Are your students ready for anatomy and physiology? Developing tools to identify students at risk for failure

Amy Gultice, Ann Witham, and Robert Kallmeyer

1 Biology Department, University of Cincinnati Blue Ash College, Blue Ash, Ohio; and 2 Department of Arts and Sciences, The Christ College of Nursing and Health Sciences, Cincinnati, Ohio

Submitted 18 August 2014; accepted in final form 12 March 2015

Gultice A, Witham A, Kallmeyer R. Are your students ready for anatomy and physiology? Developing tools to identify students at risk for failure. Adv Physiol Educ 39: 108–115, 2015; doi:10.1152/advan.00112.2014.—High failure rates in introductory college science courses, including anatomy and physiology, are common at institutions across the country, and determining the specific factors that contribute to this problem is challenging. To identify students at risk for failure in introductory physiology courses at our open-enrollment institution, an online pilot survey was administered to 200 biology students. The survey results revealed several predictive factors related to academic preparation and prompted a comprehensive analysis of college records of >2,000 biology students over a 5-yr period. Using these historical data, a model that was 91% successful in predicting student success in these courses was developed. The results of the present study support the use of surveys and similar models to identify at-risk students and to provide guidance in the development of evidence-based advising programs and pedagogies. This comprehensive approach may be a tangible step in improving student success for students from a wide variety of backgrounds in anatomy and physiology courses.

- Early registrants were significantly more likely to earn an A in registration of a personal response system electronic device.
- Between students’ success in the course and the timing of their registration of a personal response system electronic device.
- High failure rates in introductory science courses often delay student entry into career pathways, decrease the diversity of the pool of applicants to professional programs, lower morale for both students and instructors, and increase costs for students and the institution. The goal of the present study was to identify at-risk students and develop and implement the appropriate support systems or pedagogical changes that would increase their success. For example, appropriate advising and academic support have the potential to reduce this high attrition rate. Academic advisors and faculty members must help students select courses that are appropriate not only for their programs of study but also for their stage of academic progress. Effective support services and pedagogical approaches must also be integrated into the curriculum to address the specific needs of the student population. The traditional method of identifying at-risk students by their failure on the first exam means that struggling students begin the term with grade deficits and weak mastery of the foundational knowledge for the course, both of which are often impossible to overcome. Ideally, at-risk students need to be identified either before registration for the course or early in the term, to receive assistance before the first exam. Comprehensive analysis of the factors that contribute to student success has the potential to help us identify actions that we can take to ensure our students are ready for anatomy and physiology.

- Early identification of at-risk students. The development of tools for the early identification of students at risk for failure in introductory science courses has been addressed by previous studies. For example, Griff and Matter (8) examined the issue of identifying students at risk for failure in a large anatomy and physiology course. Their study found a statistical correlation between students’ success in the course and the timing of their registration of a personal response system electronic device that would allow them to participate in classroom quizzes. Early registrants were significantly more likely to earn an A in...
the course, whereas late registrants were significantly more likely to earn a D or F in the course. As such, Griff and Matter asserted that organizational skills are predictors of success in this introductory anatomy and physiology course.

In addition to organizational skills, other studies have highlighted additional factors that are predictive of student success in academia. A comprehensive 2009 report by the Iowa Department of Education (11) reported a multitude of factors that have been shown to correlate with student dropout rates in secondary school. These factors include school performance, psychological issues, family dynamics, levels of household stress, economic factors, rates of absenteeism, a student’s parental status, and the number of hours worked per week. At open-enrollment campuses with a large percentage of students entering directly from high school, many of these factors that contribute to the failure of high school students may also apply to these populations. A report on strategies to identify dropouts by Wells et al. (16), however, recognized that the factors contributing to student success vary from one group to another and that it is necessary to develop population-specific identification tools. Due to the fact that no comprehensive assessment has been developed to identify students at risk for failure in nursing and allied health courses at our campus, we are developing a tool that can be used on a broad scale to predict student performance in these courses. Development of a tool that identifies at-risk students will allow for early interventions that could potentially increase student success in introductory science courses and retention at the college.

Hypothesis. Based on our experiences working with struggling students, we hypothesized that an online survey of students enrolled in introductory biology courses could identify factors that contribute to student success in these courses. The survey included questions designed to assess students’ abilities in basic reading and math skills but no questions required specific scientific knowledge. The survey also collected general background information about students’ past performances in high school and college science classes as well as data regarding study habits, their level of employment, and childcare issues.

METHODS

Participants and procedures. During the winter quarter of 2010, >200 students enrolled in Anatomy and Physiology I or Fundamentals of Biology I (a general biology course) at the University of Cincinnati Blue Ash College participated in this pilot study. As an open-enrollment, regional campus of the University of Cincinnati, a public, Research I institution, the college enrolls >5,000 students. Students in this study were enrolled in eight sections of the two introductory science courses, taught by six different instructors.

The pilot survey was developed to explore factors that are related to student success in introductory biology courses. Students were instructed to complete the online survey during the first week of the academic term. The survey was administered via the online survey provider SurveyMonkey. The survey was a required course activity, and students were awarded credit for their participation without regard to their responses. Students were informed of the purpose of the study and that their answers would not influence their grades for the assignment or for the course. At the end of the 10-wk term, each student’s final letter grade for the course was collected and matched with his or her survey responses. Subsequently, all student names and identifiers were stripped from the data, and only aggregated survey results are reported here. This study followed university Institutional Review Board procedures.

Based on the initial analysis of the pilot survey results, 5 yr of historical data for these two courses were obtained from the college’s Office of Institutional Research. Nonidentified information regarding each student’s grade for the science course (Anatomy and Physiology I or Fundamentals of Biology I), high school and college grade point averages (GPAs), year in college, and placement test score information was collected for each quarter from autumn of 2005 through spring of 2010, and aggregated, cumulative 5-yr information is reported here.

Measures. The pilot survey consisted of 31 multiple-choice questions requesting information about each student’s high school science grades, science courses taken at the college level, the university’s math placement test (MPT) and English placement test scores, study habits, and employment status. To maintain student privacy, survey questions that were of a personal nature offered a “prefer not to answer” response. The survey also included questions designed to assess each student’s abilities in basic skills required for the course: deciphering scientific writing, interpreting graphs, and basic math skills. An example skills question is shown in Fig. 1, and additional example questions are included in APPENDIX A. No previous anatomy and physiology experience or specific scientific facts were required to successfully answer the questions.

At the end of the term, survey responses were matched to final letter grades. For the purposes of this study, a grade of C or higher was classified as “passing” or “successful.” This correlates with the department’s requirements for progression in the course sequence during the term that the survey was administered. Thus, grades of C−, D, or F or students who withdrew from the course were categorized as “failing” or “unsuccessful.”

Before analysis of the results was conducted, data were cleaned by examining the variables for missing data and outliers. For both the survey data set and historical data set, any cases with specific missing values were excluded from the analysis of that particular variable. The pilot survey data set consisted of 198 students who completed the survey and received a letter grade for the course. Survey results from students who dropped the course within the first 2 wk of the term were excluded from the analysis. Results of selected survey questions related to academic preparation are discussed in this report. Additional data collected in the pilot study are still being analyzed and will be discussed in a separate report.

The 5-yr, historical data set included 2,749 students who attempted either Anatomy and Physiology I or Fundamentals of Biology I for the first time. Data regarding students’ second or subsequent enrollments in the same course were removed from the data set. Within the historical data set, there was variability in the data available for each student. For example, 395 cases did not include high school GPAs, and 1,134 cases did not have a university MPT score. All high school GPAs were converted to a 4.0 scale. Because of the large sample size, outliers were identified using values of $Z > 4$ or $Z < -4$ (15). There were no univariate outliers. Additionally, Mahalonobis distance (13) was calculated to check for multivariate outliers. There were no multivariate outliers. The resulting data set for use in a prediction model contained 1,380 cases. Concerns about the reduction in sample size are addressed in the DISCUSSION.

APPENDIX A.
For the logistic regression conducted using the historical data set, assumptions were checked according to the assumptions described by Mertler and Vannatta (13). Detailed information regarding the sufficiency ratios, frequencies, and outliers is included in Appendix B. After the data set was cleaned and the assumptions checked, the data set was considered appropriate to use for the analysis.

RESULTS

This section presents the results of the analyses of data collected to identify academic factors that can be used to predict which students would mostly likely be at risk for failing or withdrawing from either of these introductory science courses (Anatomy and Physiology I or Fundamentals of Biology I). Significant predictive factors were identified based on the statistical analysis of the pilot survey results. The significance of this self-reported, student survey data (n = 198) collected in the winter quarter of 2010 is supported here through the analysis of a larger, 5-yr historical pool (n = 2,749). The historical data were gathered from records of students who enrolled in these courses from the autumn quarter of 2005 through the summer quarter of 2010. For the factors analyzed in this study, the historical data confirmed the pilot survey results. Results from both the pilot survey data and 5-yr historical data are shown in the accompanying figures and tables.

Failure rates. The pass/fail rates of the winter quarter of 2010 classes that participated in the survey were similar to the 5-yr historical averages for the same courses. For the purposes of this study, the failure rate includes students who earned less than a letter grade of C as well as students who withdrew from the course. During the period of this study, students were required to earn a grade of C or better to progress to the next course in the sequence and to receive credit for the course toward their program requirements.

The percentage of students who completed the pilot survey (n = 198) and failed the introductory biology courses participating in the initial study was 30.15%, whereas the combined failure/withdraw average for these courses during the 5-yr period that includes the term in which the survey was administered was 34.20%. Likewise, the 5-yr failure rates for the two courses, Anatomy and Physiology I and Fundamentals of Biology I, had comparable averages (32.7% vs. 36.4%, respectively). The 5-yr pass/fail averages for each course and their combined total averages are shown in Fig. 2.

Age. The historical data (n = 2,728) confirmed the findings from the pilot survey data and showed that students who failed or withdrew from Anatomy and Physiology I or Fundamentals of Biology I had a lower average age (mean: 23.84, SD: 6.52) than students who passed (mean: 26.43, SD: 8.03, t = 8.93, P < 0.001).

High school GPA. In the pilot survey, passing students reported higher high school GPAs than failing students, and this was confirmed by analysis of the historical data. The data collected from 2005 to 2010 (n = 2,116) indicated that students who failed or withdrew from these biology courses had a lower average high school GPA (mean: 2.62, SD: 0.60) than students who passed (mean: 2.92, SD: 0.65, t = 10.83, P < 0.001).

While the specific grades for high school courses were not available from the historical data, survey results showed a connection between high school achievement in science classes and success in these college courses. Students who failed or withdrew from Anatomy and Physiology I or Fundamentals of Biology I reported a significantly lower average high school chemistry grade (mean: 2.80, SD: 0.77) than students who passed (mean: 3.05, SD: 0.68, t = 17.22, P < 0.001). The college GPA at the time of enrollment in Anatomy and Physiology I or Fundamentals of Biology I was used for the analysis. Incoming first-year students and transfer students, who did not have GPAs from our institution, were excluded from this analysis.

Quarter hours earned. Pilot survey information regarding the relationship between college hours earned at the time of enrollment in the course and the student’s final grade for the course was supported by similar results in the 5-yr historical data set. Analysis of the historical data (n = 2,728) for the number of quarter hours the student had earned at the point of enrollment in the biology course included in this study showed that students who failed or withdrew from the course had a significantly lower average of quarter hours earned (mean: 7.68, t = 2.74, P < 0.001) than students who passed.

College GPA. Self-reported pilot survey data regarding college GPAs were also confirmed by analysis of the historical data (n = 1,672). The historical data set showed that students who failed or withdrew from the course had a significantly lower average college GPA (mean: 2.40, SD: 0.77) than students who passed (mean: 3.05, SD: 0.68, t = 17.22, P < 0.001). The college GPA at the time of enrollment in Anatomy and Physiology I or Fundamentals of Biology I was used for the analysis. Incoming first-year students and transfer students, who did not have GPAs from our institution, were excluded from this analysis.

Math skills. To test basic math competency, the pilot survey asked respondents to solve math skills questions. Two of these questions had results that distinguished successful students from unsuccessful students: a word problem that required a calculation and a problem that required interpretation of a graph. Analysis of student answers (n = 198) for these multiple-choice questions revealed that students who withdrew or failed had a significantly lower average score on these math skills.
Wald test results indicated that all variables in the model were variables. Table 2 shows the results of the logistic regression to be applied to all students. The model retained the five predictor taking these courses were first-year students, allowing the model was not included in the model because many of the students significant predictor of success in these courses, college GPA hours carried, high school GPA, and MPT Score. (Although a level biology courses. These variables were age, hours earned, which students would fail/withdraw or pass these introductory success in Anatomy and Physiology I and Fundamentals of

Table 1. Summary of analyses from the historical data (n > 1,600) and the pilot survey data (n = 198)

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Failed/Withdrawn</th>
<th>Passed</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>2,728</td>
<td>23.84 (6.51)</td>
<td>26.43 (8.03)</td>
<td>8.93†</td>
</tr>
<tr>
<td>HS GPA</td>
<td>2,116</td>
<td>2.62 (0.60)</td>
<td>2.93 (0.65)</td>
<td>10.83†</td>
</tr>
<tr>
<td>College GPA</td>
<td>1,672</td>
<td>2.40 (0.77)</td>
<td>3.05 (0.68)</td>
<td>17.22†</td>
</tr>
<tr>
<td>Term hours earned</td>
<td>2,728</td>
<td>5.39 (4.73)</td>
<td>10.20 (4.13)</td>
<td>25.64†</td>
</tr>
<tr>
<td>Term hours carried</td>
<td>2,728</td>
<td>7.68 (4.85)</td>
<td>10.32 (4.13)</td>
<td>13.79†</td>
</tr>
<tr>
<td>Math skills questions, %</td>
<td>198</td>
<td>55.00 (36.48)</td>
<td>73.55 (32.64)</td>
<td>3.32*</td>
</tr>
<tr>
<td>Mathematics placement test</td>
<td>1,604</td>
<td>315.35 (135.61)</td>
<td>402.94 (157.11)</td>
<td>11.14†</td>
</tr>
</tbody>
</table>

Values for group averages are means (SD). GPA, grade point average. *P < 0.01; †P < 0.001.

skills questions (mean: 55.00%, SD: 36.48%) than students who passed (mean: 73.55%, SD: 32.64%, t = 3.32, P < 0.01). These results and the survey data that showed unsuccessful students reported lower average MPT scores led to the analysis of the historical data regarding introductory science students’ scores on the university’s MPT.

MPT score. Self-reported pilot survey data regarding MPT scores were confirmed by analysis of the historical data (n = 1,672). Analysis of student scores on the MPT in the 5-yr historical data set (n = 1,604) showed that students who failed or withdrew had a significantly lower average MPT score (mean: 315.35, SD: 135.61) than students who passed (mean: 402.94, SD: 157.11, t = 11.14, P < 0.001). Table 1 shows a summary of the results regarding potential predictors of student success in Anatomy and Physiology I and Fundamentals of Biology I.

Logistic regression. Based on preliminary analysis of the pilot survey and the 5-yr historical data, five variables were entered into the model to determine whether they could predict which students would fail/withdraw or pass these introductory level biology courses. These variables were age, hours earned, hours carried, high school GPA, and MPT Score. (Although a significant predictor of success in these courses, college GPA was not included in the model because many of the students taking these courses were first-year students, allowing the model to be applied to all students.) The model retained the five predictor variables. Table 2 shows the results of the logistic regression. Wald test results indicated that all variables in the model were significant at either the P < 0.01 level (HS GPA) or P < 0.001 level (the remaining variables). The overall model evaluation, as assessed using the likelihood ratio test, was significant: \( X^2 (5, n = 1,380) = 657.818 \) (P < 0.001). The result of the Homer-Lemeshow goodness of fit test was not significant, at \( X^2 (8, n = 1,380) = 13.332 \) (P > 0.05), indicating that the model fitted the data well.

The logistic regression model successfully predicted group membership in 64.1% of the students who failed or withdrew and 91.1% of the students who passed. Overall, the model correctly predicted 81.6% of the sample. These results are shown in Table 3.

DISCUSSION

As an open-access campus, our college has a student-centered mission and a strong commitment to student success. As such, faculty members are well trained in effective teaching strategies, and active learning modules are consistently incorporated into the biology curriculum. In addition, the class size is small, instructors are available for individual help, and a professionally staffed science tutoring laboratory is available to students as an additional support. Withdrawal and failure rates, however, remain high in the gateway science courses that lead to professional programs in the health sciences. Solving this problem will undoubtedly require a multifaceted approach, but this study’s pilot survey of students in Anatomy and Physiology I and Fundamentals of Biology I courses has highlighted factors that correlate with student success. The hypothesis that a survey could identify factors that contribute to student failure was supported: the initial analysis of the survey results showed that there were significant differences in survey responses between passing students and failing students in terms of their high school grades, college grades, MPT scores, and other factors. While the pilot survey had a relatively small sample size (n = 198) with self-reported data, the statistically signif-
icant results were valuable in that they justified the acquisition of data from the previous 5 yr of student records. Analysis of the historical data of 2,749 students consistently demonstrated the same patterns as the survey. These results support the use of online surveys as instruments to identify factors contributing to student success in a given student population of introductory science majors.

The pilot survey addressed several potential areas that could produce obstacles for struggling students, including insufficient foundational skills, age, family commitments, and employment. Many of these issues are ones that would best be addressed before a student registers for a class (i.e., adequate math skills), whereas others (i.e., current course load) are issues that can be discussed with advisors at the time of registration. Balancing work, school, and life issues, however, often requires not only the perspective of an advisor but also student maturity, appropriate support systems, and financial assistance. Thus, for the initial analysis of the survey results, we chose to analyze survey results related to academics, such as student academic background information (high school grades, math skills, etc.) and current college status factors (hours earned, GPA, etc.), as these points are measurable from student records and available to the advisor. (The effects of lifestyle factors, such as childcare issues and hours worked per week, will be analyzed in a subsequent report.)

The original goal of the survey study was to develop a tool to identify students at risk for failure early in the term to provide support. The initial analysis of the data indicates that unsuccessful students in these courses are often beginning the term with significant academic deficits. In these content-driven biology courses, a student’s reading, writing, and mathematical skills are crucial for his or her eventual success. Professor-initiated student conferences to explain instructor and college support services have not proved sufficient support to help students overcome these gaps in preparation, but insufficient academic preparation of this student population might be addressed by specific changes in pedagogy or more intensive, extended support. Another approach would be to provide supplemental instruction for students to support specific success in the sciences (4). The fact that the number of students who do not qualify for college algebra can reach 40–50% in an introductory science class, however, may mean that providing adequate supplemental instruction may not be feasible. Other pedagogies to engage underprepared students, such as incorporating more inquiry-based content modules and increasing the number of “hands-on” activities to explain complex, abstract processes, may also be effective with some students in this population (9, 17, 18). However, this will not necessarily address the crucial reading and math skills needed to sustain the independent learning of foundational information that is critical in content-driven courses, such as Anatomy and Physiology I. As such, a student’s lack of preparation may be better addressed in some cases by remedial instruction or increased exposure to the college experience before taking these courses. Thus, the goal of this ongoing project has broadened to include the development of a model that can predict student success in introductory science courses and to share this information with students, college advisors, and biology faculty members so that it can be used to develop appropriate responses and interventions for at-risk students. This will allow students and advisors to base course selection decisions on evidence-based research rather than on speculation. A multifaceted approach could lead to appropriate remediation before a student registers for one of these challenging courses, combined with targeted tutoring and support during the course, potentially lowering withdrawal and failure rates.

The results of the analysis of this data led to the development of the current working model, which has a 91% success rate in predicting successful completion of the course. It was gratifying that the results of this study document the anecdotal evidence that faculty members had assumed contributed to the high failure rates. For example, increased age, with its assumed maturity, increases the chance of success in these introductory science courses. As expected, passing students have higher GPAs in both high school and college than failing and withdrawing students. Likewise, the more college hours a student has earned before starting one of these introductory science courses, the more likely the student is to succeed. The experience of passing previous college courses potentially helps prepare students for these challenging lecture and laboratory-based science courses that require a significant level of time management.

Surprisingly, the results of this study show that the more credit hours a student carries at the time of enrollment in Anatomy and Physiology I or Fundamentals of Biology I, the greater the chance of the student’s success in the course. While a heavier course load might be expected to negatively correlate with higher grades, this is not the case in these courses. These results could be interpreted as a sign of commitment to the educational process: successful students in these introductory biology courses are often maintaining eligibility for competitive health science programs, and this may contribute to this correlation because they are less likely to have a part-time status. In addition, students taking higher course loads may be more focused on earning a degree, must manage their time more precisely, and are more likely to be engaged within the academic community (i.e., interacting with professors, other students, or support services). The possible rationale for this correlation is similar to explanations proposed by previous studies (2, 14) that found positive relationships between the number of hours enrolled and retention.

Whether or not students are prepared for college-level science courses can be assessed by different methods, but the results of the survey’s math skills questions and the university’s MPT scores were revealing. The pilot survey asked each student to solve one problem that required an understanding of both fractions and percentages and a second problem that required interpretation of a graph. Students who passed the course had higher scores on these math skills questions than failing students. Supporting this result, the passing student group self-reported higher average MPT scores than the failing/withdrawing student group. This prompted an analysis of the 5-yr historical data, which showed the same results. A score
of 430 or above on the university MPT qualifies a student to take college-level algebra. Of the 1,604 students who did take the MPT, 75% of those who qualified for college-level algebra passed the course. Students who were required to take preparatory, precollege level math had a success rate of only 36%. This is a simple and quite significant delineation. MPT scores, however, are obviously only one component of the picture: there were students who had low MPT scores, even extremely low MPT scores, who passed the course. Other factors contributing to success, such as excellent reading and/or study skills or prior completion of preparatory math courses, are not evident in this analysis and are an avenue for future investigation.

While MPT scores were not the primary predictor of student success in the linear regression model, they were significant and are included in the model. This led us to ask how mathematical skills affect success in Anatomy and Physiology I. The connection between math and success in introductory science courses is not always obvious to students. In fact, the quantity of math calculations required in these courses is relatively small, and failure on only these assessments would not prevent a student from passing. Thus, the correlation between math skills and success in these courses is probably related to the general skills that math facility represents, such as the capacity to categorize information and to order processes. These results suggest that the university’s MPT scores could act as a guide to assist students in appropriate science course placement. Students whose initial math placement scores did not meet a minimum score could be advised that completing preparatory math courses before enrolling in either of these gateway science courses could potentially increase their chances for success. In addition, this is a key area where changes in pedagogy and support services could be targeted to at-risk students. A future analysis of the contribution of reading and writing preparedness on success in these courses might also be helpful in providing advisors with additional, evidence-based recommendations for appropriate course placement.

Taking into account the factors that showed significant differences between the passing student group and failing student group, a model using a linear regression was developed. When considering age, college hours earned, college hours carried, high school GPA, and MPT score, the model was 91% effective in predicting a positive outcome for these courses. It was less successful in predicting student failure, probably because of the factors that were mentioned previously (the completion of math or other science courses before attempting this gateway course, reading skills, study skills, etc.). Overall, the success rate of the model in correctly predicting the outcome was 81.6%.

The general reliability of the model to predict student success is enlightening in that most of the presumed factors holding back struggling students were in fact related to the failure rate. This predictive model, however, is still in need of refinement, and additional data collection and analysis are underway to improve the model’s utility. For example, a limiting aspect in this model is that student’s age is a significant contributing factor. Age is a parameter that cannot be used to promote or inhibit a student’s course selection or prompt supplemental support. In addition, further analysis of the historical data should reveal the factors that enable students whose profiles predict failure to effectively navigate these courses.

What are the key experiences that allow students to overcome initial deficits in preparation? This information is vital so that advisors can assist students in their course selection as they acquire skills and collegiate experience. An additional concern is the large reduction in sample size from the original data set \( n = 2,749 \) to the data set used for the model \( n = 1,380 \) due to missing data, such as MPT scores and high school GPAs. Comparison of the original and model data sets, however, did not show a pattern that would affect prediction for records that were excluded.

While this study does not elucidate how these factors help students master the course material and meet the demands of the course, the results do identify valid predictors of student success in these courses that can be obtained from student records to help identify at-risk students. The next phase of this project is the collection of additional survey data and the refinement of the model, using predictive factors that are not only reliable but also practical in assisting students in course selection or alerting at-risk students to be vigilant in seeking support when taking these challenging courses. Increasing the student success rate in these courses will not only increase student retention but also has the potential to increase the diversity of the pool of successful entrants to competitive allied health and nursing programs. Evidence-based advising will save students time and money by helping them to avoid failures and withdrawals. Perhaps just as importantly, evidence-based advising will also have the ability to build student confidence and overall success in both academia and the workplace, as students are guided to master foundational skills. Faculty members also need to incorporate specific changes in pedagogy and interventions that target the needs of these students. At-risk students who are identified by a reliable tool could also be guided by faculty members and advisors to use specific study strategies and to seek study skills tutoring and other support from the first day of class. Students are often unaware of their lack of preparation: it is the responsibility of college faculty members and staff to help students correctly identify their academic strengths and weaknesses and to effectively assist them in gaining the skills they need to succeed.

For faculty members, the identification of students at risk for failure in these specific courses has always been a challenge. If these factors can be used to help faculty members identify at-risk students early in the term, then academic interventions may be strategically initiated to further enhance the success rate. If science faculty members and advisors can guide underprepared students to choose supported pathways that will help them to succeed in these science courses, faculty efforts will be more efficient and effective. The goals of this study were not to keep students out of these courses but rather to help students enter the courses at the right time, with the right skills and support services they need to succeed. Understanding the myriad of factors that contribute to student success in science courses is a key to helping faculty members and institutions increase not only student success in physiology and other science courses but also in students’ professional programs and academic careers. While our current pedagogies have successfully helped the majority of students succeed in the sciences at the college level, shifting demographics require that faculty members, staff, and administrators continue to determine the specific problems facing unsuccessful stu-
APPENDIX A: ADDITIONAL EXAMPLE SURVEY QUESTIONS

What is your major?
- Undecided
- Nursing
- Radiation therapy or technology
- Dental hygiene
- Biology, Premed, Prepharmacy, other science
- Veterinary Technology
- Medical Assisting
- Medical Technology
- Clinical Research
- Education
- Social work
- My major is not listed above

Have you taken a chemistry course at the college level?
- Yes
- No

What grade did you receive in high school biology?
- A
- B
- C
- D
- F
- I don’t remember
- I did not take high school biology

In addition to school and your responsibilities in the home, how many hours do you work at a job in a typical week?
- 0 hours; I am not currently employed
- 1–10 hours per week
- 11–20 hours per week
- 21–30 hours per week
- 31–40 hours per week
- >40 hours per week
- I prefer not to answer

How many children do you have or care for on a regular basis?
- 0 children
- 1 child
- 2–3 children
- 4 children
- >4 children
- I prefer not to answer

Please read the following paragraph and answer the question shown below it:

Maintaining a healthy, functioning body, free of disease requires the coordinated actions of the organ systems of the body. For example, electrolyte concentrations in the body must be maintained at precise, homeostatic concentrations to ensure organ function. Electrolytes are soluble, inorganic molecules (such as sodium chloride) whose ionic components will conduct electricity. Decreased levels of the electrolyte potassium can cause an irregular heartbeat. One of the kidneys’ functions is to maintain plasma potassium ion levels within a specific range. The heart, in turn, ensures that plasma reaches all of the tissues and organs of the body, bathing the cells with the fluid, ions, glucose, oxygen, etc. that they need to survive and function. The brain acts as the primary control center of the body, coordinating the activities of the organs to maintain homeostasis.

Which of the following best describes the main idea of the paragraph?
- Potassium is the most important electrolyte in the body because it is involved in regulating the heartbeat.
- The kidneys regulate ion concentration levels in the blood, which supplies the cells of the body.
- Altered levels of potassium can produce an irregular heart rate, disturbing homeostasis.
- Organs work together to provide the cells of the body with appropriate levels of ions, nutrients, and other substances.
- The brain’s main function is to regulate potassium levels in the blood to preserve health.

How would you rate the stress level in your home?
- Manageable: everyone has challenges, but I feel I can handle mine right now.
- Moderate: someone in my household is experiencing financial, emotional, or physical challenges that occasionally affect my studies and other activities.
- Troubled: someone in my household is experiencing financial, emotional, or physical challenges that often affect my studies and other activities.
- I prefer not to answer.

Please describe your computer situation at home.
- I have a reliable computer and internet access.
- I have neither a computer nor internet access at home.
- I prefer not to answer.

APPENDIX B: ASSUMPTIONS FOR LOGISTIC REGRESSION

For the logistic regression conducted using the historical data set, the following assumptions were checked according to the assumptions listed by Mertler and Vannatta (13):

1. There was a sufficient ratio of cases to predictor variables.
2. To ensure power, all cells in the analysis had a frequency greater than five, and all pairs of discrete variables were greater than one and no more than 20% had frequencies less than five.
3. Multicollinearity did not exist among predictor variables.
4. There were no outliers.

The first assumption was met due to the large sample size (n = 1,380). The second assumption was checked using the Hosmer-Lemeshow goodness of fit test (13), and results indicated that the data meet this assumption. The third assumption was checked by examining correlations between the predictor variables. Only the correlation between college hours earned and college hours carried (r = 0.88) violated this assumption. Both predictor variables, however, were retained in the model because they measured distinct academic characteristics. The remaining correlation values (r < 0.43) met the assumption. The fourth assumption was met. After the data set was cleaned and the assumptions checked, the data set was considered appropriate to use for the analysis.

ACKNOWLEDGMENTS

The authors thank Sandra Parker and Byron Walton of the University of Cincinnati Blue Ash College Office of Institutional Research for their assistance in acquiring the historical data set.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS


REFERENCES