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

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INTRODUCTION

Within United States higher education more than 6.7 million college and university students participated in at least one online course in Fall 2011 (Allen & Seaman, 2013). More specifically, distance learning course enrollment in community colleges increased nine percent between 2009 and 2010, and 81% of community colleges offered at least one online degree (Instructional Technology Council, 2011). The recent increase in this educational form at community colleges is due to several factors. First, online technology

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

Although community colleges face an increased demand for online courses, laboratory based science courses were deemed poorly suited for distance learning (Bradley, 2007; Instructional Technology Council, 2011). However, these studies did not fully explain the reasons why science courses were not fitting of the online environment. A number of publications discuss online biology offerings at four-year institutions (Gilban, 2006; Swan & O'Donnell, 2009; Toth, Morrow, Ludvico, 2008). The few previous studies in the specific area of community college online biology courses, however, were small scale and conducted at single institutions (Johnson, 2002; Lunsford & Bolton, 2006). Although the literature points to the effectiveness of online biology courses within higher education, more research is needed. In order to learn more about

student success within online biology courses, research must be conducted with a larger population across multiple institutions over several semesters.

PURPOSE OF STUDY

The purpose of this study was to investigate the success of Virginia Community College System (VCCS) non-science major students in BIO 102 on campus by comparing students who completed BIO 101 online to students who completed BIO 101 on campus. If online introductory biology courses are an effective alternative to on campus biology courses, community college students who pass BIO 101, the first semester of introductory biology, should be equally successful in BIO 102 on campus, the second semester of introductory biology, independent of previous instruction mode.

RESEARCH QUESTIONS

This study was guided by the following research questions:

1. How will the mode of instruction in BIO 101 be predictive of student success in BIO 102 on campus for VCCS non-science major students?
2. What are the demographic characteristics of VCCS non-science major students who completed BIO 101 online and BIO 102 on campus? The demographic characteristics examined include age, gender, ethnicity, prior online course experience, and enrollment status during the semester of BIO 101.
3. What are the demographic characteristics of VCCS non-science major students who completed both BIO 101 and BIO 102 on campus? The demographic characteristics examined include age, gender, ethnicity, prior online course experience, and enrollment status during the semester of BIO 101.

METHODOLOGY

This study employed a quantitative design using ex post facto data. Data were obtained from the VCCS Academic Services and Research Department and included all Virginia community colleges that offer both completely online (lecture and laboratory) and completely on campus BIO 101. Hybrid offerings of BIO 101 (online lecture and on campus laboratory) were not included in the study creating a focused inquiry during a period of community college growth in online learning. The VCCS data were provided without the individual student's identity as each student was designated by a random, unique numeric code. The coding protected the students and ensured confidentiality throughout the research process.

The participants for this study included VCCS non-science major program placed students who completed online or on campus BIO 101 in the Fall 2009 or Spring 2010 semesters. The students must have then completed BIO 102 on campus within the next academic year (by Spring 2011) to ensure

consistency in retention of biological information (Custers, 2010). Non-science major introductory biology students represent the largest population served by BIO 101 and BIO 102. Most associate degrees require two science lab courses and many non-science major students choose to take biology instead of chemistry or physics (personal observation). Data were collected over two semesters to create a large sample size but ensure manageability (Arbaugh, 2004; Crewswell, 2009; Price, 2006). The data from all community colleges were aggregated, and the students were divided into two groups, online BIO 101 and on campus BIO 101. All variables were measured dichotomously, as explained below.

Mode of Instruction. The two potential modes of instruction for BIO 101 were completely online (both lab and lecture) or completely on campus (face-to-face lab and lecture).

Student Success. Student success is defined as a final course grade of C (70%) or better (Larson & Sung, 2009; Xu & Jaggars, 2011). A grade of C or better allows a community college student to receive credit for BIO 102 upon transfer to a four-year institution.

Age. Traditional college age students were defined as students between the age of 17 and 24 years old. Students older than 24 years old are categorized as nontraditional age students (Coldwell, Craig, Paterson, & Mustard, 2008).

Gender. Students were divided into two groups based on gender, either male or female, as indicated by the individual student.

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

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

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

To determine the relationship between mode of instruction in BIO 101 and student success in BIO 102, the final BIO 102 grades of the students who completed BIO 101 online or on campus were statistically analyzed through binary logistic regression (Meyers, Gamst, & Guarino, 2006). The Hosmer and Lemeshow Test accounted for the overall regression model and determined its goodness of fit. The test indicated if the model including the predictor (mode of instruction) better described the student success data as compared to the constant only model (no predictor). A Wald test estimated how well the

individual predictor of mode of instruction explained the variance (range of differences) in student success (Meyers et al., 2006; Peng, Lee, & Ingersoll, 2002). Descriptive statistics summarized the data related to the demographic characteristics of the students who complete BIO 101 both online and on campus (Sprinthall, 2007).

RESULTS

The mode of instruction in BIO 101 was not predictive of student success in BIO 102 on campus for VCCS non-science major students, Wald (1) = .228, $p > .05$. The final logistic regression model including instruction mode did not increase the classification accuracy of the constant only model at 83.1%. The adjusted odds ratio [Exp(B)] of 1.134 was very close to a value of 1.0 corresponding to an independent variable was not predictive of the dependent variable (Table 1).

TABLE 1

Logistic Regression Results with Mode of Instruction as a Predictor of Student Success in BIO 102 On Campus (N=4959) including the Wald statistic, degrees of freedom (df), the significance levels (Sig), and the adjusted odds ratio [Exp(B)].

Predictor	Wald	df	Sig.	Exp(B)
Instruction Mode	0.228	1	0.633	1.134
Constant	31.446	1	0.000	4.333

Ninety-six students completed BIO 101 online and BIO 102 on campus. More college age students completed BIO 101 online and BIO 102 on campus (77.1%) as compared to older students. Additionally, more female students (65.6%) and more Caucasian students (76%) completed BIO 101 online and BIO 102 on campus. Students who completed BIO 101 online and BIO 102 on campus were more likely to have completed a prior online course (62.5%) and most students (74%) were enrolled at a full time status during the semester of BIO 101. Table 2 illustrates the dichotomous data for students who completed BIO 101 online and BIO 102 on campus.

TABLE 2

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

Variable	Categories	Frequency	Percent
Age	17-24	74	77.1
	25 and older	22	22.9
Gender	Male	33	34.4
	Female	63	65.6
Ethnicity	Caucasian	73	76.0
	Non-Caucasian	23	24.0

Prior online	Yes	60	62.5
	No	36	37.5
Enrollment	Full time	71	74.0
	Part time	25	26.0

In total, 4863 students completed both BIO 101 and BIO 102 on campus. Overall, more college age students completed both BIO 101 and BIO 102 on campus (81.9%). More of the students were female (58%), and the majority of the students were Caucasian (59.4%). Many full time students completed BIO 101 and BIO 102 on campus (77.3%), and the majority of the students had not completed an online course prior to BIO 101 (67.6%). Table 3 shows the dichotomous demographic data for students who completed both BIO 101 and BIO 102 on campus.

TABLE 3

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

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

Findings as Related to the Professional Literature

The findings of the current study support previous research showing no significant difference in student success between students who complete introductory biology online as compared to students who complete introductory biology on campus. Lunsford and Bolton (2006) and Johnson (2002) found no significant difference in community college student grades in introductory biology comparing online and on campus sections. The current study adds to the literature by sampling community colleges online biology students within Virginia for the first time, using a larger sample size as compared to previous investigations, and collecting data over multiple semesters adding strong support to existing trends. The reinforcement of the trends already present within the literature adds weight to the conclusion that student success in introductory biology is not directly related to the mode of instruction.

The demographics of students who completed online BIO 101 and on campus BIO 102 are similar to the general characteristics of online students within the VCCS. Jaggars and Xu (2010) tracked 24,000 VCCS students investigating types of courses completed in the virtual environment, online student characteristics, and online course completion and retention. Similar to the current study, Jaggars and Xu (2010) determined women, Caucasian students, and students who previously completed an online course were more likely to enroll in an online course. One difference is in age demographics. Most students who completed online BIO 101 were younger than 25 years old while across the VCCS older students were more likely to enroll in an online course (Jaggars and Xu, 2010). Perhaps older students were intimidated by completing a course with a laboratory component in the virtual environment. It is encouraging that the results of the current study mirror the trends previously reported in VCCS online students.

Unexpected Findings

One unanticipated finding from the current study was that few students completed BIO 101 online and BIO 102 on campus resulting in very different sample sizes for the analyses (96 versus 4863). Consequently, the results may not fully explain VCCS online biology student success. A small sample size in binary logistic regression can overestimate the odds ratio inducing bias away from the null model (Nemes, Jonasson, Genell & Steineck, 2009). Although this potential error is important to note the analysis found mode of instruction was not predictive of student success in BIO 102 on campus (the null model). Nemes et al. (2009) caution against pooling studies with small sample sizes as it increases the chance of misinterpreting the results and overestimating the odds ratio. To prevent this occurrence, the current study will remain an independent entity.

It is unclear why the group of students who completed BIO 101 online and BIO 102 on campus was so small. Perhaps the students who completed BIO 101 online decided to continue in the virtual environment and complete BIO 102 online as well. The study did not request data for students who completed both semesters of introductory biology online because the selected measure of student success was final course grade in BIO 102 on campus. Comparing students who completed BIO 102 online and BIO 102 on campus would not be an identical measure. Therefore, it is unknown how many students remained in the virtual biology environment. Another possibility for the different sample sizes is that students completed BIO 102 after more than one year had elapsed since BIO 101 and therefore were not included in the sample. The one-year time frame between BIO 101 and BIO 102 was established in the participant criteria to ensure uniformity of content retention (Custers, 2010).

Most associate degrees require students to complete two science courses with laboratories. Students, however, do not have to complete both courses within the same discipline. Students may have completed BIO 101 online and then taken another science instead of BIO 102 such as a chemistry class or a geology course. Switching sciences would not impact a student's progress towards completing degree requirements but could explain the low sample size of

students who completed online BIO 101 and on campus BIO 102. Finally, students may have left the institution after completing BIO 101 online and not had the opportunity to complete BIO 102, either online or on campus. The student may have transferred or had to drop out due to poor grades, family commitments, or a change in employment. Jaggars and Xu (2010) found VCCS students who participated in an online course within the first semester or the first year were slightly but significantly less likely to persist to the following semester (68% average retention for students taking an online course as compared to 72% average retention for students enrolled in only on campus courses). Unlike the current study, Jaggars and Xu's (2010) analysis controlled for student characteristics such as gender, ethnicity, age, and prior courses completed making it challenging to draw a direct correlation. Although it is possible that VCCS students who completed online introductory biology did not persist leading to a small sample size in BIO 102 on campus further research is needed.

Implications for Practitioners

The current research gives practitioners insights regarding the demographics of VCCS students completing both online and on campus biology courses. This information can help biology professors target the student population and know, even before the first day of class, the general characteristics of the students most likely to appear in their face-to-face or virtual classroom. If professors have an idea in advance of their students' demographics they can tailor their teaching style to better accommodate the students within the classroom. As a result, students can have an improved educational experience furthering learning and comprehension. The findings suggest that online biology professors can assume most of their students are recurring online participants. Thus they can expect these students to be familiar with the time commitment required to be successful. However, students may not be as comfortable with completing laboratory activities in the virtual world, a characteristic unique to online science courses. As a result, the professor can plan to spend more time instructing students on the laboratory aspects of the online course and less time discussing how to complete online quizzes or how to post to an online discussion board. By focusing on the differences of an online laboratory atmosphere while assuming the majority of the students are comfortable with the online environment the instructor can increase efficiency of course delivery.

The current research found more female VCCS students enrolled in biology as compared to male students. Steinmann, Miller, and Pope (2004) surveyed female community college students and found female students typically studied at home and alone. Female students also reported it challenging to balance academic and personal life but were unlikely to decrease their course load (Steinmann et al., 2004) as compared to their male counterparts. Specifically in the online environment, female students participated significantly more in online discussion boards, exhibited more self confidence, and communicated more with instructors indicating a high level of engagement as compared to male students (Coldwell et al., 2008; Price, 2006; Rovai, & Baker, 2005). Knowing these characteristics and behaviors of female students and applying

them to the biology classroom will help instructors effectively teach, advise, and support the majority of the VCCS biology student population.

This study will also benefit counselors in advising students in course selection. Although the VCCS investigated the success of online students in first semester college level English and math courses (Xu & Jaggars, 2011), the current study is the first focused on the success of VCCS students enrolled in online introductory biology. The findings will help counselors inform students of course delivery options as students try to fulfill degree requirements. Students may be reluctant to register for online courses but the current study indicates that many different groups of students can be well served through BIO 101 online.

Implications for Action

Jaggars and Xu (2010) found that fewer VCCS students completed online courses in the natural sciences, which includes biology. It was unclear from the research if there were few online course options within natural sciences or if VCCS students were being advised not to participate in online science courses. The current study found very different sample sizes between students who completed online BIO 101 and on campus BIO 102 as compared to students who completed both courses on campus, supporting Jaggars and Xu's conclusion. With the knowledge that mode of instruction in BIO 101 is not predictive of student success in BIO 102, administrators should consider adding more sections of online biology. Online courses can be more cost effective as the student does not have to invest gas money to travel to and from campus or pay for childcare (Sander, 2008). One of the goals of the VCCS's six-year strategic plan Achieve 2015 (Wood, 2010) is to increase access to higher education. This research points to online biology courses as an option for Virginia community colleges to effectively serve students while reaching strategic goals of increased student educational access.

In addition to adding more online biology courses community colleges should promote online introductory biology to students. Students deserve to be well informed of not only courses available to fulfill degree requirements but also course delivery options. There are many different methods available to contact students including counselors, new student orientation sessions, the institutional website, Facebook pages, and student emails (Neibling, 2010; Zastrow, 2007). A combined communication effort incorporating all of these tools will effectively reach the largest student population informing them of the potential to complete introductory biology in the online environment.

Recommendations for Further Study

The current study is considered to be emerging research. The goal was to present overall trends of online introductory biology within the VCCS. With a baseline indicating mode of instruction in BIO 101 is not predictive of student success in BIO 102 on campus the next step is to conduct focused investigations to learn more detailed information. Future studies should aim to standardize more variables, for example, instructor or teaching methods, to help educators and administrators gain further knowledge about VCCS online biology.

One interesting and unexpected finding of the current study was that many VCCS students who complete BIO 101 online do not take BIO 102 on campus. There could be many reasons for this choice, as discussed previously, but future research should investigate this question in more detail. Are students taking another science course? Are students staying in the online environment to complete BIO 102? Are students not retained at the institution? The study indicated that students who do complete BIO 101 online and BIO 102 on campus are mostly female, college aged students, Caucasian, full time students, and have previously completed an online course. Are more male students or more part time students who complete BIO 101 online then exploring different options for their second science course at the community college? Answering this question will help administrators make informed course offering decisions and help counselors advise students in creating their course schedules.

There are many different definitions of student success. The current study measured student success by final course grade in a subsequent biology course. Future studies should investigate student success in online biology with alternative measures, for example retention, withdrawal rates, or time to graduation. Johnson (2002) found no significant difference between community college student withdrawal rates in online and on campus introductory biology. Overall online VCCS courses had lower completion and student persistence as compared to on campus classes (Jaggars & Xu, 2010), but it is unknown if these trends are present in VCCS online biology. Community college students cited many reasons for withdrawing from online courses including time constraints, the amount of time required to receive instructor responses, technical or computer issues, institutional problems, and incompatible learning styles with the online environment (Aragon & Johnson, 2008; Packham, Jones, Miller, & Thomas, 2004). Is persistence related to online course taking in general or the specific type of online course associated with persistence? Further research is needed. Additionally, measures such as retention and time to graduation are used to track institutional success (McLeod & Young, 2005). Learning about these measures in relationship to biology courses will help community college leaders discover how well the institution is serving students. Using different measures of student success in future research will broaden the understanding of online biology effectiveness within community colleges.

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

CONCLUSION

The goal of the current research was to conduct a large-scale study of community college student success in online introductory biology. Since the investigation included participants from multiple institutions over several semesters, it not only adds to the existing literature but it increases support for online biology courses. This support can potentially change practitioner's opinion that teaching online laboratory based science courses is challenging. The study was the first investigating online biology within Virginia and measured student success in a different way by tracking student final grades in a subsequent course. As the VCCS is very invested in online education the results of this study are valuable and have the potential to increase student access to online biology courses. As many students complete introductory biology to fulfill associate degree requirements, the results of the current study provide community college leaders, administrators, biology professors, counselors, and students with valuable information about online biology course options.

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