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Pathways to Success in Anatomy and Physiology at the Community College: The Role of Prerequisite Courses

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Gatekeeper courses such as Anatomy and Physiology are often referenced in discussions regarding the national shortage of persons in allied health professions. In an attempt to bolster access to STEM professions, some community colleges are mandating prerequisite courses such as Natural Sciences and/or General Biology for STEM gatekeeping courses. In this study, we examined which of these prerequisite courses helped students to pass Anatomy and Physiology and whether the courses are an additional barrier to STEM field completion. This was the first study to evaluate whether a prerequisite course was predictive of success in Anatomy and Physiology, and it contributes to the body of literature regarding student success in the sciences.

Coursework in Anatomy and Physiology is a common requirement for nursing and other allied health programs (Harris, Hannum, & Gupta, 2004). Often called a gatekeeper course, Anatomy and Physiology is front and center of a national debate about how to remedy a serious allied health professional shortage. The United States is experiencing a severe shortage of nurses and other kinds of workers who require allied health degrees (American Association of Colleges of Nursing [AACN], 2014). This unmet national demand for nurses and healthcare professionals is exacerbated because a significant number of students in healthcare programs at community colleges and universities exit the pipeline by failing gatekeeper courses such as Anatomy and Physiology (Hamshire, Willgoss & Wibberley, 2013). The study presented in this article examines prerequisite course pathways to Anatomy and Physiology at community colleges.

Literature Review

The demand for healthcare workers is increasing nationwide. Higher education is responding by examining various interventions designed

to increase completion (Abele, Penprase, & Ternes, 2011). Within the healthcare field, the National League for Nursing Accrediting Commission recommends that nursing programs have an attrition rate of 20% or lower (Brown & Marshall, 2008). 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 & Moore, 2009). Anatomy and Physiology is often identified as a gatekeeper course for students, since it has a high withdrawal and failure rates (Hopper, 2011). With a success rate (a final grade of C or better) of around 50%, many institutions are exploring innovative ways of increasing student success within Anatomy and Physiology. One such innovation involves changes in course prerequisites for Anatomy and Physiology.

Nursing Preparation and Retention. 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 and other countries around the world, there is a shortage of nurses (Occupational Outlook Handbook, 2018). 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, community colleges are attempting to identify support interventions that are most successful for nursing students and which help to attract more nursing students (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). Further, nursing student attrition has been identified as a major contributor to the nursing shortage (McLaughlin et al., 2010).

Findings from studies on prerequisites in general are mixed. Some studies have found prerequisites to be effective (Harris, Hannum, & Gupta, 2004; McCoy & Pierce, 2004), while others report no impact, or even negative effects of requiring students to complete a prerequisite course (Abou-Sayf, 2008). Nevertheless, research on prerequisites in biology courses such as Anatomy and Physiology has been limited (Harris, Hannum, & Gupta, 2004; Stickney, 2008). Few studies have focused on prerequisites in Anatomy and Physiology, and most research has utilized qualitative methods (Sturges & Maurer, 2013). It is important to evaluate

these prerequisite courses to ensure the required curriculum is preparing students for the rigors of Anatomy and Physiology.

Purpose of Study

The purpose of this study was to assess pathways to Anatomy and Physiology at community colleges that include and do not include prerequisite courses. Specifically, this study investigated whether prerequisite Natural Science or General Biology courses were correlated with student success (passing grade) in Anatomy and Physiology when compared with students who do not complete prerequisite courses. We hypothesized that students who take prerequisite courses will perform better in Anatomy and Physiology than students who do not. In part, we expect this because students have greater exposure to the material but also because the prerequisite courses become the new gatekeeping mechanism.

Methods

For this study, we concentrated on students who took Anatomy and Physiology at two community colleges in the same state in the southeastern United States. Within that community college system, two colleges 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. Using a quantitative, quasi-experimental design, we made several comparisons. First, we compared a control group (no prerequisite) to a treatment group (prerequisite). We then examined differences in the type of prerequisite by comparing students who took General Biology (GenBio) to students who took a specially designed prerequisite Natural Sciences course (NAS).

The two colleges were selected for this study because they offered the exact same Anatomy and Physiology (A&P) course and General Biology (GenBio) and implemented a Natural Sciences (NAS) course as a prerequisite. The NAS course was designed specifically to act as an A&P prerequisite and covered the scientific method, characteristics of life, basic chemistry, cell energy, enzymes and transport, cell reproduction, DNA structure and transcription and translation, medical and anatomical terminology, and homeostatic control of the body. The NAS dosage, however, differed at the two institutions. At Community College A, NAS was offered as a two-credit, eight-week course, but Community College B offered NAS as a three-credit, 16-week course. Since the community colleges were different sizes and were located in very different service

regions, comparisons were made within each institution. Students who enrolled in Anatomy and Physiology before the prerequisites were implemented were compared to students at the same schools who enrolled in A&P after the prerequisites were implemented. Using ex post facto data, we made the following comparisons:

1. Community College A: No Prereq compared to NAS 8-week
2. Community College B: No Prereq compared to NAS 16-week
3. Community College A: GenBio compared to NAS 8-week
4. Community College B: GenBio compared to NAS 16-week

For each comparison, we control for age (continuous), gender (M, F), ethnicity, and college-level placement in English/Math (Yes, No). 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.

Results

We first tested if having no prerequisite was equally effective as having a Natural Science course for passing Anatomy and Physiology. For each college, data for 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. Each of these descriptors was used as independent variables, although the 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.

Table 1. Descriptors for Community Colleges A and B Pre- and Post-Prerequisite Implementation

		Community College A	Community College A	Community College B	Community College B
		2010/2011	2014/2015	2006/2007	2014/2015
Descriptor		N = 2399	N = 1762	N = 190	N = 394
Age	Mean Age	27	26	27	26
	Traditional	40.27	41.09	42.63	44.16
	Nontraditional	59.73	58.91	57.37	55.84
	Age Range	16-60	17-62	16-59	16-52
Gender	Male	16.97	17.20	20.53	21.32
	Female	83.03	82.80	79.47	78.68
Ethnicity	White	55.61	52.50	79.47	69.80
	Black	32.35	28.21	13.68	13.71
	Other	12.05	19.30	6.84	16.50
Developmental Placement*	Development in English and/or Math	60.19	28.89	59.47	21.32
	College-Level English and Math	39.81	71.11	40.53	78.68
NAS 2**	No NAS 2	100.00	47.33	83.68	52.79
	NAS 2	0.00	52.67	16.32	47.21
General Biology	No Bio 101	80.95	82.29	86.32	93.40
	Bio 101	19.05	17.71	13.68	6.60
Success in Anatomy and Physiology	Successful (C or Better)	47.10	52.50	57.89	58.63
	Unsuccessful (W, F, or D)	52.90	47.50	42.11	41.37
	Withdrawal	28.14	24.01	25.26	18.53
Grade in Bio 141	F	19.05	20.37	10.00	13.20
	D	5.71	3.12	6.84	9.64
	C	12.84	12.15	12.63	11.93
	B	16.84	17.71	16.32	15.74
	A	17.42	22.64	28.95	30.96

* Placement tests changed during this time frame 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 into 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.

Table 2. 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	Percentage of Students College A Post-Implementation
		2010-2011 N = 2399	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

Table 3. Statistically Significant Results, Community College A Pre- and Post-Prerequisite as Indicated by Multinomial Regression When Withdrawals are Compared to Course Grades in Anatomy and Physiology

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 (Black)	-.653	.184	12.579	1	.005	.521	.363, .747
W to B	Age	.016	.007	5.231		.022	1.016	1.002, 1.030
	Developmental Placement	-.684	.113	36.796	1	.000	.505	.405, .629
	Ethnicity (Black)	-.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)	-1.341	.192	48.629	1	.000	.262	.179, .381
	General Biology (Bio 101)	-.365	.159	5.280	1	.022	.694	.509, .948

Table 4. 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	Percentage of Students College B Post-Implementation
		2006-2007	2014-2015
		N = 159	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

Table 5. Statistically Significant Results, Community College B Pre- and Post-Implementation as Indicated by Multinomial Logistic Regression When Withdrawals Are Compared to Course Grades in Anatomy and Physiology

Comparison	Factor	B	SE	Wald	Df	Sig	Exp (B)	95% CI for Exp (B)
W to F	NAS 2	-1.118	.400	7.789	1	.005	.327	.149, .717
W to B	Age	.054	.022	6.335	1	.012	1.056	1.012, 1.101
	Developmental Placement	-1.059	.380	7.775	1	.005	.347	.165, .739
W to A	Age	.105	.021	23.998	1	.000	1.111	1.062, 1.159,
	Developmental Placement	-2.029	.421	214.216	1	.000	.131	.059, .298
	Ethnicity (White)	18.353	.551	1110.435	1	.000	1.07E ⁻⁸	3.63E ⁻⁹ , 3.15E ⁻⁸
	NAS 2	.906	.382	5.635	1	.018	2.474	1.171, 5.225

The major findings focused on the analyses of the prerequisite course. Several data sets showed a negative relationship between having completed the prerequisite course and higher grades in Anatomy and Physiology. At Community College A, for example, when pre-implementation data were compared to post-implementation data, completing the NAS 2 course was a significant contributor to the final grade in Anatomy and Physiology. General Biology was a better predictor of earning a final grade of D or B at Community College A than was NAS 2 completion. The 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. Grades of A went from 17.42% of students to 20.80%, grades of B went from 16.84% to 15.73%, and grades of C 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 presented in Table 2.

A second comparison was done to rotate the ethnicity of Black for the category of “Other.” The model generated using multinomial logistic fit data significantly better than the intercept-only model $\chi^2(35) = 457.041, p < .0005$. The resulting model had a Nagelkerke pseudo R^2 value of .133, explaining around 13.3% of variation.

The analysis continued with the comparison of Community College A data from the 2010–2011 academic year to the 2014–2015 academic year. This comparison is interesting because only 52% of students completed the required prerequisite in the 2014–2015 academic year. This indicates a large number of students—834—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. These students may have received approval from a counselor to bypass the course, may have successfully completed the challenge exam, or may have had prior coursework approved as a substitute for NAS 2. Students who did not take the required prerequisite may have enrolled directly in the target course.

The findings from the Community College A pre- and post-prerequisite data show NAS 2 to be significant in the category of withdrawals compared to final grade of D. Surprisingly, as indicated in Table 3, not taking the course was associated with a 1.56 times increase in the likelihood of earning a D instead of the W. 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 that 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 would be eliminating students before they were allowed to enroll in Anatomy and Physiology I. Therefore, NAS 2 becomes the actual “gatekeeper” course.

The comparison performed using the 2014–2015 academic year’s data from Community College A provides an interesting analysis challenge. As mentioned, 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 or 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 available for analysis. The statistical analysis of these data indicated students without NAS 2 were 1.41 times as likely to earn a grade of A in Anatomy and Physiology when compared to students with the NAS 2 course. This indicates the NAS 2 course is not helping students catch up academically to students who entered Bio 141 directly.

The 2014–2015 data for Community College A were further broken down to specific demographics of students to explore the 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. The 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. For developmental students, NAS 2 appeared to not have an effect on Anatomy and Physiology grades.

In college-level students, there was a significant difference in final grades 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. These students were somehow allowed to bypass the prerequisite, although that is not allowed according to college policy. The prerequisite may not be preparing

students for the rigors of Anatomy and Physiology, since students without it did as well or better than students with the prerequisite.

Age appeared to be an important factor for students at Community College A in the 2014–2015 academic year as well. When traditional-college 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 the course grade in Anatomy and Physiology for nontraditional students. The difference in the final grade for Anatomy and Physiology was statistically significant for traditional students without and with the NAS 2 course.

This study also explored how the NAS prerequisite course impacted student grades in Anatomy and Physiology at Community College B. In this comparison, data from the 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 the 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. As indicated in Table 4, 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 decreased from 28.30% to 23.12%.

As indicated in Table 5, 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, $\chi^2(24) = 38.30, p = .052$. The resulting model was a good fit to the observed data: $\chi^2(6) = 79.124, p < .0005$. A pseudo R^2 Nagelkerke was .211. 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: $\chi^2(1) = 9.936, p = 0.002$. 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: $\chi^2(1) = 30.065, p < .005$. Age

was also a significant factor, with a positive increase of 1.065 more likely to be successful in NAS 2: CI (.044, .90), $\chi^2 (1) = 33.367, p < .005$.

Based on these data, it appears the prerequisite had mixed results at this community college. Statistically, not completing NAS 2 was found to be a significant factor influencing the grade in Bio 141, but only for students withdrawing instead of earning an F. Generally, students without NAS 2 outperformed students with the prerequisite. Although it is positive that the percentage of withdrawals declined, and the percentage of C grades increased from the pre to post time frame, 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 because the 2006–2007 academic year included a wide range of students, and the 2014–2015 data only included students who had taken NAS 2. This means students with some background in college-level science were excluded from the post-prerequisite data. The NAS 2 course does not appear to be better preparing students for Anatomy and Physiology.

Discussion

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, perhaps in other courses or the ability to pass a challenge exam, which appears to be a more important factor influencing student success in Anatomy and Physiology. Previous research indicated outside coursework can increase student success: Abele, Penprase, and Ternes (2011), and Sturges and Maurer (2013) found 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) 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 onto the prerequisite. It may be, 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.

Age. Age turned out to be a significant predictor of grade in Anatomy and Physiology in many of the comparisons. There is some indication 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, nontraditional-age students may face outside demands that hinder their performance, as indicated in Starck, Love, and McPherson (2008), and Stickney (2008).

In most comparisons, age was positively associated with a grade, often a passing grade. This contradicts 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 often corresponded to increased grades. Starck, Love, and McPherson (2008), and Stickney (2008) suggested older students are more at risk for negative course and program outcomes. In math it has been reported that nontraditional-age students are more likely to succeed in college-level mathematics courses; nontraditional-age students are 1.36 times as likely to succeed in their college-level math course when compared to traditional-age students (Wolfle & Williams, 2014). The difference in the findings in the current study may be related to theories on self-efficacy. Older students, though they may deal with other life-related 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 adding a higher credential in their field, which can serve as a powerful motivator to earn the higher grade.

Ethnicity. Ethnicity was a factor in most of the regressions completed. At Community College A, when pre- and post-prerequisite data were compared, 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.

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 generated models. Students of color were less likely to earn higher grades than White students. There are many examples with the literature that point to an achievement gap between White and minority students. Specifically, Wolfle and Williams (2014) found this in mathematics courses: White students were as much as 1.29 times more likely to do well in college-level courses than minority

students. The current study suggests a similar but smaller relationship in Anatomy and Physiology courses.

Developmental Placement. In the last set of comparisons, developmental placement was separated into two regressions: 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 finding is interesting in relation to what other studies have found. It is possible that students who require additional coursework prior to a target course may not complete the target course, and graduation rates are typically lower for developmental students (Amos, 2011). 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 (Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). Passing college-level math and English courses has been found to be important for the completion of many credentials or a degree at the community college (Roksa et al., 2009). It may be that students are enrolling in the Anatomy and Physiology course without completing their recommended developmental coursework. If they are coming into the A&P course without those basic skills, they are much more likely to not fare as well. Students should be at college-level in math and English before attempting Anatomy and Physiology.

General Biology as a Prerequisite. There is indication that General Biology might also work as a prerequisite course for Anatomy and Physiology. 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 concerning 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 confirms the findings of Sturges and Maurer (2013), who suggested previous coursework in chemistry and biology are correlated with student success in Anatomy and Physiology.

Unexpected Findings. In the 2014–2015 data set, 834 students were identified who had not taken the required prerequisite or 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. 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 data set was compared across several characteristics, NAS 2 turned out to only be a significant predictor of grade in Anatomy and Physiology for traditional students.

NAS 2 also was a predictor, in a negative way, for students who were college-ready when they entered college. Students without NAS 2 did better in Anatomy and Physiology than students with NAS 2. This is an interesting finding because it clearly indicates the prerequisite may not be helpful for students, especially for traditional-age, college-level students. A study by Abele, Penprase, and Ternes (2011) suggested that introductory biology, chemistry, or even psychology courses are necessary to ensure student success in nursing programs. Another study by Sturges and Maurer (2013) found prior science coursework is important for success in Anatomy and Physiology. This does not appear to be the case for NAS 2 because the findings of the current study indicate it does not prepare students for the rigor of Anatomy and Physiology.

Implications for Practitioners

The implications of this study for community college leaders center around the need for community colleges and other institutions of higher education to consider their individual student populations, develop their own customized interventions to advance student success in Anatomy and Physiology, and to pay closer attention to data on success in Anatomy and Physiology. There is also the broader need for institutions to collaborate and discuss interventions that have 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. This achievement gap also spanned ethnicity and age. Regardless of the differences, it is evident institutions need to consider how 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 the participating community colleges had different strategies to deal with success in Anatomy and Physiology, and each had varying success at increasing success in the target course. 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. Since the prerequisites examined in this study were not consistently effective, community colleges may try different types of interventions to determine which is most successful for their students. In this regard, there is a need for collaboration within the field of biological sciences to encourage educators to share what they know about success in Anatomy and Physiology. In this study, it was evident 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, college leaders could make more informed decisions regarding which interventions are likely to best serve students at their institutions.

Also, prerequisite courses are not all the same. This study showed that General Biology, a three-credit, 16-week course, may work well as a prerequisite for Anatomy and Physiology. Some students may prefer to take a course for credit, rather than a developmental type prerequisite course. This may also be the preference for students who are veterans since they cannot use GI Bill money to pay for developmental credits. On the other hand, some students may prefer an eight-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 they will not finish. In many cases, even students who are underprepared academically 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 well in Anatomy and Physiology. Students are required to be college-level prior to taking the target course, but exceptions obviously exist. These students need academic support to ensure they are successful in allied health programs.

Collaboration among colleges is important. Individual institutions are each implementing interventions and redesigning curricula to increase student success and work toward 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, institutions are looking at ways to better serve students and to meet success metrics. Community colleges, in particular, have an interest in meeting the need for healthcare workers in the local communities. This study suggests prerequisites may or may not increase success in Anatomy and Physiology, but it also indicates the institutions in this study are each attempting to increase student success in this important course.

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 students' grades in Anatomy and Physiology; it was, but not in all comparisons. With this information, one of the next steps is to examine whether the prerequisite was effective for a variety of student populations. Additionally, longitudinal data on students with and without the prerequisite would reveal more information on pathways to success. A longer study would help to develop a more comprehensive assessment of pathways to success, and it could include completion data in the evaluation.

There is also a need for qualitative data from students who withdrew or failed in Anatomy and Physiology. Interviews with students may reveal trends in why they are not successful in Anatomy and Physiology, while interviewing students who were successful may indicate which support helped students complete this difficult course.

Conclusion

This study adds not only to the body of literature on prerequisite courses, but also to the body of literature on allied health education and post-secondary science education. This study may influence institutional decisions on implementing prerequisites for science courses with high failure rates, such as Anatomy and Physiology. This information is valuable for leaders of all institutions of higher education where Anatomy and Physiology is a challenging course for students. This study was the first to evaluate whether a prerequisite course was predictive of success in Anatomy and Physiology, and it contributes to the body of literature on demographic variables that are important for student success in the sciences. This study indicates there may not be a large difference between the genders and success in Anatomy and Physiology.

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 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, and prerequisite courses play a role in determining whether a student is likely to succeed in Anatomy and Physiology. Although this study does not provide weighty evidence that NAS 2 succeeds at preparing students for the rigors of Anatomy and Physiology, a prerequisite course, such as General Biology, may increase student success in Anatomy and Physiology.

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