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# Contributing Factors to Student Success in Anatomy & Physiology: Lower Outside Workload & Better Preparation.

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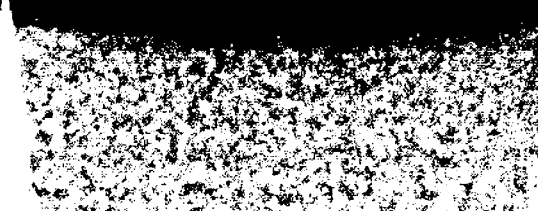
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## CONTRIBUTING FACTORS TO Student Success in Anatomy & Physiology:



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DAVID E. HARRIS   LYNN HANNUM   SAT GUPTA

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**B**asic science courses such as Anatomy & Physiology are requirements of virtually all undergraduate programs in the health sciences including those in nursing. There is ample evidence that success in these courses correlates both with success later in the program (Henderson & Orr, 1989; Neuman, 1991) and with passing state licensure examinations (Bello et al., 1977; Dean & Fisher, 1992). However, little is known about the factors that correlate with success and failure of students in undergraduate Anatomy & Physiology.

In an effort to understand the factors associated with success in undergraduate Anatomy & Physiology coursework, we studied students enrolled in the first semester of a traditional two-semester Anatomy & Physiology course sequence. We collected general demographic facts, information about prior preparation for the study of Anatomy & Physiology, and data about

other factors in our students' lives that might limit their study time. We then determined the factors that correlate with final course grade. Our results suggest steps that high school and undergraduate biology faculty might take to enhance the likelihood of student success in Anatomy & Physiology and other basic science courses of an undergraduate health science curriculum.

## Methods

### Setting

Lewiston-Auburn College (LAC), is a small (~1000 full time equivalent students), liberal arts, commuter college that is part of the University of Southern Maine (USM). It is located in Lewiston, Maine, a working-class community in central Maine with an important ethnic tradition (60 % Franco-American). LAC offers several interdisciplinary degrees including a degree in Natural & Applied Sciences. It also offers a master's program in occupational therapy and the extension of the four-year bachelor's degree in nursing from the USM College of Nursing & Health Professions located in Portland, Maine, 45 miles to the south.

The Anatomy & Physiology course at LAC is a traditional two-semester sequence. It includes 2.5 hours of lecture and 3 hours of laboratory time per week, and awards 4 college credits. During the period of this study,

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the course utilized a standard undergraduate textbook (Martini, 2001). The course grade was determined from the class grade (75% of course grade) and the laboratory grade (25% of course grade). The class grade was computed from three one-hour exams (20% of class grade each), weekly quizzes (20% of class grade combined), and weekly homework assignments (20% of class grade combined). The laboratory grade was computed from a similar mix of examination, quiz, and homework grades. Both the laboratory and class grades also included an opportunity for students to write an extra credit paper due at the end of the semester.

The Anatomy & Physiology courses at LAC are service courses both for the USM bachelor's degree in nursing and for several nearby associate degree nursing programs. They are also introductory courses for the LAC Natural & Applied Science major and prerequisites for three area master's degree programs in the health sciences (Nursing, Occupational Therapy, and Physician Assistant). Thus, students in the Anatomy & Physiology classes may have a range of backgrounds and goals.

LAC is an institution that prides itself on the accessibility of its programs and student-centered nature of its pedagogy. Both class and laboratory faculty made themselves available to students in a variety of settings. All faculty held weekly "office hours" and multiple review sessions prior to each exam. The class instructor also held weekly review sessions open to all students.

## Data Collection

The study population consisted entirely of students taking the first semester class of Anatomy & Physiology at LAC during fall 2000 (one class section) and 2001 (two class sections) from a single instructor (DEH). DEH and another instructor taught laboratory sessions attended by these students. The instructors coordinated the curriculum so that all lab sections used similar assignments and measurement tools.

Using an individual questionnaire, we collected information about student demographics, other factors that could impact student study time (work hours, other coursework, and number of dependent children), and background in science courses (both high school and undergraduate). We also used a previously validated set of questions (Stratford & Finkel, 1996) to assess students' attitudes toward science. In these questions, higher numbers represent a more positive attitude toward science. The maximum possible score was 35.

During the first class of the semester, after obtaining informed consent, students were asked to complete the questionnaire and to include the last four digits of their social security number. This acted as a unique identifier. Student participation was voluntary. At the end of the semester, each student's questionnaire

answers were tabulated and linked to their course grade. This protocol was approved by the USM Institutional Review Board.

## Statistical Analysis

All study information was entered on the Excel spreadsheet (Microsoft Corporation, Redmond, WA) for initial analysis, and then transferred to the statistical software Minitab (Minitab Inc., State College, PA) for more detailed scrutiny.

To determine the correlates of success in Anatomy & Physiology, we performed a stepwise linear regression analysis with course grade as the dependent variable and the following independent variables: age, sex, type of degree desired (associate's, bachelor's or master's), number of hours per week of paid employment, number of credit hours of coursework during the study semester (including the 4 credits of Anatomy & Physiology), number of children at home, number of mathematics and science courses taken in high school, number of credit hours of mathematics and science coursework completed in college, and science attitude score. For this model, during the initial search, all variables were considered with an Alpha-to-Enter of 0.15 and an Alpha-to-Remove of 0.15. However, in the final analysis, variables were called significant and included in the model only if they had p-values < 0.05. One variable with a p value close to 0.05 was also included in the final model as a nearly significant predictor.

As a secondary analysis, we also compared nursing majors to non-nursing majors. For this analysis, we employed independent sample t-tests for continuous variables and a chi-square analysis for categorical variables. The data sets were large enough (N= 65 for nursing majors group and 26 for non-nursing majors group) so that normality of the data was not a serious issue in the use of t-tests. Descriptive results are reported as Mean±SD unless noted otherwise.

## Results

### Study Subject Characteristics

A total of 107 students began the first semester of Anatomy & Physiology during the fall of 2000 and 2001 in classes taught by DEH. Of this number, 7 students (2 in 2000, 5 in 2001) did not complete their questionnaires, and 9 students (5 in 2000, 4 in 2001) left the class prior to mid-semester. This left 91 students in the study (34 in 2000, 57 in 2001).

The students in this study were overwhelmingly (82%) female and had an average age of 28 years with 31% of students 30 years old or older (i.e., non-traditional age). On average, the students in this study worked 29 hours per week at paid employment and

**Table 1. Student Characteristics**

	Nursing (N=65)	Non-Nursing (N=26)	P-value	All Students
Age (Years)	28.9±8.3	26.2±6.5	0.112	28.1±7.9
Sex (% Female)	85	77	0.394	82
Final Grade (%)	73.1±14.2	79.3±14.7	0.073	74.9±14.5
Degree Type (% A/B/M)	54/40/6	12/73/15	0.001*	42/49/9
Work Time (Hrs/wk)	28.1±13.8	31.6±15.1	0.317	29.1±14.9
Current Coursework (Credit hours)	10.0±4.2	10.0±5.1	0.981	10.0±4.4
Dependent Children (#)	1.0±1.1	0.4±0.7	0.002*	0.8±1.0
High School Preparation (Courses)	3.4±1.3	4.2±1.3	0.017*	3.6±1.3
College Preparation (Credit hours)	4.7±6.3	10.5±8.7	0.004*	6.3±7.5
Science Attitudes Score	28.1±4.2	28.8±3.7	0.461	28.3±4.1

Student profiles with breakdown by major (nursing vs non-nursing): Data are reported as mean±SD for continuous variables. "Degree Type" is reported as percent students seeking associate (A) bachelor's (B), or master's (M) degrees. "High School Preparation" reflects the number of courses in mathematics and science taken in high school. "College Preparation" reflects the number of credit hours in mathematics and science completed at the post-secondary level. Significance at  $P < 0.05$  is indicated with \*.

were taking 10 hours of coursework (including the 4 hours of Anatomy & Physiology). Just under 1/2 of students (45/91=49%) cared for children at home. About 40% of students sought associate's degrees, 50% sought bachelor's degrees and 10% sought master's degrees. Prior to beginning this course, the students had, on average, completed 3.6 high school courses and 6.3 credit hours of undergraduate study in the areas of mathematics and science. They had a mean Science Attitude Score of 28 (of a possible 35). The mean course grade was 75%, which corresponds to the letter grade C (Table 1). Of the 91 students in this study, 35% received a grade of D or F while 31% received a grade in the C range (C-, C or C+), 18% received a grade in the B range, and 16% received a grade in the A range.

### Correlates of Success in Anatomy & Physiology

The completed stepwise linear regression model identified three independent variables that correlated significantly (at the  $p < 0.05$  level) with final course grade. These were (in order of descending significance): number of mathematics and science courses taken in high school ( $p = 0.010$ ), number of mathematics and science credits taken in undergraduate school ( $p = 0.015$ ), and number of credit hours of coursework during the study semester ( $p = 0.025$ ). A fourth independent variable, number of hours of paid employment per week,

showed a strong but non-significant trend toward correlation ( $p = 0.054$ ) and was also included in the model.

The two preparation variables (high school mathematics and science courses taken, and undergraduate mathematics and science credits taken) correlated positively with final course grade while the two variables that impacted on student study time (number of hours of coursework and paid employment during the study semester) correlated negatively with course grade. Number of children showed a non-significant negative correlation with final course grade ( $p = 0.093$ ). The regression equation was:

Final grade =

$$74.7 + 2.9 \cdot \text{HP} + 0.481 \cdot \text{CP} - 0.77 \cdot \text{CC} - 0.20 \cdot \text{WT}$$

Where: HP = high school preparation (the number of high school mathematics and science courses completed)

CP = college preparation (the number of college mathematics and science credit hours completed prior to taking Anatomy and Physiology)

CC = current credits (the number of credit hours of college coursework being taken during the study semester)

WT = work time (the number of hours per week of paid employment during the study semester).

Although no causal relationship is implied, this model predicts that the final course grade a student receives in Anatomy and Physiology will increase 2.9 points for every high school mathematics and science course he/she has taken, and will increase 0.481 points for every college mathematics and science course credit he/she has completed. However, the model also predicts that course grade will decrease 0.77 points for every credit hour of study and 0.20 points for every hour of paid employment that the student assumes each week. The completed four-variable model had an  $R^2$  value of 18.3, indicating that these four variables explain only 18.3% of the variation in final course grade. This  $R^2$  was highly significant given that, for the final model,  $p=0.002$ .

### Nursing vs. Non-Nursing Majors

Nursing majors ( $N=65$ ) were similar to non-nursing majors ( $N=26$ ) in age, sex distribution, number of hours per week of paid employment, and number of hours of coursework during the study semester. The two groups also had similar attitudes toward science (Table 1).

However, nursing and non-nursing majors differed in important ways. When compared to non-nursing majors, nursing majors had significantly less preparation for the study of Anatomy & Physiology in high school, and in college. Nursing majors cared for significantly more children at home than did non-nursing majors. Nursing and non-nursing majors also had significantly different distributions in the degrees they sought. The majority of nursing majors sought associate degrees while the majority in non-nursing majors sought bachelor's degrees. There was a trend, which did not reach statistical significance at the  $p<0.05$  level, toward nursing majors receiving lower final grades than non-nursing majors (Table 1).

### Discussion

#### Personnel Shortages in the Health Sciences

The US is currently experiencing personnel shortages in healthcare professions. In nursing, a 28.7% decrease in the number of students sitting for the national licensure examination between 1995 and 2001 (Rosseter, 2002) and an aging of the current population of registered nurses (Beurhaus et al., 2000; US Department of Health and Human Services, 2001) is producing a nursing shortage just as evidence is mounting that the presence of highly trained professional registered nurses at the bedside enhances the recovery of hospitalized patients (Needleman et al., 2002).

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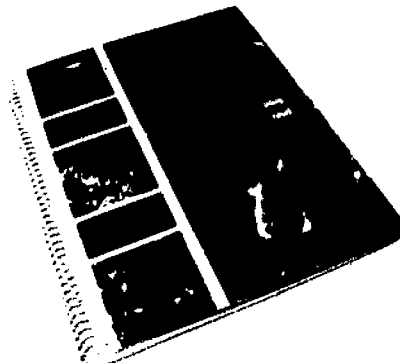
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These occupational shortages represent future employment opportunities for our students. They also represent challenges for those of us who teach in the biological sciences at the secondary and undergraduate levels. Obviously, we wish to encourage capable students to pursue study in the health sciences and to optimize the retention of those who have the potential to become qualified professionals. However, to provide the support students need to graduate healthcare programs, we must have an insight into the factors that correlate with student success and failure in the study of basic biology.

### **Importance of Success in Undergraduate Basic Science Education**

Because it is a requirement for programs of study in health sciences, a basic science course such as Anatomy & Physiology can assume an unplanned "gatekeeper" function to professional advancement. This seems to be the case at LAC. Students taking Anatomy & Physiology at LAC have a range of educational and professional goals, and each professional program has its own grade requirements. For instance, area nursing programs commonly require a minimum grade of C or C- in basic science courses, while the occupational therapy master's program at LAC requires a B or above. However, it is clear from the fact that 1/3 of students in this study received a grade of D or F, that many of the students who take Anatomy & Physiology at LAC do not achieve the grade they need to continue with their course of study. Some of these students may retake the course and receive higher grades, however others may change their professional goals or drop out of higher education completely.

The nursing profession is struggling to educate and retain professionals who combine the specialized skill and knowledge needed to function in the modern healthcare system with the caring that is a traditional hallmark of nursing (Future Steering Committee, 2002). It is possible that this high failure rate reflects a slowness on the part of educators to communicate the technical nature of the nursing profession to prospective students.

One possible response to this high failure rate would be to lower the grading standards in Anatomy and Physiology and to pass more students without improving student learning. Even if this approach were ethically and professionally acceptable to undergraduate faculty, it would be counterproductive for practical reasons. Completion of Anatomy & Physiology coursework with a minimum grade of B (Dean & Fisher, 1992) and maintaining a minimum of a C average in all college science coursework (Bello et al., 1977) have been shown to predict success in completing a nursing cur-

riculum. Furthermore, achievement in undergraduate science coursework predicts success for nursing students in state licensure examinations (Henderson & Orr, 1989; Neuman, 1991). Because students need the knowledge they gain in undergraduate science courses, such as Anatomy & Physiology, to succeed as healthcare professionals, secondary and undergraduate science faculty should examine methods to optimize student success in Anatomy & Physiology without reducing learning standards.

### **Predictors of Success in Undergraduate Basic Science Education**

We have found that the final grade in an undergraduate Anatomy & Physiology course is positively correlated with the amount of previous study of mathematics and science in both high school and college. This adds to existing evidence showing that studying biology in high school positively impacts undergraduate biology grades for first-year nursing majors in England (McKee, 2002). It is also in general agreement with studies that show a positive correlation of rigorous high school academic background (Hamilton, 1997; House, 2000) and preparation in mathematics and science (Sadler & Tai, 2001) with success in undergraduate science study.

These findings suggest that high school and undergraduate faculty and academic advisors should encourage students with an interest in the health sciences in general, and students with an interest in nursing in particular, to increase their exposure to mathematics and science courses. Undergraduate institutions could also consider developing supplemental or remedial courses specifically designed to enhance the likelihood of success in Anatomy & Physiology. An approach similar to this has been shown effective at improving the chemistry grades of nursing majors (Van Lanen & Lockie, 1997).

We have also found a negative correlation between factors that reduce the time students have available for study (e.g., other coursework and paid employment) and course grade in Anatomy & Physiology. We are not aware of any other studies that addressed these issues directly, however this result is certainly in agreement with the anecdotal impressions of both faculty and students at LAC. This finding raises an interesting caveat. Faculty at LAC (and elsewhere) commonly provide opportunities for extra faculty-student contact (e.g., review sessions) and include the option for extra credit assignments in their grading systems. However, for students who are struggling from a lack of study time, these opportunities may offer little help. If this is the case, one solution might be for academic advisors to

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## Contributing Factors to Student Success

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work with students to help them develop more realistic educational timetables and schedules.

### Additional Paths to Success

The  $R^2$  value (18.3%, Table 2) for the linear regression model in this study, while highly significant, leaves room for the search for additional predictors of final student grade in Anatomy & Physiology. Thus, there may

in undergraduate introductory biology courses. It is also likely that there is no single right answer for all students or for every institution. This suggests that faculty should be open to new ideas and willing to experiment.

### Study Limitations

Because it did not employ a randomized design, this study provides information of correlation, but does not address causation. For instance, the significant correlations between exposure to mathematics and science course work (in both high school and college) and final grade in Anatomy & Physiology (Table 2) could simply

indicate that students with more science aptitude both take more science courses and achieve better grades in those courses. However, given the evidence that supplemental chemistry instruction led to improved grades for those (mainly nursing) students who chose to access it (Van Lanen & Lockie, 1997), undergraduate programs of remedial or supplemental instruction for Anatomy & Physiology seem reasonably likely to help some students.

Other limitations flow from our study population. Given the nature of the student body at LAC, the study population was fairly homogeneous in, for instance, geographical distribution (LAC is a commuter college) and sex.

Thus, these results may not apply to other student groups. The limited  $N$  of this study also reduces the statistical power of our analysis. However, the sample size was large enough to both detect significant differences between the nursing and the non-nursing students and to find significant predictors of final course grade. In addition, we were interested in the fact that, given the time-intensive nature of child rearing, number of children was not a significant predictor of final grade in this study.

**Table 2. Correlates of Final Grade**

STEP	1	2	3	4
<b>Constant</b>				
Coefficient	64.6	63.4	67.9	74.7
<b>High School Preparation (Courses)</b>				
Coefficient	2.8	2.4	2.8	2.9
P-value	0.012	0.031	0.014	0.010
<b>College Preparation (Credit hours)</b>				
Coefficient		0.43	0.43	0.48
P-value		0.033	0.031	0.015
<b>Current Coursework (Credit hours)</b>				
Coefficient			-0.59	-0.77
P-value			0.079	0.025
<b>Work Time (Hrs/wk)</b>				
Coefficient				-0.20
P-value				0.054
<b><math>R^2</math></b>	6.8	11.6	14.7	18.3

Results of stepwise linear regression analysis using final course grade as the dependent variable and the following independent variables: age, sex, type of degree desired, number of hours per week of paid employment (work hours), number of credit hours of coursework during the study semester (current coursework), number of children cared for at home, number of mathematics and science courses taken in high school (high school preparation), number of credit hours of mathematics and science coursework completed in college (college preparation) and science attitude score. For the completed model,  $R^2 = 18.3\%$  and  $p = 0.002$ .

be any number of ways to improve student learning (and grades) in undergraduate Anatomy & Physiology courses. Although they may be difficult to evaluate quantitatively, a variety of techniques including computer assisted learning (Harris, 1997; Wharrad et al., 2001), investigative approaches to laboratory learning (Norton et al., 1997), cooperative learning (Trautwein et al., 1997), and student-centered pedagogy (Heady, 1997) have been proposed to improve student learning

(Two other variables that impacted student study time, hours of paid employment and other coursework, were included in the regression model.) One possible explanation is that collecting data on only the number of children (as we did here) is inadequate because it ignores important factors such as the age of the children and the level of support in the home environment that impact how much time a student with children has to study.

## Conclusions

Working with a largely non-traditional, predominantly female, undergraduate student population, we have found that prior preparation in mathematics and science in both high school and college provide significant positive correlation with final grade in undergraduate Anatomy & Physiology. However, factors that could reduce student study time, including the level of concurrent coursework and the number of weekly hours of paid employment, correlate negatively with final grade. We also found that nursing majors began the study of Anatomy & Physiology with significantly less prior preparation in mathematics and science (at both the high school and college levels) than did non-nursing majors. More study is required to determine if these correlational findings indicate a cause-and-effect relationship. However, these findings suggest that biology faculty at the secondary and undergraduate levels might help students entering healthcare professions, including nursing, by encouraging them to increase their exposure to mathematics and science coursework (including supplemental and remedial instruction) and, if possible, limit the factors that reduce their study time when taking Anatomy & Physiology.

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