Characteristics of Student Success in a Graduate Physiology Course

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Abstract

Data were obtained from 309 students enrolled over a 23-year period in Advanced Physiology and Anatomy of Domestic Animals, including a 30-question pretest. There were 184 (59.6%) female and 125 (40.4%) male students. Pretest averaged 60.6 ± 0.76 (± SE) and final score averaged 86.1 ± 0.26. Analyses of variance for pretest score showed that degree sought ($P < 0.02$), department of study ($P < 0.05$), BS institution ($P < 0.001$) and background courses in physiology ($P < 0.02$) and biochemistry ($P < 0.001$) affected pretest scores. The pretest score was 59.5 ± 1.8 for incoming MS students, which was lower than scores for incoming PhD students (64.4 ± 2.0). Students from US Land Grant institutions, US non-Land Grant institutions and Virginia Tech scored higher on pretests than students from Chinese institutions. Final score was affected by gender ($P < 0.02$), previous degree ($P < 0.001$), pretest score ($P < 0.001$) and completion of background courses in anatomy ($P < 0.05$), organic chemistry ($P < 0.02$), biochemistry ($P < 0.001$) and statistics ($P < 0.02$). Pretest score and courses in biochemistry and anatomy were positively related to final score. Final score was 86.2 ± 0.97 for females compared to 84.9 ± 0.97 for males. The MS students had a final score of 85.3 ± 0.63 which was lower than that obtained by PhD students (87.9 ± 0.72). Although cause is not always apparent, multiple factors affect performance in graduate physiology and anatomy.

Introduction

The background of international students attending graduate school in the United States is often of concern because preparation of students often differs from educational systems in the United States. Transition to graduate study for international students can be difficult. Because of a number of factors, many international students arrived only a few days before classes begin. Adjustments to changes in culture may be severe. Factors that affect the final grade of graduate students were assessed by Gwazdauskas et al. (1986) under the quarter system. At that time, the course was part of a three-quarter graduate sequence in physiology. Then, international students had lower pretest and final grade scores than students who graduated from major colleges or universities in the U.S. There has been a change in source of international student populations taking graduate physiology and anatomy in this institution with more students now representing cultures of eastern Asia than in Gwazdauskas et al. (1986). Other factors shown to impact student success in various courses taken at a university include a negative class size effect (Becker and Powers, 2001), hands-on teaching models (Partridge, 2001), student standing in the class, undergraduate or graduate; (Wattiaux and Crump, 2006) and curriculum background and gender (Kensinger and Muller, 2006). The proportion of females enrolled as graduate students at Virginia Tech in the College of Agriculture and Life Sciences increased from 35.4% in 1990 to 55.7% in 2011 (Institutional Resources, 2013).

Pretesting has been used to evaluate and assess how background foundation influenced success in the current class (Collins et al., 1999; Bing et al., 2011; Schwartz et al., 1974; Saleh et al., 2007; Usta, 2011). Collins et al. (1999) and Schwartz et al. (1974) found that more background courses were associated with higher pretest and posttest achievement. Students with background classes in biochemistry, cell physiology and organic chemistry generally performed better in graduate physiology than students without these background classes (Gwazdauskas et al., 1986).

The objective of this study was to reassess the factors reported by Gwazdauskas et al. (1986) in light of a more intense semester course and changes in graduate student enrollment over the past 23 years to reassess characteristics affecting pretest and final grade scores in a graduate domestic animal physiology and anatomy course.

Materials and Methods

Data were collected from August 1988 to December 2011 for 309 students enrolled in Advanced Physiology and Anatomy of Domestic Animals, a 5-credit graduate

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offering with 4 h of lecture and one 3-h laboratory each week. The course is a graduate-level survey of general physiology. Major topics include cardiovascular (12 lectures), respiratory (four lectures), renal (four lectures), endocrine and reproduction (four lectures), neural (nine lectures), sensory (five lectures), motor (three lectures), digestive (nine lectures) and skeletal (three lectures) physiology. Laboratory experiments approved by the IACUC included bovine jugular catheterization with blood volume determination and changes in blood characteristics associated with dehydration and water loading; physiograph experiments which evaluated contractile properties of smooth and skeletal muscle in response to sympathetic and parasympathetic drugs and electrical stimulation and blood pressure changes in sheep in response to vagus nerve stimulation and the effects of sympathetic and parasympathetic drugs; sheep brain dissection; stereotaxic surgery to acquaint the student with the use of stereotaxic instruments placing a cannula into the lateral cerebral ventricle of a chicken; and digestion experiments that determined the selective absorption of compounds from the gut and evaluated isotope collection techniques for comparing rates of metabolism of compounds to understand how metabolic procedures can be used.

Student background information obtained on the first day of class included: name, department of study, degree(s) and institution(s) and courses taken as undergraduate or graduate students in histology, anatomy, embryology, physiology, cell physiology, organic chemistry, biochemistry, cytology, genetics and statistics. Following discussion of the syllabus and class expectations, a 30-question pretest was administered. Students were assured the pretest would not affect their final grade. The pretest included 15 multiple choice questions on general physiology and 15 short answer or definition questions of basic terminology and units of measure. Approximately 10 minutes were allowed for the pretest. Final score in the course ranged from 68.3 to 97.0 and was based on a weighted combination of grades for the highest nine of 10 quizzes, four hourly exams, five laboratory reports, two lecture presentations and an oral final examination.

Students originated from 10 departments. These included Animal and Poultry Sciences (APSC; n = 167), Dairy Science (DASC; n = 95), Human Foods, Nutrition and Exercise (HNFE; n = 33), Biological Sciences (BIOL; n = 5), Agricultural Education (n = 1), Crop and Soils Environmental Sciences (CSES; n = 1), Education (n = 1), Food Science and Technology (FST; n = 1), Fisheries and Wildlife (FWL; n = 2) and Veterinary Science (VetSci; n = 3). For the final statistical analyses Agricultural Education, CSES, Education, FST, FWL and VetSci were combined into one department called 'other.'

Because over 50 colleges were represented, baccalaureate schools were combined to represent six subgroups: They were grouped into six different university designation as: 1) Virginia Tech, 2) Land Grant Universities, 3) non-Land Grant U.S. Universities and Colleges, 4) schools in India, Sri Lanka and Pakistan, 5) schools in China and 6) 'other' included baccalaureate schools in Africa and the Middle East, schools in Central and South America, European Institutions, Australian and New Zealand institutions and schools in Korea and Taiwan.

Least squares analyses of variance (Glimmix procedure of SAS 9.2) of pretest scores and final numerical grade, one score per student, were used to evaluate the effects of gender, degree (undergraduate, MS or PhD), department of study, BS institution, year the class was taken and background courses. Several interactions were tested as well. When variables were not significant, models were reduced. The final reduced model for pretest score included gender, degree, gender by degree interaction, department of study, BS institution group and a yes/no response to background classes in physiology and biochemistry. Removal of non-significant effects lead to the final reduced model for final score that included gender, degree, department of study, BS institution as describe above and a yes/no response to background courses in anatomy, physiology, organic chemistry, biochemistry and statistics. Pretest scores were included as a covariate in models to evaluate final score.

Results and Discussion

There were 184 (59.6%) female students and 125 (40.4%) male students. This proportion generally matches that of Kensinger and Muller (2006) who found females comprise 54% of students enrolled in dairy production classes. The percentage of female students in this class had increased from 10 years earlier, which reflected the 20% change in the graduate student population in our college over the past 20 years (Institutional Resources, 2013). The pretest average was 60.6 ± 0.76 (mean ± SE) and the final score was 86.1 ± 0.26. There were no significant year effects for pretest score or final score.

Table 1 shows the analysis of pretest scores. The degree attained by the student prior taking the class ($P < 0.02$), department in which the student was enrolled ($P < 0.05$), college/university where the student obtained their BA or BS degree ($P < 0.001$) and previous courses in physiology ($P < 0.02$) and biochemistry ($P < 0.001$) affected pretest score. The effects of background courses in physiology and biochemistry were positive (regression coefficients were 4.71 ± 1.89 and 6.78 ± 1.77, respectively). This result indicates that the pretest score was 4.7 points higher when physiology was previously taken and 6.8 points higher when biochemistry was previously taken. These results indirectly support Gwazdauskas et al. (1986) who found that organic chemistry increased pretest scores, because organic chemistry is usually a prerequisite to biochemistry. The importance of background knowledge leading to greater success has also been reported by Collins et al. (1999); Wattiaux and Crump (2006); and Schwartz et al. (1974).

Table 1. Analysis of variance of pretest scores in a graduate physiology class.

Effect	df	Pr > F
Gender	1	0.8237
Prior Degreey	2	0.0145
Gender*Degree	2	0.0709
Department of Origin	4	0.0302
BS Institutionz	5	0.0002
Prior Physiology	1	0.0134
Prior Biochemistry	1	0.0002
Residual	277	

[y]Prior degree refers to students currently working on a BS degree, MS degree or PhD degree.

[z]Baccalaureate schools were combined to represent six subgroups: Initially, they were grouped into 10 different university designation as: 1) Virginia Tech, 2) US Land Grant Universities, 3) non-Land Grant US Universities and Colleges, 4) Africa and the Middle East, 5) India, Sri Lanka, and Pakistan, 6) Central and South America, 7) European Institutions, 8) Australia and New Zealand, 9) China, and 10) Korea and Taiwan. In the final analyses Middle East and African Institutions were combined with those in Central and South America, Europe, Australia and New Zealand, and Korea and Taiwan into one BS Institution called 'other'.

There were no differences due to gender for pretest score with the females averaging 64.4 ± 3.4 and the males averaging 63.5 ± 3.4. These pretest scores were approximately 10 points lower than those previously reported (Gwazdauskas et al., 1986) a reflection of less time given for the pretest (10 vs. 15 minutes) or possibly due to changes in demographics of the student population.

The pretest scores were 68.0 ± 6.5 for undergraduates and not different from graduate students. The 59.5 ± 1.8 for incoming MS students, who were lower (P < 0.02) than incoming PhD students (64.4 ± 2.0) is consistent with differences reported by Gwazdauskas et al. (1986) suggesting more retention of basic materials or greater academic experience of PhD students as supported by Schwartz et al. (1974) and Collins et al. (1999). Undergraduates in this course were superior students as their advisors suggested they enroll in courses at the graduate level and consent was given prior to enrollment.

Department of study had a significant impact on pretest scores (Table 2). Students from HNFE had higher pretest scores than students from APSC. Most students in HNFE were in the exercise physiology option of study and may have had a better background in physiology than students in APSC.

Students' BS institution had a significant effect on pretest score (Table 3). Students from schools designated as U.S. Land Grant institutions, U.S. non-Land Grant institutions and Virginia Tech had higher pretest scores than students from Chinese institutions. Apparently, incoming graduate students from institutions of higher education in China had the most difficulty with the pretest and this may likely be due to lack of familiarity with English (Gwazdauskas et al., 1986). Many Chinese students had arrived in the U.S. just before classes began. Scores for students from different types of U.S. institutions did not differ; suggesting that the background education tested here is comparable across the country.

Table 2. Least squares means for pretest scores by department of origin of the students.

Department	Mean	SE
Animal and Poultry Sciences	60.5[a]	2.28
Biology	62.9[ab]	5.99
Dairy Science	60.6[ab]	2.54
Human Nutrition, Foods and Exercise	67.3[b]	3.16
Other[z]	68.6[ab]	4.89

[ab] Means with different superscripts differ at P < 0.05 by Tukey-Kramer Adjustment for differences.

[z] Departments Agricultural Education; Crop and Soils Environmental Sciences; Education; Food Science and Technology; Fisheries and Wildlife; and Veterinary Science were combined into one department called 'Other'.

Table 3. Least squares means of pretest scores for baccalaureate institutions attended by graduate students taking graduate physiology.

College/University	Mean	SE
U.S. Land Grant	69.3[a]	2.90
U.S. non-Land Grant	65.9[a]	3.03
Virginia Tech	69.1[a]	2.65
Indian, Sri Lankan, and Pakistani	62.1[ab]	4.15
Chinese	56.6[b]	3.69
Schools in the Mideast, Africa, Central and South America, Europe, Australia, New Zealand, Korea and Taiwan	60.8[ab]	3.88

[ab] Means with different superscripts differ at P < 0.05 by Tukey-Kramer Adjustment for differences.

Table 4. Percentage of 308 students completing background courses during their undergraduate or previous graduate degree program.

Background course	Mean (%)
Genetics	88.3
Organic Chemistry	85.1
Statistics	82.2
Anatomy	81.5
Biochemistry	76.6
Cell Physiology	29.2
Embryology	20.1
Histology	20.1
Cytology	9.7

The percentage of students with various background courses is presented in Table 4. Less than 30% of students had previously taken histology, embryology, cell physiology, or cytology.

The statistical analysis of final score is in Table 5. Analysis of variance for final score showed that gender (P < 0.02), previous degree (P < 0.001), pretest score (P < 0.001) and background courses in anatomy (P < 0.05), organic chemistry (P < 0.02), biochemistry (P < 0.001) and statistics (P < 0.02) impacted student performance. The regressions on pretest score (0.07 ± 0.02), biochemistry (2.32 ± 0.69) and anatomy (1.44 ± 0.66) were positively related, while previous courses in organic chemistry (-1.95 ± 0.79) and statistics (-1.71 ± 0.71) were negatively related to final score. Note that with pretest in the model, significant differences were adjusted to average pretest scores, although the adjustment was not great (0.07 for each point difference in pretest score). The significance of pretest score and background courses in biochemistry support a previous report (Gwazdauskas et al., 1986) and the addition of the positive relationship with anatomy indicate that these background courses enhance understanding the mechanisms of physiological function. It is difficult to explain the detriment of organic chemistry and statistics on final score. Typically, organic

chemistry is a prerequisite for biochemistry. An analysis without anatomy and biochemistry background in the model resulted in the same direction for the regression coefficients for organic chemistry and statistics, but no significance on final score. In further data assessment there were 17.2% of the students with no statistics or organic chemistry background courses and 12.3% of students with statistic, but without organic chemistry, suggesting students more mathematically inclined do not do as well as students with a more biologically related background.

The differences in gender were associated with final score of 86.2 ± 0.97 for females compared to 84.9 ± 0.97 for males, supportive of Gwazdauskas et al. (1986) and more recently Bing et al. (2011). Females apparently were better prepared or more motivated to perform in graduate physiology even as their proportion increased from 43.6% female for this class during 1988 to 1990 to 69.2% female during the 2009 to 2011 fall semesters.

Table 5. Analysis of variance of factors that affect final scores in a graduate physiology class.

Effect	df	Pr > F
Gender	1	0.0139
Degree	2	0.0002
Department	4	0.4118
BS Institutions[z]	5	0.7849
PreTest Score	1	0.0005
Anatomy	1	0.0304
Physiology	1	0.1543
Organic Chemistry	1	0.0145
Biochemistry	1	0.0008
Statistics	1	0.0162
Residual	271	

[z]Baccalaureate schools were combined to represent six subgroups: Initially, they were grouped into 10 different university designation as: 1) Virginia Tech, 2) US Land Grant Universities, 3) US non-Land Grant Universities and Colleges, 4) Africa and the Middle East, 5) India, Sri Lanka, and Pakistan, 6) Central and South America, 7) Europe, 8) Australia and New Zealand, 9) China, and 10) Korea and Taiwan. In the final analyses Middle East and African Institutions were combined with those in Central and South America, Europe, Australia and New Zealand, and Korea and Taiwan into one BS Institution called 'other'.

Table 6. Least squares means of final scores based on department of study of students enrolled in graduate physiology. There was no statistical difference.

Department	Mean	SE
Animal and Poultry Sciences	85.6	0.78
Biology	83.9	2.05
Dairy Science	85.1	0.89
Human Nutrition, Foods and Exercise	85.3	1.11
Other[z]	88.0	1.81

[z] Departments Agricultural Education; Crop and Soil Environmental Sciences; Education; Food Science and Technology; Fisheries and Wildlife; and Veterinary Science were combined into one department called 'Other'.

Table 7. Least squares means of final scores based on baccalaureate college of students enrolled in graduate physiology. There was no statistical difference.

College/University	Mean	SE
U.S. Land Grant Universities	85.9	1.02
U.S. non-Land Grant Universities & Colleges	86.1	1.05
Virginia Tech	85.8	0.95
Institutions in India, Sri Lanka, & Pakistan	85.6	1.46
Institutions in China	84.5	1.27
Other[z]	85.5	1.37

[z] Baccalaureate schools were combined: Middle East and African Institutions, Central and South America, Europe, Australia and New Zealand, and Korea and Taiwan into one BS Institution called 'Other'.

Significant differences were found in final score based on degree being pursued by the student. The current BS students had a final score of 83.5 ± 2.25, while MS students had 85.3 ± 0.63 which was lower than that of PhD students (87.9 ± 0.72). The differences suggest that accumulated knowledge is beneficial for having success in graduate physiology (Collins et al., 1999; Lambert, 1976; Bing et al., 2011; Saleh et al., 2007) or students who pursue additional degrees are better students and self- selection plays a role in academic success.

While BS institution and department of study were important to pretest scores, they did not impact final score in the class (Tables 6 and 7). Final scores ranged from 83.9 ± 2.05 for Biology students to 88.0 ± 1.81 for students from 'other' departments. The range in final scores by area of baccalaureate study was 84.5 ±1.27 for students from China to 86.1 ± 1.05 for students from U.S. non-Land Grant colleges and universities. It appears that students from China are able to overcome language deficits throughout the semester and score as well as the rest of the student population, unlike the earlier findings of Gwazdauskas et al. (1986).

Summary

Higher pretest scores were associated with greater academic knowledge (PhD students), especially with taking courses in physiology and biochemistry, as also was demonstrated by HNFE majors contrasted with APSC, the home of this course. Students from China were least prepared for the pretest, probably due to language and cultural difficulties. For final score, higher pretest performance, PhD status and background courses in anatomy and biochemistry continued to define success. Females outperformed males in the course. Distinctive changes through the past two decades have been the influx of high-performing females and Chinese students who quickly adapt to English.

This study provides an example of the potential of improving performance in a course by identifying which students are doing well and not, why and pro-actively remedying potential background deficiencies in future students. It also illustrates how student populations and preparedness in this basic courses change over time, creating the need for teachers to identify the changes and react to them.

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