Student Performance and Success in Entry-Level Undergraduate Biology Courses

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Abstract

Although attending college may be viewed as a rite of passage to a majority of students, some students face unique challenges in their pursuit of a college degree in science. This study is an attempt to gain better understanding of student performance and success in entry-level undergraduate science courses. Six variables- ethnicity, gender, high school GPA, high school chemistry, school financial support, and work hours were used as independent variables and course final performance as a dependent variable. The study attempted to explore two research questions: 1) What were the variables of performance in entry-level biology courses? and 2) What were the predictors of success in entry-level biology courses? Multiple regression models and logistic regression models were used to address the above two research questions. The results suggested that high school GPA had a strong association with students' performance in entry-level biology courses. Additionally, high school GPA and high school chemistry were the predictor variables for students' success in entry-level biology courses. A further study with a longitudinal and quasi-experimental research design is recommended to assess students' performance and success entry-level science courses.

Problem

The global market economy substantially impacts the United States workforce and its postsecondary institutions. To successfully compete and maintain sustainability in this technically demanding work environment, America will need well educated and highly skilled manpower trained in the disciplines of Science, Technology, Engineering, and Mathematics (STEM). Given the current patterns of globalization and college level education competitiveness, low college retention is representative in STEM fields, and high attrition rates in these fields is not surprising. In the late 1990's, 50% of both minority and non-minority students entering college to major in the fields of natural sciences changed their majors within two years of taking their first college science class (Seymour & Hewitt, 1997). Furthermore, dropouts and failure rates are higher in college courses such as biology, chemistry and physics as compared to non science courses (Gainen, 1995; Woods & Gentile, 2003). Even though research in this area roots from different disciplines ranging from science to non-science majors, in the present study I focused on the student population in entry-level biology courses. To date, research has established that college student success in science is reflective of several factors (e.g., demographic, academic, and socio-economic factors). However, none of the studies have examined theses variables to determine their link to college students' success in entry-level science courses. It has been documented that poor academic performance often forces at-risk students to discontinue their academic venture (American Council on Education, 1996). Although theoretical models have been designed to address students' retention in undergraduate mathematics and science courses, yet, there is not any mathematical model developed to assess students' performance and success in entry-level biology course. To fill this gap in the education literature, the present research seeks

answers to the questions: (1) What were the predictors of student performance in entry-level biology courses? (2) What were the predictors of student success in entry-level biology courses?

Research Design/Procedure

Data were collected from student participants' enrolled in entry-level biology courses–Functional Biology and Organismal Biology. Participation in this study was completely voluntary. The data were collected in two consecutive semesters, the fall of 2007(Cohort One) and the spring of 2008 (Cohort Two) during the laboratory sections. There were 16 laboratory sections in the Functional Biology course and 18 in the Organismal Biology course with an average class size of approximately 18 students in each. Therefore, the total sample consisted of n=230 in Functional Biology, n=252 in Organismal Biology in cohort one and n=180 in Functional Biology, n=191 in Organismal Biology in cohort two. Each course was again divided into two groups–all student participants and biology major student participants.

In this study, six independent variables–genders, ethnicity, high school GPA, high school chemistry, school financial support, and work hours were used. Data analysis was conducted using multiple regression analysis and binary logistic regression analysis. Before running each of the analyses, all the related assumptions were checked.

For the multiple regression analysis, final course grades were used as univariate dependent variable. For the logistic regression analysis, course final grades were used as dichotomous dependent variables which were divided into two categories–successful and not successful to assess students' success in the courses. Students who completed the course and received at least a grade of "C" or higher comprised the successful group, whereas students receiving a grade of "D," "F," and "W" (Withdrawal) comprised the non successful group. The cut-off grade of "C" was used to differentiate successful and not successful groups because the student participants must maintain a grade of "C" or higher in prerequisite courses in order to pursue a science degree in the institution of study.

Findings

The results from the demographic information analysis suggest that only half of student participants enrolled in these courses were biology majors and out of which 58% were successfully able to complete these courses. Multiple regression analysis was conducted using six variables–ethnicity, gender, high school GPA, high school chemistry, school financial support, and work hours. The results were interpreted based on the analyses of samples from both cohorts one and two. High school GPA was a consistent statistically significant predictor of final course score for all samples. For the sample of all students in cohort one, having taken high school chemistry was an additional statistically significant predictor. Other variables, such as gender and students having taken high school chemistry, also showed significant results in different groups.

Using the same six variables, binary logistic regression analysis was further conducted to assess if the same predictor variables showing the association with final course grades were the predictor variables of students' success in these courses. The results from logistic regression analysis showed that except for a few groups, high school GPA was a consistent predictor of students' success in these courses (Tables 1 and 2).

Table 1

Regression Analysis Summary for Selected Variables Predicting All Students' Scores in Entry-Level Biology in Cohort Two

Variable	B	SEB	β
High School GPA	19.122	0.701	0.898***
High School Chemistry	5.649	2.641	0.070*

$R^2 = 0.46$(N= 386, $p < 0.05$).
*$p < 0.05$,***$p < 0.001$.

Table 2
Summary of Logistic Regression Analysis Predicting if Students were Successful in Organismal Biology Cohort Two

	β	SE	Wald	*p*-value	Odds ratio Exp(B)	95% CI for odds ratio Lower	Upper
High School Chemistry	0.547	0.434	1.584	0.008	0.578	1.246	1.356
High school GPA	0.949	0.325	8.519	0.003	2.583	1.365	4.887
School Financial Support	0.296	0.303	0.950	0.329	1.344	0.741	2.438

Discussions

The present study used demographic and academic frameworks to create a mathematical model. Six demographic and academic variables were used to assess students' performance and success in entry-level biology courses. The study used both multiple regression and binary logistic regression analysis because correlation does not represent predictability. Many studies in the science education research use either regression or logistic regression analysis to assess students' performance or success, so the present study went beyond this boundary and tried to address both these parameters– correlation and predictability. The results from both these analyses will help the department and/or institutions to seek the issue of students' performance and success in entry-level biology courses in more depth.

The multiple regression analysis indicated that there were strong statistical relationships between students' high school GPA, high school chemistry, and gender and their final course performance. However, to measure if the same variables were predicators of success in entry-level courses, the logistic regression analysis was conducted. The results indicated that high school GPA, high school chemistry, and gender, ethnicity, school financial support were strong predictor variables for student success in entry-level college biology courses. Based on the results from this study, I suggest that the department can use a mathematical equation to predict student success using these variables. Based on these results, if these significant variables are known, these equations can be used to predict student success in the respective entry-level biology courses. This will be valuable information for not only the relevant department but for the higher education community as a whole. It should be noted that the predictive equation developed for these courses may be used at other institutions in Texas where these courses are transferable. This research could be replicable among a group of similar

schools to see if the results would be the same. If the results match, then it can be concluded that the mathematical model is applicable to other institutions. Following are the significant findings from the study.

Out of six variables, high school GPA was one of the predictors, which showed a strong relationship with students' performance in entry-level science courses. More importantly, it was the same predictor variable that was more likely to impact students' success in entry-level science courses in all groups and sub-groups. DesJardins, McCall, Ahlburg, and Moye (2002) suggested that there was a positive relationship between student high school GPA and college achievement. Furthermore, a study by Cambiano, Denny, and De Vore (2000) suggested that high school preparation had a positive effect on freshmen college performance. Similarly, Nordstrom (1990), Cabrera, Nora, and Castaneda (1993), Hu and St. John (2001), Leppel (2002), Perna (1998), and Tinto (2004) found that high school GPA was a stronger predictor of student college persistence and performance. A study by Johnson (2000) also revealed that students who were more likely to earn a GPA higher than 2.00 were less likely to leave college for academic reasons. Johnson further suggested that high school GPAs and SAT scores had a positive effect on student persistence and performance and also added that college first-year GPA was the most important factor of student success and its effect was the most substantial in the initial semester enrollment.

However, the opposite trends were reported by Jones and Watson (1990) and Weissberg, Owen, Jenkins, & Harburg (2003). The authors suggested that high school performance often failed to predict with a high degree of accuracy, college success because of two associated reasons: first, the high school curriculum may not have prepared the student for college work, and second, the high school GPA were poor predictors of college success due to grade inflation and a lack of standardization in high school grading systems.

Apart from students' academic variables being associated with students' performance and success, studies have addressed relationships between attitudes and achievement by students. For example, a study conducted by Gungor, Eryilmaz, and Fakioglu (2007) measured the relationship between freshman physics achievement and affective characteristics. The results revealed that achievement motivation (meaning the student has a strong desire to achieve in that course) had a positive relationship with physics achievement.

The overall results of multiple regression analysis suggested that high school GPA was a strong variable of students' performance and predictor of student success in the entry-level biology course. However, the relationships between students' performance and other variables were consistently weak and non-significant in most groups except for gender and high school chemistry taken. The analysis of all students in biology of cohort two, high school GPA and high school chemistry were strongly associated with students' performance in the entry-level biology course. High school GPA as a predictor of student success in introductory biology course is supported by several studies (Gibson & Gibson, 993; Johnson & Lawson, 1998; Mitchell & Lawson, 1988; Tamir, 1969; Tamir, Amir, & Nussinovitz, 1980).

The present study suggested that high school GPA as one of the best predictors for predicting students' performance and success in entry-level science courses. The results recommend that if we can predict student performance in entry-level biology

courses and their success based upon their final course grades, then we can create an entry-level science student success model that can predict student success based on high school academic background. This study has a potential to be expanded in the future to further develop a predictive model.

Conclusion

Over the past half century poor student performance in science and a high percentage of students leaving science programs have been a great concern to science educators, professionals, businesses/industries, and policy makers. This research provides an overview of certain academic variables that are relatively important predictors of students' performance and success in entry-level biology courses. As students' success in the prerequisite courses is a "basic requirement" for a student to continue to pursue a science degree, it is important to incorporate empirically-based procedures into the process of future student retention research. In the present study, different units of analysis indicated high school GPA as a consistent predictor of student success, with other variables such as high school chemistry, ethnicity, gender, school financial support as additional predicator variables in different groups. The different outcomes resulted in the present study may be attributed to methodological and procedural differences between the studies (e.g., which variables are examined, how variables are operationalized, how intervening variables are controlled for, and the difference in statistical techniques used), the specific content of each of the freshman programs, and the unique differences between the cohort student populations themselves. A longitudinal study with a larger sample size with a modified instrument is suggested to advance our understanding of students enrolled in the entry-level biology courses and their retention and attrition behavior.

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