Ten Years in the Human Anatomy and Physiology I Classroom: A Retrospective Analysis of Student Preparation, Engagement, Performance, and the Impact of COVID-19

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Abstract

Reflections on the efficacy of pedagogical changes and practices and their effect on student performance are often hindered by incomplete data, small sample sizes, and the confounding variables of multiple instructors and teaching sites. Observations from such retrospective analyses, however, are highly sought after by instructors and administrators interested in what methods significantly enhance student learning and comparisons of student success across instructors and institutions. Compilation of student data from ten years of Human Anatomy and Physiology I at the University of Mississippi enabled statistical analyses of how changes in course design over ten years of instruction, including remote instruction during the COVID-19 pandemic, were associated with student engagement and performance in Human A&P I with a large data set (n=3305) from students taught by a single instructor. Univariate analysis of variance, bivariate correlation, and discriminant function analysis (DFA) tests revealed multiple significant differences over time. Specifically, the DFA indicated that 89.5% (Discriminant Function 1) of the variation in overall course performance (i.e., letter grade) is explained by student performance variables of exam average, lab practical average, lab quiz average, and the number of Supplemental Instruction (SI) sessions attended. For Discriminant Function 2, 8.1% of the variation is explained by student engagement variables of the number of missed lecture assignments, lab assignments, and online assignments. Institutionally, these results will be used to continue effective course practices, identify engagement strategies that enhance student motivation and reduce anxiety, and develop a performance dashboard that will both identify struggling students and coach students towards success in A&P.
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Key words: anatomy, physiology, human, education, active learning, laboratory, prerequisites, performance, engagement, COVID-19, pandemic, meta-analysis, retrieval practice, backwards design, course blueprinting, high-structure

Introduction

Milestones in an academic career can be as celebratory, and provoking of self-reflection and assessment (Seithers et al., 2021), as personal milestones. The completion of the Fall 2020 academic semester also marked the completion of ten years of my teaching Human Anatomy & Physiology (A&P) I at the University of Mississippi. These ten years saw a 25% increase in course enrollment combined with a campus-wide increase in careers in the health professions (U. Miss, 2014), implementation of a Supplemental Instruction program (U. Miss, 2022; Eroy-Revels et al., 2019), an increased role of undergraduate teaching assistants in the laboratory (Hopp et al., 2019; Luckie et al., 2020), use of evidence-based teaching practices including emphases on time management and self-disciplined study, and ended with a global pandemic disrupting nearly all components of higher education (Schaefer, 2022).

In 2011 my charge was to assume control, as the sole instructor, of the Human A&P program and teach the two, sequential courses. These two courses, Human A&P I and II are challenging and have high attrition rates; Lunsford and Diviney (2020) describe Human A&P as a challenging, entry-level course that is often viewed as a "killer" course by students. Students often enroll in A&P under-prepared, relying on study habits that served them well in high school incorrectly assuming that college is like high school and the responsibility for their learning is the instructor's rather than theirs (Lunsford and Diviney, 2020). These factors lead to a high attrition rate and a risk of students having their goals dashed and leaving higher education with large debts and diminished prospects (Lunsford and Diviney, 2020). With a goal of improving positive student outcomes (e.g., engagement and enjoyment as well as increased performance) while reducing negative outcomes (e.g., frustration and complacency as well as decreased performance), the University of Mississippi courses have changed to reflect needs of both the course curriculum and student goals, limitations of course administration (e.g., academic calendar, lecture and laboratory space, etc.), and limitation of course (e.g., laboratory equipment) and student resources both financial and temporal. Using the high-impact, pedagogical techniques of course blueprinting (Coderre et al., 2009; Villarroel et al., 2018), backwards design (Wiggins and McTighe, 2005; Emory, 2014), and

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high-structure (Wilton et al., 2019; Beck and Roosa, 2020) in conjunction with careful selection and development of learning activities and assessments and regular opportunities for retrieval practice (Bae et al., 2019; Dobson et al., 2017; Ritchie et al., 2019), has led to subjective year-to-year improvements in outcomes but analyses had never been undertaken to identify long-term, statistically significant changes.

Examination of attrition, or DFW rates (i.e., percent of students not meeting the requirement of passing A&P I in order to enroll in A&P II), and identification of at-risk students is common because of its important for students, educators, and administrators alike and has been the focus of several reports. Russell et al. (2016) found that factors associated with a higher pass rate included higher age (of the student); not taking a developmental reading, writing, or math class; taking any college credits prior to A & P I; not repeating any college course with or before A & P I; not being a first-generation student; taking a freshman biology, chemistry, or physics class before A & P I; and taking a daytime class. Sturges et al. (2016) found positive correlations between motivation, hours of study, and undergraduate grade point average and passing rates. Keller and Hughes (2021) examined the relationship between declared major and success in A&P I and found no significant differences in a two-year study. Young et al. (2019) found a significant, positive relationship between self-efficacy and gender (female). In an analysis of prior coursework and success in A&P I, Hopp (2009) found that a positive relationship between previous coursework in chemistry and success in A&P I.

These reports have both strengths and weaknesses. Russell et al.'s (2016) large sample size (over 3500 students) and length of study (13 years) is countered by variability in course resources (e.g., texts, lab manuals), faculty, campus, and grading cutoffs. Similarly, Sturges et al. (2016) has a large sample size (over 1200 students) but draws its data from both A&P I and II courses taught by multiple instructors over a two-year period. Young et al.'s (2019) data are based on a single semester's study. Small sample sizes and limited time frames of study make inferences on factors associated with passing rates in A&P I challenging to produce. In 2016 the Human Anatomy and Physiology Society undertook an investigation into high attrition rates and the impact of prior coursework (e.g., prerequisites) on success in Anatomy and Physiology courses (Hull et al., 2016). The survey was broad in the scope of questions while narrow in the response variable (attrition) but failed to obtain enough responses (an estimated 220) to be able to perform statistical analysis to detect treatment effects while minimizing the potential for Type I and Type II errors (Jackson, 2017). While the present study only focuses on one Human Anatomy and Physiology course and cannot take the place of broad sampling of instructors and institutions, the sample size is large, and consistency of instructor and course grading scales enables greater insight into success rates in A&P I.

Institutional policy (e.g., contact hours, delivery format) and structural resources (e.g., lecture and lab room sizes and availability) may constrain development of the ideal A&P course experience, but incorporation of Human Anatomy and Physiology Society (HAPS) Learning Outcomes (HAPS 2019a) with backwards design and course blueprinting principles can create an enriching and rewarding experience for students and educators. The backwards design framework starts with identification of learning outcomes and supports curriculum planning and alignment to achieve congruence between student outcomes and measurable learning verbs or "facets of understanding" [(e.g., explanation, interpretation, application, perspective, empathy, and self-knowledge) Wiggins and McTighe, 2005; Emory, 2014]. Identification of assessments appropriate to the desired learning outcomes is the second step of backwards design and can be simultaneously incorporated with course blueprinting principles. While the primary function of a course blueprint is to validate assessment tools, it can also be used to guide the selection of learning activities (Coderre et a., 2009; Villarroel et al., 2018). A course blueprint can be constructed methodically and quantitatively enabling objective insight to the relative weighting of course assessments (McDonald et al., 2016) and should be maintained through a systematic monitoring of course content (Coderre et al., 2009; Villarroel et al., 2018).

With practical applications for supporting the success of underrepresented minorities in introductory biology courses, a high-structure course design (Wilton et al.., 2019) can also be used for human A&P courses. Courses with increased structure incorporate multiple formative assessments or interventions, including pre-class videos/reading coupled with quizzes, in-class active learning modules, mock exams, and small near-peer collaborative workshops to effectively promote student performance (Wilton et al., 2019). Bae et al. (2018) found that free recall and practice quizzing were the most singularly effective forms of retrieval practice (as compared to test generation and keywords) but combining practice quizzing and test generation with free recall led to significant gains in performance.

In practice, a high-structure design can model the self-discipline and time management skills that first and second-year undergraduate student lack (Lunsford and Diviney, 2020), and the visual and conceptual content within an A&P course provides multiple opportunities for retrieval practice and formative assessments. Implementation can be free-form and one-on-one, or small group, methodical (daily, weekly, etc.) and quantifiable using internet or publisher-provided resources. The latter provides convenience to the instructor, particularly with large classes, of synchronously entering scores into a learning management system.

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However, changes in the curriculum of a course and its administration are rarely implemented solely for convenience, but rather are done to increase student proficiency in engagement and learning outcomes achieved. Empirically demonstrating that these objectives have been met is challenging due to small sample sizes; multiple instructors with changing instructional responsibilities; increased demands on both students and instructors; interaction of factors affecting student achievement; factors outside the influence of students or instructors; and inconsistent record keeping. This study is uniquely positioned to minimize these challenges of demonstrating positive, long-term impacts of curricular changes due to the following features: a single individual (Britson) was the instructor of record; lectures met three times per week at on the same week days and times; laboratory sections met once per week for 2 hours on the same days and times; the sequence of lecture and laboratory topics remained the same; and the number of major assessments (lecture exams and laboratory practicals) remained nearly unchanged during the study period (2010-2020). The exceptions were due to the COVID-19 pandemic and the home institution shortening the fall 2020 semester by 1.5 weeks resulting in an altered lecture sequence and number of lecture exams. Diligent record keeping and the construction of a cumulative data set during these ten years presented an opportunity to combine reflection with statistical analyses, and comparison of a pandemic altered curriculum to the unaltered curriculum, both powered by data from over 3300 students. With a large data set, both Type I and Type II statistical errors can be avoided with increased sensitivity (Kaplan et al., 2014; Faber and Fonseca, 2014). Calculation of effect sizes (Cohen, 1988; Lakens, 2013) will also enable a reasoned interpretation of results [(i.e., determination of differences between statistical significance and real-world, classroom significance (Britson, 2020)].

The primary objective of this retrospective analysis was to examine how changes in course design over ten years of instruction were associated with student engagement and performance in Human A&P I. Longitudinal trends will be used to evaluate the impact of difference course delivery on students during a full semester of remote instruction due to the COVID-19 pandemic. In addition to contributing to the development of an A&P success dashboard that would potentially be useful to both instructors and students, the data set, in its size and breadth, can be a useful tool for other instructors wanting to compare their courses and data.

Materials and Methods

Human Anatomy and Physiology (A&P) I at the University of Mississippi is a 4-credit, combined lecture-lab course and is continued by Human A&P II which is also 4-credit, combined lecture-lab course. Human A&P I centers around the Human Anatomy and Physiology Society Learning Outcome Modules A through H (Body Plans through Nervous System; HAPS 2019a) and Human A&P II continues with Modules I through R (General and Special Senses through the Reproductive System; HAPS 2019a). Both courses are designed to meet the needs of students in the general education curriculum and in the allied health fields. Human A&P I is offered during the fall and first summer sessions while Human A&P II is offered during the spring and second summer sessions. Separate, advanced human anatomy, comparative anatomy, histology, and embryology courses are offered for students majoring in the sciences.

Students enrolled in Human A&P I at the University of Mississippi during the fall semesters of 2011-2020 were the subjects (n=3305) from which data were collected for this study [approved as Exempt under 45 CFR 46.101(b) (#4); University of Mississippi Institutional Review Board Protocol #21x-314]. Students in their 2nd year of study represented 44.4% of the group; students in their 3rd year, 22.7%; students in their 4th year, 17.4%; students in their 1st year, 12.1%; and students in their post-undergraduate education, 3.3%. Over 75 declared programs (i.e., majors) were represented with the largest groups coming from students majoring in exercise science (27.8%), allied health (pre-nursing, occupational therapy, cytotechnology, dental hygiene, health information management, radiological science, medical technology, etc.; 26.3%), general studies (10.6%), dietetics and nutrition (8.3%), biological sciences (7.4%), pre-pharmaceutical sciences (4.8%), and chemistry (2.1%). Common career goals included nursing, physician assistant, physical therapy, medicine, and dentistry (Hillhouse and Britson, 2018; O'Connor and Britson, 2017). De-identified, prior preparation data [highest ACT score, high school grade point average (GPA), and undergraduate GPA)] for students enrolling for the first time in Human A&P I for the study period were obtained from the universities office of Institutional Research Effectiveness and Planning (IREP). Within the prior preparation data, sample sizes were unequal across years because the students may not have submitted a score, may have entered as a transfer, or may have just started their undergraduate education. The IREP office refrained from linking the data to individual students without written consent from each student. As this report is a retrospective study, these consent forms were not available.

Throughout the ten-year time frame of this study, all Human A&P I students were taught by the same instructor (Britson) in a single lecture section, and in the same auditorium, meeting at 8am on Mondays, Wednesdays, and Fridays during the fall semesters. Best practices for A&P instruction in large classrooms (e.g., student assistants, personal response systems, active learning, attendance tracking when feasible; Hill et al., 2017; Dogrell, 2021; Marwaha et al., 2021) were used throughout the study. Students met in groups of 30 for 2-hour lab sessions once per week.

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Curricular modifications throughout the study are mapped by year in Table 1. The earliest changes included the adaption of a virtual cadaver resource for self-study and lab preparation (Kerce, 2013), and the reduction in the Teaching Assistant (TA) to student ratio in the lab from 1:30 to 1:15. This reduction enabled lab instruction to be more aligned with HAPS course and safety guidelines (HAPS, 2019b) and used an 'experienced TA paired with a new TA' model (Hopp et al., 2019) to enhance instruction and student engagement as well as curriculum continuity from year to year. Three to six, peer-led Supplemental Instruction (SI) sessions have been offered each semester throughout the study period. Weekly attendance was recommended throughout the study but was additionally encouraged by offering a small amount of extra credit (typically no more than 1 percentage point) starting in 2014. This incentive was part of an "extra credit bucket" of a variety of activities [e.g., volunteering for student research projects (Hillhouse and Britson, 2018; O'Connor and Britson, 2017), participating in course surveys, completing additional online homework, etc.] students could pursue to add up to 3-4 percentage points to their score at the end of the semester.

<table>
<tr><th></th><th>Fall 2011</th><th>Fall 2012</th><th>Fall 2013</th><th>Fall 2014</th><th>Fall 2015</th><th>Fall 2016</th><th>Fall 2017</th><th>Fall 2018</th><th>Fall 2019</th><th>Fall 2020</th></tr>
<tr><td>Virtual Cadaver</td><td>No</td><td colspan="4">Yes, Anatomy & Physiology Revealed, 2011</td><td colspan="5">Yes, PAL (Practice Anatomy Lab; Heisler, et al., 2013)</td></tr>
<tr><td>Extra Credit Bucket Offered (Including for SI attendance)</td><td colspan="3">No</td><td colspan="7">Yes</td></tr>
<tr><td>Laboratory TA to student ratio</td><td colspan="3">1:30</td><td colspan="7">1:15</td></tr>
<tr><td>Grade Equity Standardization on Lab Practicals</td><td colspan="4">No</td><td colspan="6">Yes</td></tr>
<tr><td>Lecture Text</td><td colspan="5">Tortora and Derrickson 2011, 2013</td><td colspan="5">Amerman 2015, 2018</td></tr>
<tr><td>Laboratory Manual</td><td colspan="5">Allen and Harper 2011, 2014</td><td colspan="5">Whiting 2015, 2018</td></tr>
<tr><td>No-Risk Bonus Questions Included in Final Exam</td><td colspan="5">No</td><td colspan="5">Yes</td></tr>
<tr><td>Item Analysis after each lecture exam</td><td colspan="5">No</td><td colspan="5">Yes</td></tr>
<tr><td>Graded Online Homework</td><td colspan="5">No</td><td colspan="5">Yes (Mastering A&P, Pearson Education, 2021a)</td></tr>
<tr><td>Weekly Study Plans Provided</td><td colspan="5">No</td><td colspan="5">Yes</td></tr>
<tr><td>Word Banks Provided with Lab Practicals</td><td colspan="6">No</td><td colspan="4">Yes (Britson, 2020)</td></tr>
<tr><td>Number of Questions Per Lecture Exam</td><td colspan="8">50</td><td colspan="2">45</td></tr>
<tr><td>Tracked lecture attendance</td><td colspan="7">No</td><td colspan="2">Yes (Learning Catalytics, Pearson Education, 2021b)</td><td>No</td></tr>
<tr><td>Lecture Quizzes (In Person)</td><td colspan="9">Yes</td><td>No</td></tr>
<tr><td>Number of Lecture Exams</td><td colspan="9">5</td><td>4</td></tr>
<tr><td>Number of Students Completing the Course</td><td>283</td><td>353</td><td>345</td><td>362</td><td>348</td><td>355</td><td>349</td><td>327</td><td>342</td><td>243</td></tr>
</table>

Table 1. *Implemented course design modifications in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020.*

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Several course changes, including a change in lecture textbook and lab manual, took place in the fall 2016 semester marking a shift to a "high-structure" course design (Wilton et al., 2019; Beck and Roosa, 2020) to enhance student engagement and performance. Multiple (i.e., 2-4 per week), low-stakes online homework assignments were added to the course to facilitate retrieval practice, an effective strategy to promote anatomy recall (Dobson et al., 2017; Bae et al., 2019; Ritchie et al., 2019). Assessments were developed and selected according to backwards course design principles (Wiggins and McTighe, 2005), and weekly study plans (e.g., checklists for all recommended and required student activities) were developed and provided as a guide to how all elements of the course integrated with the others [e.g., a course blueprint (Coderre, 2009)].

Changes in lecture exam formats throughout the study period included a gradual decrease in the use of publisher provided test banks and an increase in use of self-authored exam questions. Attending professional development sessions on authoring and analyzing exam questions via item analysis at the 2016 HAPS Annual conference (Burgoon and Quinn, 2016), enabled increased use of Learning Outcome linked exam questions and exam validity. The number of questions per exam was reduced from 50 to 45 in the fall of 2019 to assess how the reduction might affect student stress levels and outcomes on the exams. Laboratory practical formats included spotter exams with word banks provided beginning in the fall semester of 2017 (Britson, 2020). Grading equity sessions to standardize the marking of full, partial, or zero credit on lab practical questions (Winter, 2002) began in the fall of 2015 to ensure that student scores were equivalent from one TA to another.

No-risk, cumulative bonus questions (typically 8-10 questions) were added to the last exam in the course as a means for students to increase their performance in course. Students would benefit if questions were answered correctly but would not lose points if answered incorrectly. For the purposes of this manuscript, bonus question points or extra credit points are not included in the earned course scores presented later. Weighting of assessments used to calculate the earned course scores across the study period are presented in Table 2.

In the fall semester of 2020, most courses at the University of Mississippi were delivered via the internet. In Human A&P I, lecture content was pre-recorded and available through the university's Learning Management System (BlackBoard™). The lecture time period (i.e., 8-8:50am, MWF) was used for "Q&A" sessions, via video conferencing (Zoom™), in which students could ask for additional examples, clarifications, explanations, etc., of any course content. A laboratory teaching assistant was available to help moderate the chat window, admit students to the session, and aid the instructor. Students were required to log in to at least one Q&A session per week. Lecture Q&A sessions were not held on days in which students had lecture exams or laboratory practicals.

Additionally, the Fall 2020 semester was shortened by 1.5 weeks such that final exams were completed before the Thanksgiving holiday. This change in course length necessitated elimination of the basic chemistry content (HAPS Learning Outcomes Modules C1 to C5; HAPS, 2019a) and a reduction in the number of lecture exams from 5 per semester to 4. Except for module removal, the sequence of remaining course content was the same as in prior semesters. Lecture exams were taken through BlackBoard™

	Fall 2011 - 2015	Fall 2016 - 2019	Fall 2020
Lecture exams	65%	60%	60%
Lecture quizzes (in person)	10%	5%	
Online homework		10%	18%
Laboratory quizzes	8%	8%	6%
Laboratory formative assessments	7%	7%	6%
Laboratory practicals	10%	10%	10%

Table 2. *Assessment weightings used to calculate course grade in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020.*

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with remote video monitoring (e.g., Proctorio™; Woldeab and Brothen, 2021). The number of questions and length of each exam remained at 45 questions and 50 minutes. On the day of the exam, students were able to complete the exam between 8am and 5pm. Questions were randomly selected from a curated pool of questions, per content chapter, and randomly presented all at once to students once they completed the Proctorio™ verification process.

Lab sessions were held synchronously (1-hour 50 min time periods, once per week) via Zoom™ and were led by 2 laboratory teaching assistants (TA). As in previous semesters, sessions began with a pre-lab quiz followed by a short introduction of lab objectives by the TAs. Students were then randomly assigned to groups to 3-4 students to complete the in-lab formative assessment. In addition to online publisher content (e.g., Mastering A&P™ Pearson Education, 2021a; Practice Anatomy Lab™, Heisler, et al., 2013; etc.), resources such as Lt Online™ (ADInstruments, 2022) allowed us to continue use of PowerLab activities similar to the in-person lab experience. Unlike previous semesters, lab sessions began the first week of classes allowing us to include all lab topics and to meet with students regularly. The two lab practicals tested students over the same topics and used photographs of the models, histological specimens, dissection specimens, etc. Lab practicals consisted of 50, free-response identification question with word banks provided (Britson, 2020) and like the lecture exams were taken through BlackBoard™ with remote video monitoring. Students were allowed 60 minutes to complete the practicals. TAs were required to confer with the instructor on issues of partial credit, no credit, etc. for grade normalization. Raw scores for lab practicals from the Fall 2020 semester were normalized to an average of 75 using a s-z-score transformation (Winter, 2002) due to particularly low scores prior to their use in calculating the student's earned score for the course.

For analyses, year was considered the independent variable with the following dependent response variables: highest ACT, high school GPA, undergraduate GPA, earned course score (no extra credit included), exam average, lecture quiz average, lab quiz average, lab practical average, average performance on online homework, number of SI session attended, number of missed lectures, number of missed labs, number of missed lecture assignments, and number of missed online assignments. Assessment averages were only calculated with scores from completed assessments. Assessments not attempted were tabulated by assessment category. No additional independent variables were used as doing so would force use of an experimental design where none existed. Rather, analyses were conducted to explore relationships between variables and patterns over time.

A one-way analysis of variance (ANOVA) was used to analyze temporal changes in the dependent variables. Bivariate correlation analyses were performed to explore relationships between the independent variable and dependent variables. Effect size (Cohen, 1988; Lakens, 2013) was calculated for all ANOVA (partial Eta squared) and correlation (Pearson's *r*) analyses. Due to the large sample size, the level of significance was set at p=0.001 for both types of analyses. Since the large number of error degrees of freedom in the analytical models makes significant differences more likely as well as Type I errors of interpretation, G*Power 3.1 was used to calculate the minimum sample size required to achieve significant results with a large effect size at the p=0.001 level for the ANOVA (Faul et al., 2007) analyses. Randomly selected subsets of the data set were then used to conduct these conservative analyses. A Discriminant Function Analysis, with letter grade earned used as the grouping variable, was performed to determine which variables contribute the most to variation in the data set and how these variables discriminate between the groups. All analyses were performed using SPSS (Statistical Package for the Social Sciences), Version 27, licensed to the University of Mississippi.

Results

Statistically significant differences were found between ACT scores (F = 29.931; df = 9,3520; p < 0.001), high school GPA (F = 25.301; df = 9,3508; p < 0.001), and undergraduate GPA (F = 20.704; df = 9,3617; p < 0.001) for the initial enrollment of students in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020 (Table 3). Effect sizes (partial Eta-squared, h^2) were medium for both ACT (h^2 = 0.071) and high school GPA scores (h^2 = 0.061), and small for undergraduate GPAs (h^2 = 0.049). A random selection of 210 student records (5.7%; rounded to 6% for SPSS operations which allowed only whole numbers) was obtained to meet the minimum sample sizes required for detecting significant results with a large effect size at p = 0.001. There were no significant differences in ACT scores (F = 1.596; df = 9,175; p = 0.12), high school GPA (F = 0.815; df = 9,178; p = 0.603), or undergraduate GPA (F = 1.018; df = 9,181; p = 0.428) from the random selection of 6% of students initially enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020. Sample sizes will vary for reasons listed earlier (e.g., students may not have submitted a score, may have entered as a transfer, or may have just started their undergraduate education).

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	Mean	Standard Deviation	n	Min, Max
Highest ACT score				
2011	22.28 [a]	3.72	336	13, 32
2012	22.78 [a]	3.93	409	15, 36
2013	22.82 [ab]	3.88	357	14, 33
2014	23.08 [ab]	3.84	389	15, 33
2015	23.12 [ab]	3.90	383	15, 33
2016	23.95 [bc]	3.66	390	15, 33
2017	24.33 [c]	3.82	384	16, 33
2018	24.98 [cd]	4.13	335	13, 35
2019	25.92 [d]	4.27	328	15, 35
2020	24.82 [c]	4.48	219	17, 35
High School GPA				
2011	2.88 [a]	0.63	359	0.82, 4
2012	3.46 [ab]	0.45	402	2, 4
2013	3.48 [ab]	0.46	370	1.2, 4
2014	3.50 [abc]	0.46	392	2.05, 4
2015	3.53 [bc]	0.45	387	2, 4
2016	3.61 [cd]	0.42	396	1.83, 4
2017	3.68 [d]	0.36	376	2.29, 4
2018	3.71 [d]	0.37	329	2.23, 4
2019	3.72 [d]	0.39	328	2.08, 4
2020	3.65 [d]	0.40	218	1.67, 4
Undergraduate GPA				
2011	2.88 [a]	0.63	359	0.82, 4
2012	2.95 [a]	0.61	417	0.62, 4
2013	2.94 [a]	0.65	370	0.42, 4
2014	2.95 [a]	0.61	402	0.96, 4
2015	2.99 [ab]	0.61	396	0.88, 4
2016	3.14 [bc]	0.53	400	1.25, 4
2017	3.14 [bc]	0.61	389	0.5, 4
2018	3.21 [c]	0.54	337	1.08, 4
2019	3.26 [c]	0.56	335	0.82, 4
2020	3.28 [c]	0.58	222	0.59, 4

Table 3. *Prior performance scores for students at the time of initial enrollment in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020. Within each categorical variable, means with the same letter are not significantly different at the p = 0.001 level. Sample sizes are not equal across years because the students may not have submitted a score, may have entered as a transfer, or may have just started their undergraduate education.*

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Among the dependent response variables (Table 4), the number of missed lecture assignments, number of missed lab assignments, and number of missed lectures were not significantly different as calculated from a one-way, univariate ANOVA with either the overall data set or a random subset of the data for testing with the minimum sample size to detect significant differences at the p=0.001 level. Performance on lecture quizzes, pre-lab quizzes, and in-lab formative assessments were significantly different at the p=0.001 level using the overall data set, though the effect size was small for each.

	data set	random selection	df	F	p	h²
earned course score	2011-2020	na	9,3295	10.349	<0.001	0.027
		7% (p=0.001)	9,217	3.032	0.002	0.112
exam average	2011-2020	na	9,3295	15.605	<0.001	0.041
		7% (p=0.001)	9,217	2.648	0.006	0.099
lecture quiz average	2011-2019	na	8,3040	15.718	<0.001	0.04
		7% (p=0.001)	8,199	2.086	0.039	0.077
average performance on online homework	2016-2020	na	4,1612	53.845	<0.001	0.118
		21% (p=0.001)	4,355	21.179	<0.001	0.193
pre-lab quiz average	2011-2020	na	9,3052	19.414	<0.001	0.054
		7% (p=0.001)	9,203	2.164	0.026	0.088
in lab formative assessment average	2011-2020	na	9,3294	6.631	<0.001	0.018
		7% (p=0.001)	9,217	0.797	0.619	0.032
lab practical average	2011-2020	na	9,3293	26.944	<0.001	0.069
		7% (p=0.001)	9,217	3.681	<0.001	0.132
number of SI sessions attended	2011-2020	na	9,3295	55.971	<0.001	0.133
		7% (p=0.001)	9,217	5.709	<0.001	0.191
number of missed lectures	2018-2019	na	1,667	5.68	0.017	0.008
		50% (p=0.001)	1,331	1.793	0.182	0.005
number of missed lecture assignments	2011-2019	na	8,3053	0.751	0.646	0.002
		7% (p=0.001)	8,199	0.533	0.831	0.021
number of missed lab assignments	2011-2020	na	9,3295	1.021	0.42	0.003
		7% (p=0.001)	9,217	0.351	0.956	0.014
number of missed online assignments	2016-2020	na	4,1612	15.049	<0.001	0.036
		21% (p=0.001)	4,355	7.751	<0.001	0.08

Table 4. *One-way, univariate analysis of variance (ANOVA) results with effect sizes for selected response variables from for students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020. Overall sample size may differ due to inclusion of a resource (e.g., online homework or tracking of lecture attendance) or the COVID-19 pandemic altering course formats. Random samples were selected to analyze the minimum sample size to detect significant differences at the p=0.001 level.*

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The earned course score (Fig. 1), exam average (Fig. 2), and number of missed online assignments (Fig. 3) were significantly different at the p=0.001 level using both the overall data set and the minimum sample size required to detect significant differences at that level. For each variable the effect was small with the overall sample size and medium with minimum sample size. Student-Newman-Keuls post-hoc pairwise comparison tests using the overall sample size revealed that the earned course score was significantly higher for students in 2020 as compared to students from all other semesters, and the number of missed online assignments was significantly lower for 2020 students as compared to students from all other semesters. The exam average was significantly higher for students from 2013, 2014, and 2020 as compared to students from all other semesters.

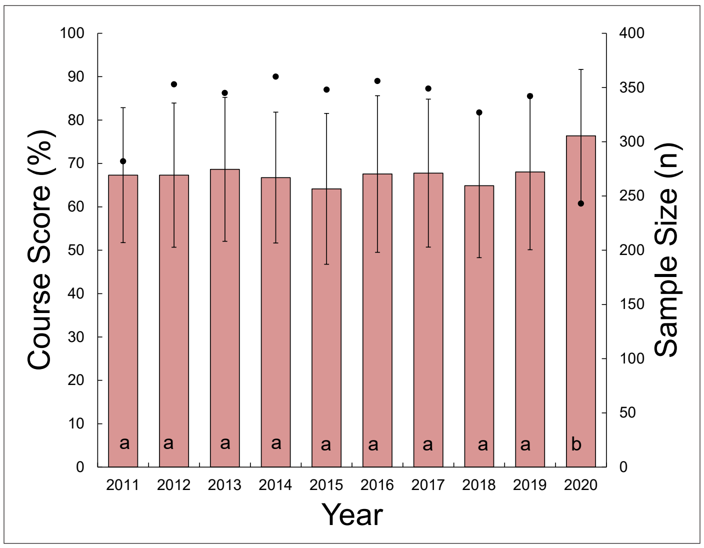

Figure 1. *Mean course score (±1 standard deviation) earned by students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2011 through 2020. Means with the same letter are not significantly different at p ≤ 0.001. Yearly sample sizes are depicted by dots according to the secondary axis.*

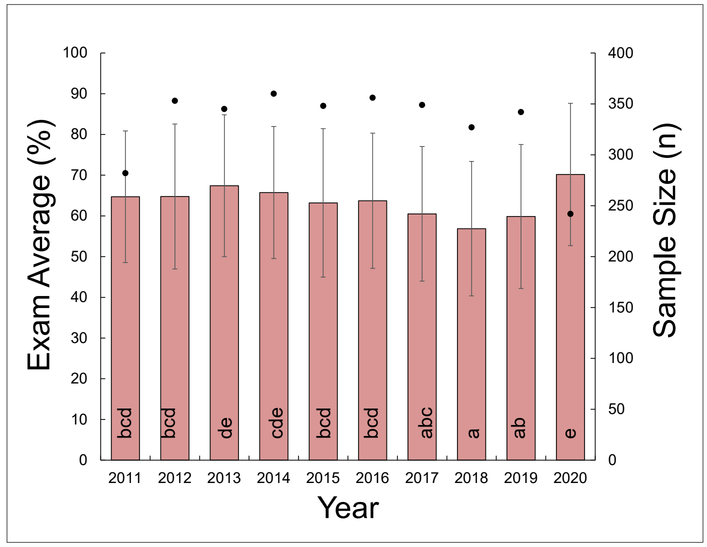

Figure 2. *Mean exam average (±1 standard deviation) earned by students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2011 through 2020. Means with the same letter are not significantly different at p ≤ 0.001. Yearly sample sizes are depicted by dots according to the secondary axis.*

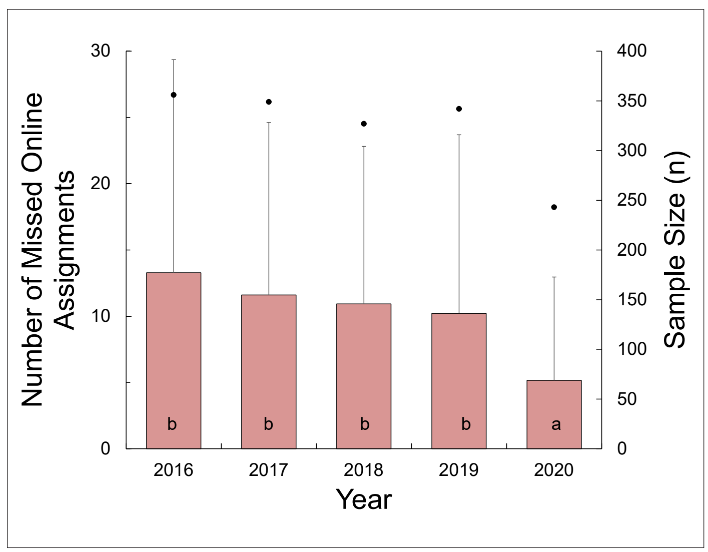

Figure 3. *Mean number of missed online assignments (+1 standard deviation) earned by students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2016 through 2020. Means with the same letter are not significantly different at p ≤ 0.001. Yearly sample sizes are depicted by dots according to the secondary axis.*

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The average lab practical score (Fig. 4) was significantly different at the p=0.001 level using both the overall data set and the minimum sample size required to detect significant differences at the p=0.001 level with a medium effect size for each. Student-Newman-Keuls post-hoc pairwise comparison tests using the overall sample size revealed that the average lab practical score was significantly lower for students in 2015 and 2020 as compared to students from all other semesters.

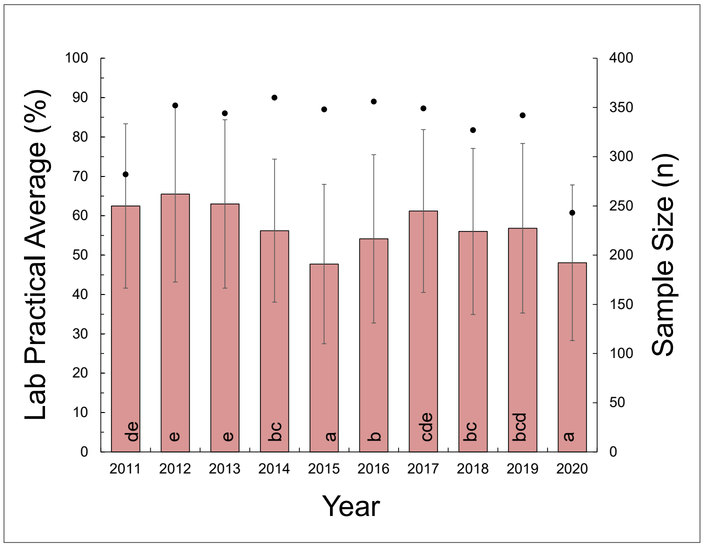

Figure 4. *Mean lab practical average (±1 standard deviation) earned by students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2011 through 2020. Means with the same letter are not significantly different at p ≤ 0.001. Yearly sample sizes are depicted by dots according to the secondary axis.*

Both the average score on online assignments (Fig. 5) and number of SI sessions attended (Fig. 6) were significantly different at the p=0.001 level using the overall data set and the minimum sample sizes required to detect significant differences at the p=0.001 level. There was a medium effect size on the average score on online assignments for the overall sample size and the minimal sample size for testing at p=0.001. Student-Newman-Keuls post-hoc pairwise comparison tests using the overall sample size revealed that the average score on online assignments increased from 2016 to 2020. There was a medium effect size for the number of SI sessions attended using the overall sample size and a large effect when using the minimal size sample sizes needed for testing at the 0.001 level. Student-Newman-Keuls post-hoc pairwise comparison tests using the overall sample size revealed that fewer SI sessions were attended in 2011, 2012, 2013, and 2020 as compared to all other semesters.

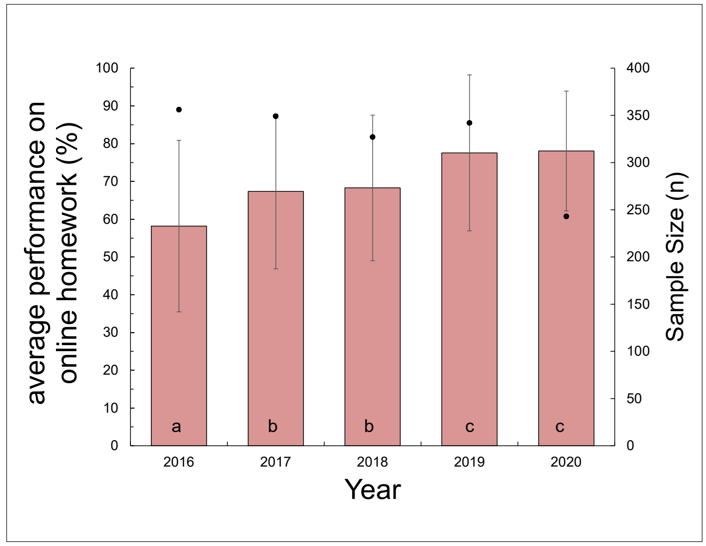

Figure 5*. Average performance on online homework (±1 standard deviation) earned by students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2016 through 2020. Means with the same letter are not significantly different at p ≤ 0.001. Yearly sample sizes are depicted by dots according to the secondary axis.*

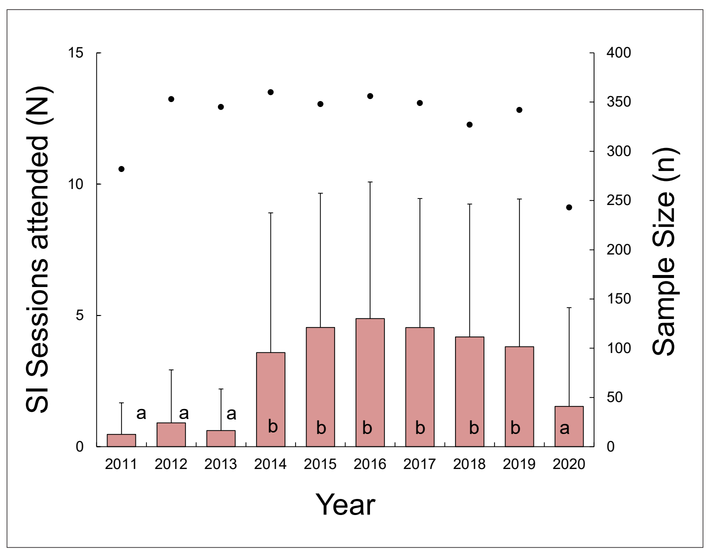

Figure 6. *Mean number of supplemental instruction (SI) sessions (+1 standard deviation) attended by students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2011 through 2020. Means with the same letter are not significantly different at p ≤ 0.001. Yearly sample sizes are depicted by dots according to the secondary axis.*

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Significant, pairwise correlations (two-tailed) between the independent variable (semester) and dependent variables were numerous (Table 5). Of the 74 possible pairwise comparisons, only three (semester vs. number of missed lectures, number of missed lecture assignments, or lecture quiz average) were not significant. Eight of the 74 possible pairwise comparisons involved the independent variable (semester), but the effect size was small for 7 of these comparisons, with the remaining comparison at a medium effect size. Of the remaining pairwise comparisons, 51 had a large effect size exceeding r = ±0.5.

		semester	earned course score	exam average	number of SI sessions attended	number of missed lectures	number of missed online assignments	number of missed lab assignments	number of missed lecture assignments	average performance on online homework	lecture quiz average	in lab formative assessment average	Pre-lab quiz average
earned course score	Pearson Correlation	0.058											
	Sig. (2-tailed)	0.001											
	n	3305											
exam average	Pearson Correlation	-0.074	0.965										
	Sig. (2-tailed)	0.000	0.000										
	n	3304	3304										
number of SI sessions attended	Pearson Correlation	0.206	0.25	0.198									
	Sig. (2-tailed)	0.000	0.000	0.000									
	n	3305	3305	3304									
number of missed lectures	Pearson Correlation	-0.092	-0.56	-0.476	-0.364								
	Sig. (2-tailed)	0.017	0.000	0.000	0.000								
	n	669	669	669	669								
number of missed online assignments	Pearson Correlation	-0.171	-0.699	-0.569	-0.302	0.648							
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000							
	n	1617	1617	1616	1617	669							
number of missed lab assignments	Pearson Correlation	0.013	-0.669	-0.582	-0.183	0.549	0.639						
	Sig. (2-tailed)	0.451	0.000	0.000	0.000	0.000	0.000						
	n	3305	3305	3304	3305	669	1617						
number of missed lecture assignments	Pearson Correlation	0.002	-0.702	-0.631	-0.224	0.661	0.68	0.768					
	Sig. (2-tailed)	0.906	0.000	0.000	0.000	0.000	0.000	0.000					
	n	3062	3062	3062	3062	669	1374	3062					
average performance on online homework	Pearson Correlation	0.329	0.764	0.632	0.311	-0.644	-0.915	-0.588	-0.629				
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
	n	1617	1617	1616	1617	669	1617	1617	1374				
lecture quiz average	Pearson Correlation	0.018	0.685	0.63	0.235	-0.52	-0.547	-0.45	-0.621	0.626			
	Sig. (2-tailed)	0.315	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
	n	3054	3054	3054	3054	664	1372	3054	3049	1372			
in lab formative assessment average	Pearson Correlation	-0.113	0.626	0.551	0.171	-0.527	-0.59	-0.945	-0.728	0.544	0.442		
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
	n	3304	3304	3303	3304	669	1617	3304	3061	1617	3053		
pre-lab quiz average	Pearson Correlation	-0.06	0.802	0.724	0.188	-0.555	-0.664	-0.726	-0.623	0.748	0.586	0.722	
	Sig. (2-tailed)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	n	3062	3062	3062	3062	668	1377	3062	3057	1377	3054	3061	
lab practical average	Pearson Correlation	-0.151	0.826	0.781	0.184	-0.463	-0.511	-0.555	-0.539	0.602	0.567	0.546	0.763
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	n	3303	3303	3302	3303	669	1617	3303	3060	1617	3052	3302	3060

Table 5. *Pearson correlation coefficients (r) for students enrolled in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020 (maximum sample size, n=3305). Correlation coefficients that exceed ± 0.5 (i.e., a large effect size) for a significant (p<0.001) correlation are underlined, and correlations on the diagonal are not depicted.*

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In the discriminant function analysis using the overall data set (Fig. 7), the first discriminant function (DF1) explains 89.5% of the variation in the data set with an Eigenvalue of 7.204, and the second discriminant function explains 8.1% of the variation with an Eigenvalue of 0.648. Using this model, 83.6% of the cases are classified correctly into the grouping variable (e.g., letter grade). Variables loading most heavily onto DF1 are the exam average (0.849), lab practical average (0.609), and lab quiz average (0.414); all variables expressing student performance. Variables loading most heavily onto DF2 are the number of missed lecture assignments (0.735), number of missed lab assignments (0.602), and number of missed online assignments (0.374); all variables expressing student behavior (i.e., engagement). The only engagement variable loading positively to DF1 was the number of SI sessions attended (0.143). The number of SI sessions attended is significantly correlated with the exam average (Fig. 8) using the overall data set, although the effect size is small (r=0.198).

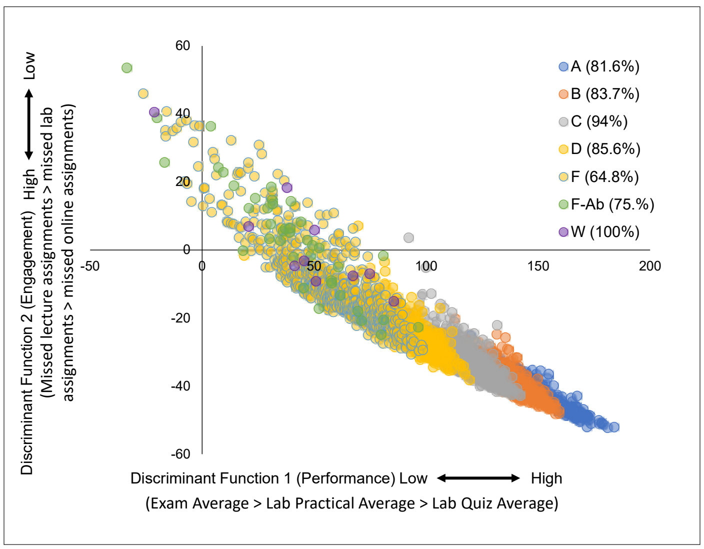

Figure 7. *Discriminant function analysis plot grouped by letter grade recorded for students enrolled in Human Anatomy and Physiology I at the University of Mississippi (n=3304) from 2011 through 2020. Each data point represents the paired discriminant functions for the combined loadings for the variables: exam average, lab practical average, lab quiz average, missed lecture assignments, missed online assignments, percent correct of attempted online homework, in lab formative assessment average, number of missed lab assignments, lecture quiz average, missed lectures, and number of Supplemental Assessment sessions attended. Variables that load the most to Discriminant Functions 1 (Performance) and 2 (Engagement) are mentioned on the x and y axes. In the legend, classification results of the discriminant function analysis are listed as percent correctness for each grouping variable.*

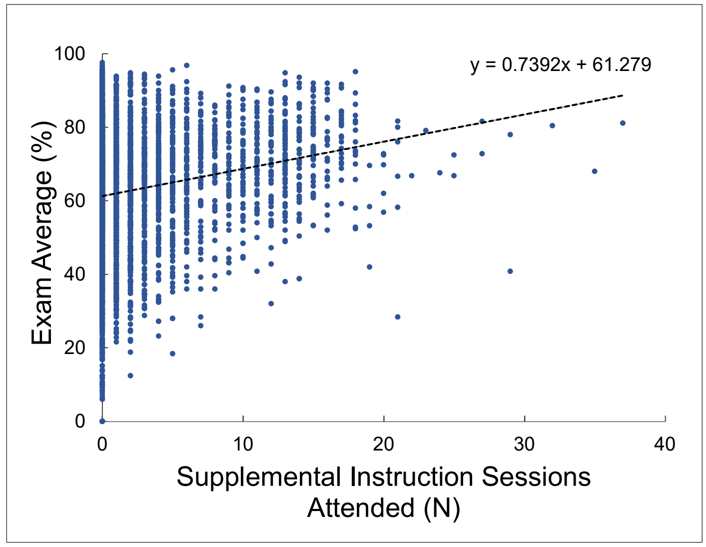

Figure 8. *Correlation between the number of Supplemental Instruction (SI) sessions attended and average exam score, with regression line, earned by students enrolled in Human Anatomy and Physiology I at the University of Mississippi (n=3304) from 2011 through 2020.*

Discussion

When statistically significant results from a study are numerous, it is no easier to gain insight into effective teaching practices than when significant results are absent. Including the additional consideration of a large data set increases statistical power but interpretations and conclusions of results would be suspect without measures to evaluate effect size and influence of sample size. Incorporating results from one-way ANOVAs (including those from a randomly selected sample), correlation analyses, and discriminant function classification analyses to identify large and persistent patterns within a large data set will move us forward in identify a suite of best, effective practices as well as equitable practices leading to student success in Human Anatomy and Physiology.

Students come to Human A&P I at the University of Mississippi from a diverse background in terms of both academic preparation and career goals. The omission of linked preparation scores to course scores in Human A&P I is an unfortunate reality that must be acknowledged in presenting interpretation of these results. Going forward with yearly inputs to the data set, permission will be obtained from students enrolled in Human A&P I to link their preparation scores with course performance scores. I recommend that all instructors who track long term data in their courses begin obtaining permission to link scores to increase the robustness and completeness of future analyses.

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Significant differences, and steady increases, were found throughout the preparation score data set (entire sample) for highest ACT score, high school GPA, and undergraduate GPA. However, the effect sizes were small to medium, and the difference between the minimum and maximum mean ACT score, high school GPA, and undergraduate GPA were 3.64 points, 0.84 points, and 0.4 points, respectively. Minimum levels of each variable are important for admittance and scholarship offers at the University of Mississippi (U Miss, 2022) as well as many other institutions. But do these variables add information that will help us as instructors identify the skills and background information that students bring to our courses enabling us to be more effective at teaching the skills and content that our students need in our courses? Statistically significant differences between ACT scores, high school GPA, and undergraduate GPA were absent when analyzing a randomly selected, minimum sample size needed to identify significant results with a large effect size at the $p=0.001$ level.

In light of the overall lack of significance with minimal sample sizes, subsequent results from analyses on engagement and performance can be interpreted with reduced, *though not eliminated*, consideration of the potentially confounding variables of ACT score, high school GPA, and undergraduate GPA. Hopp (2009) found successful completion of a prior Chemistry course to be an indicator of success in A&P I. Results from prior studies (e.g., Russell et al. 2016; Sturges et al., 2016; Young 2019; Keller and Hughes, 2021), indicate that prior content knowledge and/or academic skills are correlated with success in Human A&P I. Should a specific level of knowledge or skills be consistently identified from multiple investigators across institutions, how do we and should we standardize quantification of this knowledge/skill as an entry tool for enrolling in Human A&P? Conversely, as more institutions offer test-optional admissions as a means to increase equitable access to higher education (Lewis et al., 2021), would we be cancelling out increased access by enforcing minimum standards? Use of the HAPS Human A&P I Exam (HAPS 2019c) as a standardized entry tool would be helpful for knowing what content knowledge our students bring to our courses, allowing us to modify course delivery (to meet the Learning Objectives) rather than prevent enrollment. However, the HAPS A&P Exam does not give us an indication of the study skills, self-motivation, and self-discipline that are also critical for success in Human A&P I. A studying examining the role of prior skills, entry level knowledge, use of standardized MSLQs (Orsini et al., 2016; Abdel-Meguid et al., 2019), and student outcomes is needed to move forward with continued improvement and implementation of teaching practices.

Qualities of engagement in the A&P student include regular interaction with course content, making connections between content areas, preparation for class or lab activities, taking advantage of study sessions or open lab sessions, willingness to help classmates, focus on coursework, willingness to ask questions, managing course responsibilities, etc. (Johnson and Gallagher, 2021). These are all qualities that instructors promote with a curriculum of effective teaching practices such as course blueprinting, backward design, high structure, and retrieval practice. Using the adjective of "effective" for teaching practices implies objective quantification of these qualities through performance on course assessments. However, these teaching practices help all students in all areas of an A&P course rather than just promote engagement, and isolating increases in engagement from performance can be difficult.

Attendance in lectures, labs, and study/SI sessions as well as completion of assignments is a simple measure of engagement because it is assumed that increases will be seen in all of these variables in the engaged student (Dogrell, 2021). In the present study, isolation of these variables from performance enables use of a more objective assessment variable for engagement, and possible one that could be incorporated into a course dashboard. Students are generally reliable in their attendance in lectures, labs, submission of in-lecture assignments, and submission of in-lab assignments as there were no differences in these variables across the years of the study in the entire data set or subsets. Similar to the report of Utz and Bernacki (2018), it is in the voluntary attendance (e.g., SI sessions) and submission of frequent, low-stakes assessments (e.g., online homework) that differences are detected. Attendance at SI sessions increased once a small incentive was offered to students attending. While attendance at any single SI session would only add a maximum of 0.08% extra credit points to a student's overall course percentage, each SI session attended was correlated with a 0.739% increase in their exam average. This increase in exam average would lead to an increase of 0.4% to the overall course percentage, for each SI session attended. The gain in performance is greater than the incentive. The number of missed online assignments decreased over time with only the 2020 mean number being significantly lower than the other years in which online assignments were required. This difference will be discussed later in the pandemic teaching section of the Discussion.

Given the number of pedagogically effective course modifications that were implemented during the years of this study, few modifications were found to be directly related to changes in dependent variables once procedures for evaluating effect size and influence of sample size were examined. Meaningful changes (e.g., backwards design, course blueprinting, high-structure, retrieval practice, decrease in TA to student ratio in the lab, selection of different publisher resources, questions per exam, etc.) were made with a great deal of research and deliberation prior to implementation, but student performance remained stable. Many of these variables were likely interacting with each other resulting in further difficulty in interpreting

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results. From a different perspective, the lack of statistically significant results with large effects sizes [e.g., 45 vs. 50 questions per lecture exam; provision of word banks for lab practicals (Britson, 2020)] while still achieving learning outcomes could be considered a positive outcome. Each of these changes were subjectively associated with reduced confusion, stress, and test anxiety. Subjective feedback from SI leaders and TAs indicates that students struggle with a great deal of anxiety associated with their performance goals for the course and potentially unmet expectations (Leary and Bryner, 2021). Ideally, as educators we would like to see simultaneous increases in performance and engagement with decreases in anxiety and stress, and further investigation into the sources, effects, and mitigation of stress in A&P students (Fornier et al., 2017; El-Baze et al., 2018) is warranted.

While the number of significant pairwise correlations between variables were numerous, the correlations show a common theme: both engaged, high-performing students and less engaged, low-performing students are consistent in these attributes within and across the years of the study. In constructing a mathematical model (e.g., a discriminant function analysis) to explain variation within the data set, using letter grades earned as the grouping variable when the letter grade is determined by performance, uses circular logic. However, in the discriminant function analysis performance explains 89.5% of the variation rather than 100%. If performance was the only factor influencing the letter grade, the plot in Fig. 7 would be a horizontal line.

Consistent student attributes of performance and engagement, and the similar percent of passing (A, B, and C) and not passing (D, F, and W) letter grades in the present study as compared to published percentages from Human A&P I courses (over 12,000 students total) across a range of institutions from 2-year colleges to R1 doctoral granting universities (Table 6), indicate that a "A&P Success Dashboard" would be both feasible and useful if timely interventions were identified by instructors and implemented by students. In immediate practice, one of two approaches is used to aid the struggling student. First, if the student is completing and submitting all coursework, the student needs help understanding, and demonstrating that understanding, of course content. Second, if the student is not completing and submitting coursework, the student needs help with time management, self-discipline, and time-on-task focus. Isolating these messages with examination of fixed vs. growth mindsets in students (Stuart and Wolcott, 2021) would be useful data that could be added to a success dashboard.

On initial examination it would appear that the many challenges faced (e.g., internet and technology inequities, lack of engagement, difficulty focusing, time management inconsistencies, etc.; Schaeffer 2022) during pandemic teaching did not translate into decreased performance as

	Percent Passing (A, B, C)	Percent Not Passing (D, F, W)	Sample Size (n)
Abdullahi and Gannon, 2012	36	64	1429
Atamturktur et al., 2015	59	41	1042
Beeber and Biermann, 2007	65.4	34.6	
Caplan, 2015	67	33	61
Griff and Matter, 2008	72	29	222
Guiltice et al., 2015	67.3	32.7	2728
Harris et al., 2004	65	35	91
Hopp, 2009	56.4	43.6	546
Hopper, 2011	38	62	101
Keller and Hughes, 2021	69	31	306
Langtree, 2014	65.7	34.3	248
Rosenzweig, 2006	51.1	48.9	2236
Russell et al., 2017	58.4	41.6	3693
Young et al., 2019	73.3	26.6	60
Mean, Published Reports	**60.25**	**39.75**	
Present Study	**61.55**	**38.39**	**3305**

Table 6. *Percent of passing (A, B, and C) and not passing (D, F, and W) grades earned in Human Anatomy and Physiology I at the University of Mississippi from 2011 to 2020 compared to published reports. Percentages for specific letter grades were not available from each report. Successfully passing Human A&P I with a letter grade of C or better is a requirement for enrollment in Human A&P II at the University of Mississippi and is aligned with the curriculum guidelines recommended by the Human Anatomy and Physiology Society (HAPS 2019b).*

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course scores were higher in fall 2020 than all other years. Confounding this result is that both lab practical scores in fall 2020 were normalized to an average of 75 using z-score transformation, and that there were 4 lecture exams rather than 5 during the semester. The lecture exam average was significantly higher in fall 2020 (70.163%) than all other semesters except for 2013 (67.406%) and 2014 (65.735%). During 2011 to 2019 exams were administered in-person, at 8am, in a large lecture hall seating a maximum of 400 individuals, and in a single class session. In 2020, students had the same 50 minutes to complete an exam but could take the exam at their convenience between 8am and 5pm on the exam day and in their preferred location and testing environment. Students also reported that they had more time to study because there were no social activities competing for their time. Though measures were taken to reduce the potential for academic dishonesty (e.g., remote proctoring, randomized selection and presentation from a question pool, etc.), it is unlikely that all forms of academic dishonesty were eliminated. The number of missed online assignments in 2020 was half of the number observed in the four previous years, potentially due to the lack of distinction between types of assignments as all assignments were submitted remotely. Collectively, a higher exam average, transformed lab practical scores, and fewer missed online assignments likely increased the calculated course score for fall 2020. With all lectures, labs, and testing for Human A&P I returning to the in-person format at the University of Mississippi in fall 2021, further analyses comparing changes in time management, study, hands-on, and testing skills from the pre-pandemic to late-pandemic time periods will provide information on how we teach and interact with our students.

Conclusions

Moving forward with the insights gained from this retrospective analysis will internally include: (1) construction of a performance dashboard within the learning management system that emphasizes engagement as well as performance, (2) identification of students' intrinsic and external motivations that can then be used to develop engagement strategies that build upon these motivations, (3) identification and mitigation of sources of anxiety in students that affect engagement and performance, and (4) development of the "new normal" of the A&P experience post-pandemic. Externally, I offer these analyses and insights for colleagues searching for a comparison group for their own investigations into student performance.

About the Author

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