on these statistics, for Community College A, older students are more likely to earn a final grade of F when compared to withdrawals, but in the A category, older students were more likely to earn an A or B.

When Community College A was compared to Community College C, age was a significant predictor of grade for the category of A χ^2 (1) = 15.279, $p < .0005$. The B statistic in this comparison was 1.049. This indicates that age is a significant factor to consider when exploring what demographic variables are important to student success in biology courses.

At Community College B, age was also found to be a significant predictor of grade in Biology 141. In the ordinal regression, the B statistic was 0.067, with an Exp (B) of 1.065, and a *p* value of less than .0005. This means when students without NAS 2 were compared to students with NAS 2, as age increased, so did the chances of earning the next highest grade. When Community College B was compared to Community College D, Age was significant in the ordinal regression χ^2 (1) = 25.243, $p < .0005$, with an Exp (B) of 1.041.

There is some indication that age was negatively affecting students, with older students more likely to earn a grade of F for some comparisons. This may be that in some respects, non-traditional age students may not have the skills they need to do well, or may face outside demands that hinder their performance, which corresponds to much of the literature (Beauvais et al., 2004; Starck, Love & McPherson, 2008; Stickney, 2008).

In most comparisons, age was positively associated with a grade, often a passing grade. This is largely different than what most of the literature suggests. Age is recognized as a significant factor in retention, especially for allied health students (Shelton, 2012). In this study, age was often corresponding to increased grades. Beauvais et al. (2004), Starck, Love, and

McPherson (2008), and Stickney (2008), all suggested that older students are more at risk for negative course and program outcomes. In mathematics courses it has been reported that non-traditional age students are more likely to succeed in college level mathematics courses, with non-traditional students being 1.36 times as likely to succeed in their college level mathematics course when compared to traditional age students (Wolfle, 2013; Wolfle & Williams, 2014).

This difference in the findings in this study may be related to theories on self-efficacy and motivation. Older students, though they may deal with other responsibilities, may have more belief in their ability to handle the coursework in nursing/allied health programs. Students in these programs may be switching careers, or looking to earn a higher credential in their field, which can serve as a powerful motivator to earn the higher grade. Bandura (1997) and Shelton (2012) both highlight the importance of students feeling that they have the ability to do well.

Additionally, this finding may relate to Tinto's theory of retention (1993). Tinto proposed that students persist when they share goals similar to other individuals. Since Anatomy and Physiology is a course most allied health/nursing students need to continue, students may be forming a supportive environment with each other, which helps them adapt to the culture of their campus and program. If non-traditional students are taking classwork together, a community may form, that may be helping students succeed within this course.

Ethnicity

Ethnicity was a factor in most of the regressions completed. Ethnicities of African American/Black, and Other were significant in many of the comparisons. At Community College A, when pre and post prerequisite data were compared, African American/Black students were less likely to earn the grade of B or A when compared to White students. The Exp (B) on this data was .262 and .548, indicating that these students were .262 and .548 times less

likely to earn the grade of B or A than White students. Ethnicity was significant when Community College A was compared to Community College C, again in the categories of B and A final grades, with African American/Black students being .546 and .280 times less likely to earn a B or A grade than white students.

In the Community College A 2014-2015 data, ethnicity was significant for D, B, and A grades. The ethnicity of Other here was associated with a .277 decrease in earning a final grade of D for Anatomy and Physiology. The ethnicity of African American/Black was significant, associated with a .498 and .234 decrease in the likelihood of earning a final grade of B or A.

At Community College B, ethnicity seemed to be less of a factor, likely due to the homogeneity of the student population. In the pre post prerequisite comparison, ethnicity was not a significant factor. When Community College B was compared to Community College D, the ethnicity of Other was a significant factor when compared to White students. Here, minority students were .024 times more likely to earn a lower grade than White students.

Minority students may face additional challenges in college level science courses, and the differences between White and minority student groups abounded in many of the models generated. African American/Black students were less likely to earn the higher grades than White students, and, in some comparisons, students who identified as Other were less likely to earn a lower grade in Anatomy and Physiology. In the literature, studies abound that find an achievement gap between White and minority students. Wolfle (2012) found that in mathematics courses, White students were as much as 1.29 times as likely to do well in college level courses than minority students. This study suggests smaller relationships, but illustrates the significance of ethnicity with regard to science courses such as Anatomy and Physiology. Within allied health and nursing programs, race has been shown to be a significant factor for student

success, with minority groups being less likely to complete a program (Starck, Love, & McPherson, 2008; Stickney, 2008).

Developmental Placement

In the majority of research questions, developmental placement was negatively associated with grade for the categories of final grade of C, B, and A, or what is defined as success, and was found to be a significant factor in ordinal regressions as well. Therefore, students who did not place in to college level Math and English were .207-.579 times as likely to do poorly in Anatomy and Physiology I. In the last set of comparisons, developmental placement was separated into two regressions: one for students in developmental Math and/or English, and students who were college ready when they started. For students who were placed into developmental courses, ethnicity and age were the significant factors in the model. College level students had gender, ethnicity, and the NAS 2 course as significant variables in the regression model. This illustrates the difference between the two groups: the prerequisite course may be a difference among college level students: some that have a background necessary to do well in Anatomy and Physiology, and those that do not. NAS 2 was not a significant variable for the students who were placed into developmental courses.

This finding is interesting in relation to what other studies have found. It is often suggested that students who require additional coursework prior to a target course often do not complete the target course, and that graduation rates are typically lower for developmental students (Amos, 2011; Yates, 2010). In mathematics courses, some studies report that students who had completed developmental mathematics courses perform as well as students who came into college ready for college level mathematics courses (Bahr, 2008; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). Passing college level Math and English courses has been found to be

important for completion of a certificate or degree in community colleges (Roksa et al. 2009).

This may or may not be the case in with a developmental type prerequisite in the sciences. It may be that students are enrolling in the Anatomy and Physiology course without completing their recommended developmental coursework in English and/or Math. If they are coming into this course without those skills, they may not fare as well. Community colleges may also implement college level English or Math as a necessary prerequisite to Anatomy and Physiology. Students should be college level before attempting Anatomy and Physiology.

General Biology as a Prerequisite

This is indication that General Biology might also work as a prerequisite type course for college level Anatomy and Physiology courses. At Community College A, 46.94% of General Biology students were successful in Anatomy and Physiology, compared with 59.61% of NAS 2 students. Having just General Biology was a significant predictor in the model for these data for the categories of W to D (Exp(B)=2.113, p = .005), and W to B (Exp(B) = 1.533, p = .009). At Community College B, 64% of General Biology students were successful in Anatomy and Physiology, while 48.37% of students were successful with the NAS 2 course. Though General Biology was not a significant predictor in the resulting model, success rates were higher.

There may be a few reasons for the differences between General Biology and NAS 2 in regard to the success rates in Anatomy and Physiology. At Community College A and B, General Biology is a 16-week lab course. Taking a full semester science course with a lab may be what is important for preparing students for the rigors of Anatomy and Physiology. This agrees with the Sturges and Maurer (2013) study, which suggested that previous coursework in chemistry and biology are correlated with student success in Anatomy and Physiology. In some respects, it may not matter what previous science a student has in college, just that they have

completed some college level science coursework before attempting to complete Anatomy and Physiology.

Unexpected Findings

One of the unexpected findings of this study was that the two comparison colleges, Community College C and Community College D had both increased their success rates during the timeframe that the prerequisite course was added at Community Colleges A and B. These colleges increased their success rate without adding an additional course to the curriculum of students. These two colleges obviously took other steps to help ensure student success in Anatomy and Physiology. They may have looked at the course content, and added more active learning or hands on activities. They may have increased the use of technology within the course. It is difficult to say, but both have had improvement in success rates to roughly 93% and 62% success.

Based on this, there is indication that conversations among biology faculty at the various community colleges are important. If colleges share data on how various interventions helped with student success in Anatomy and Physiology, institutions may be able to implement interventions that have been effective for other allied health students at other community colleges. Sharing this information should allow other colleges and universities to work together to understand what support is needed to increase success in Anatomy and Physiology.

The evaluation of the NAS 2 prerequisite at Community College A and Community College B was interesting. At Community College A, data indicates that the prerequisite has helped to improve success from pre implementation to post implementation. At Community College B, success rates actually decreased from around 55% to around 44%. At this college, the 16 week NAS 2 course may be less effective.

Community College A also had a very unexpected finding. In the 2014-2015 data set, a large number of students were identified that had not taken the required prerequisite and had not taken General Biology, which was also an accepted prerequisite that academic year. It is unlikely that such a large number of students successfully passed the challenge exam, and findings at this college are a result of an anomaly in the college's online registration system. Students were allowed to enroll in the target course without the required prerequisite. When the whole data set was considered, students without the prerequisite did as well or better than students who had completed it. When this dataset was compared across several characteristics, NAS 2 turned out to only be a significant predictor of grade in Anatomy and Physiology for traditional students, and was positive for students without the prerequisite performing better than students with NAS 2. It also was a predictor for students who were college level when the entered the VCCS, but again in a negative way. Students without NAS 2 did better in Anatomy and Physiology than students with NAS 2.

This is an interesting finding because it captures that the prerequisite may not be helpful for students, especially for traditional age, college level students. In the literature, a study by Abele, Penprase, and Ternes (2011) suggested that introductory biology, chemistry, or even psychology courses are necessary to ensure students success in nursing programs. Another study by Sturges and Maurer (2013) found that prior science coursework is important for success in Anatomy and Physiology. This does not seem to be the case with NAS 2. This course does not appear to prepare students for the academic rigors of Anatomy and Physiology.

Further, this study indicates that the prerequisite course did not make a difference for traditional age, college level students. This indicates a need to address specific target groups of students. Maybe some other content, or other format of the class would be beneficial to the non-

traditional, or developmentally placed students. Perhaps a longer course, or a course for non-traditional age students would better serve these students.

Implications for Practitioners

The implications this study has for community college and higher education in general, centers around the need for community colleges and other institutions of higher education to consider their individual student populations, develop their own interventions to help student success in Anatomy and Physiology, and to evaluate those data on success in Anatomy and Physiology. There is also the broader need for institutions to collaborate and discuss interventions that have been helped increase success and completion of students in the allied health fields.

Community colleges, along with other higher education institutions, should carefully consider their individual student populations that are struggling in Anatomy and Physiology. This study illuminated the fact that demographics do matter for success in Anatomy and Physiology. Most notably, gaps were evident in students who are developmentally placed into college level Math and/or English. These students did not fare as well as students who were college level in most of the comparisons that were completed. This achievement gap also spanned ethnicity, and in some cases, age. Regardless of the differences, it is evident that institutions need to consider that these demographic factors influence success within science, and allied health programs.

Along with considering the populations of students the college serves, institutions should evaluate the data they have on success in Anatomy and Physiology. In this study, it was obvious that the four community colleges included had different strategies to deal with success in Anatomy and Physiology, and each had varying success at increasing success in the target

course. It is important for institutions to examine what impact an intervention is having in order to modify the intervention to ensure that it is having the greatest impact on students and attainment.

Since Anatomy and Physiology is a gatekeeper course, focusing on ways to improve student success in the course has a direct relationship to the number of allied health students who complete their program. Institutions and faculty may consider trying different types of interventions to determine which is most successful for their students. There is a need for collaboration within the higher education field of biological sciences for educators to share what they know about success in Anatomy and Physiology. In this study, it was evident that the outside colleges must have implemented some other non-curricular intervention that did increase success rates in Anatomy and Physiology. If practitioners shared this information, colleges could make more informed decisions regarding which interventions are likely to best serve students at their institutions.

Also, prerequisite courses may not all be the same. This study showed that General Biology may work well as a prerequisite for Anatomy and Physiology. This course is a three credit, 16-week course. Some students may prefer to take a course for credit, rather than a developmental type prerequisite course. This may also be the preference for veteran students, since they cannot use GI Bill money to pay for developmental credits. On the other hand, some students may prefer an 8-week course, and may only want to pay for two credits.

If prerequisites are added to programs, students may face financial issues in paying for additional credits, and may take more time to complete their degree, increasing the chance that they do not finish. In many cases, students who are academically prepared may not need to take a prerequisite course before Anatomy and Physiology.

Additionally, this study highlighted the importance of academic preparation prior to attempting a college level science, such as Anatomy and Physiology. Students who were initially placed in developmental classes did not fare as well as college level students in Anatomy and Physiology. Students are required to be college level prior to taking the target course, but deficiencies obviously exist. These students need some outside support or prior preparation to ensure that they are successful in allied health programs as well.

Collaboration among the VCCS's colleges is important. Individual institutions are each implementing interventions, and redesigning curricula to try to increase student success and work towards increasing the number of graduates of allied health and other programs. Sharing information about strategies that were effective, and strategies that were not effective, should help other colleges make decisions about what types of changes can benefit their students. With performance based funding on the horizon, all institutions are looking at ways to better serve students. Community colleges especially have an interest in meeting the need for healthcare workers in the local communities. This study suggests that prerequisites may or may not increase success in Anatomy and Physiology, but indicates that the institutions utilized in this study are each attempting to serve these students in a more effective way. Institutions can implement changes that help improve student success in Anatomy and Physiology.

Recommendations for Future Study

This study is a fundamental part of evaluating pathways to success in Anatomy and Physiology, but it is just a start. The goal of this study was to determine if a prerequisite course was a significant predictor of student grade in Anatomy and Physiology, and it was, but not in all comparisons. With this information, one of the next steps is to look at if the prerequisite was effective for various student populations. For example, developmental students could be

compared in each research question to determine if developmental placement is a stronger predictor. This should be completed for several demographic variables, including financial aid status and other science coursework. Although data were not available for Pell eligibility, obviously a direct measure of socioeconomic status would be an important indicator. How far in the program a student was when they took these courses and veteran status are two other variables that should be included in these models.

Admittedly, this study featured comparisons of two snapshots in time. Longitudinal data on students with and without the prerequisite would reveal more information on these pathways to success. The prerequisite is still new at Community College A, so the impact may not fully be obvious. Community College B may have had other years where the prerequisite's impact is clearer. A longer study would be useful in completing a more comprehensive assessment of pathways to success in Anatomy and Physiology. Completion data would also be an important part of a longer study.

More data are generally needed to expand upon this study. Data on student preparation before Anatomy and Physiology is vital, since NAS 2 completion was associated in a negative way for Anatomy and Physiology success. It may be that students who take Anatomy and Physiology without the necessary prerequisite have outside coursework or preparation, as deemed appropriate by college counselors. At Community College A and B, they may have had to study or review content prior to completing a challenge exam for the NAS 2 course. Regardless, there are other variables that may be stronger predictors of student success in Anatomy and Physiology.

There is also a need for qualitative data in addition to the quantitative data presented in this study. Interviewing students who withdrew or failed Anatomy and Physiology may reveal

trends in why students are not successful in Anatomy and Physiology. Interviewing students who were successful may indicate what student characteristics and support help students complete the difficult course. Faculty may also have some insight on what barriers students face, both personally and academically.

Finally, this study cannot assert causation, since it did not feature random assignment and selection. A true experiment regarding these prerequisites would be useful in determining if the prerequisite is the cause. Matching students into a control and experimental group based on demographic variables would strengthen the quantitative discussion on the effectiveness of a prerequisite course to Anatomy and Physiology.

Concluding Remarks

The purpose of this study was to assess four pathways to Anatomy and Physiology at two VCCS institutions, Community College A and Community College B, to determine which pathway leads to the greatest percentage of successful students. The research succeeded in this goal. The findings on the effectiveness of implementing a prerequisite, or using General Biology as a prerequisite to Anatomy and Physiology, indicated that a prerequisite, such as General Biology, may be a useful intervention to increase student success, but it may not work for all student groups, and the course that is implemented as a prerequisite may be important. This study did not find any indication that the NAS 2 course itself is successful at producing Anatomy and Physiology ready students. Developmental students may struggle in Anatomy and Physiology, especially younger students in developmental courses. This study adds to the body of literature on prerequisite courses, but also to the body of literature on allied health education, and college science education. This study may influence institution's decisions on implementing prerequisites for science courses with high failure rates, such as Anatomy and Physiology. This

information is valuable not only to the VCCS, but also to all institutions of higher education where Anatomy and Physiology is a problematic course for students. This study was the first to evaluate whether a prerequisite course was predictive of success in Anatomy and Physiology, and contributes to the body of literature on what demographic variables are important for student success in the sciences. This study also indicates that there may not be a large difference between the genders and success in Anatomy and Physiology.

This emerging research investigated demographic variables, and different prerequisite courses that influence student success in Anatomy and Physiology. More research is needed to explore this concept fully. Qualitative research, in addition to the inclusion of several other demographic variables would add more information to the understanding of prerequisites in Anatomy and Physiology. The study offers several suggestions on how this research could be expanded upon to strengthen academia's understanding of prerequisites in the college sciences.

Community colleges are responding to the mounting pressure to increase the number of graduates. Along with this pressure is the fundamental mission of a community college: to serve the local community. Since local communities face shortages of healthcare workers throughout the United States, and throughout the world, community colleges are examining ways they can meet both of these demands. Anatomy and Physiology is a difficult course that many students do not pass. Student demographics play a large role in determining whether a student is likely to succeed in Anatomy and Physiology. Though this study does not provide much evidence that NAS 2 succeeds at preparing students for the rigors of Anatomy and Physiology, a prerequisite course, such as General Biology, may help increase student success in Anatomy and Physiology for particular groups of students at certain institutions, but may not have a large impact at others.

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Education

Ph.D. Community College Leadership, ***Old Dominion University,*** 2016
M.S. Biology, ***Old Dominion University,*** 2010
B.S. Biology, ***Niagara University,*** 2006

Professional Experience

2011-present	Assistant Professor, Biology, Tidewater Community College, Portsmouth, VA
2008-2011	Education Specialist, Nauticus, National Maritime Museum, Norfolk, VA
2006-2008	Graduate Teaching Assistant, Old Dominion University, Norfolk, VA

Presentations

"Eliminating Statistics Phobia: Using Statistics for Hypothesis Testing in General Biology II and Environmental Science II." Tidewater Community College Faculty Professional Development Day, Norfolk, VA, August 2016.

"Removing Excess and Increasing Alignment with OER in General Biology 102." Tidewater Community College Learning Institute, Portsmouth, VA, May 2016, and VCCS OER Peer Group Meeting, Midlothian, VA, April, 2016.

"Dolphin Morbillivirus: A Case Study in Investigative Science." Science Case Net Conference, University of Delaware, Newark, DE, June 2014.

Recent Awards

Professional Development Award for Scholarly and Creative Engagement, Tidewater Community College, 2015
Old Dominion University Community College Leadership Fellowship, Old Dominion University, 2014
Science Case Net Fellow, Science Case Network, 2014
Climate Stewards Grant for Climate Change Education, NOAA, 2012

Professional Affiliations

ABLE (Association for Biology Laboratory Education)
NABT (National Association of Biology Teachers)