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Integrating Lecture and Laboratory in Anatomy and Physiology: Student Perceptions and Performance

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The authors determined whether positive perceptions of integrating lecture and lab in Anatomy and Physiology courses persisted from 2015-2018. Students (843) and instructors (56) completed the Student Assessment of Their Learning Gains survey; perceptions were positive and consistent between both groups. Participant narratives identified the ability to immediately apply theoretical knowledge in lab as an important positive attribute in improving student learning. The authors also determined whether student performance rates, including unsatisfactory grades (C-, D, F, W), improved during integrated years. Results showed that unsatisfactory grades fell in the integrated years, while results for quiz and exam grades, compared between integrated and traditional years,xlkw were inconclusive.

There has been movement away from the traditional lecture form of instruction in college science courses toward more use of active learning (Henderson, Beach, & Finkelstein, 2011). Freeman et al. (2014) collated responses from 338 university instructors to create a definition of active learning: "Active learning engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work" (pp. 8143-8144). One form of active learning involves the integration of lecture and laboratory activities, in which, within the

same class period, students move back and forth between brief didactic presentations and lab activities designed to illustrate, reinforce, and immediately apply the theoretical material, typically through group work and discussion.

Several studies have reported positive student response and performance in these integrated courses in the disciplines of physics (Beichner, 2008; Cummings, 2008; Gaffney et al., 2008; Gatch, 2010; Gok, 2011; Hoellwarth, Moelter, & Knight, 2005; Kohl, Kuo, & Ruskell, 2008; Yoder & Cook, 2014), chemistry (Bailey, Kingsbury, Kulinowski, Paradis, & Schoonover, 2000; Oliver-Hoyo, Allen, Hunt, Hutson, & Pitts, 2004), microbiology (Lux, 2002), genetics and evolution (Roy, 2003), evolution and ecology (Burrowes & Nazario, 2008; Cummings, 2008; McDaniel, Lister, Hanna, & Roy, 2007), neuroscience (Round & Lom, 2015) and engineering (Ghanat, Grayson, Bubacz, & Skenes, 2018a, b; McPheron, Thangaraj, & Thomas, 2017). Within these integrated courses, investigators used a variety of metrics to measure performance, including standardized national exams, course exams, and rates of unsatisfactory grades and retention. Freeman et al. (2014) conducted a meta-analysis of 225 studies reporting data on student performance in courses using several types of active learning, including integrated courses, compared to their performance in traditional lecture instruction and concluded that active learning techniques increased students' exam scores and reduced failure rates.

In response to the growing evidence of the effectiveness of active learning, and in an effort to improve student success, we recently transitioned our Anatomy and Physiology (A&P) courses from the traditional model (with lecture and lab separate) to an integrated studio model. A&P is a critical gateway course typically taken early in the curriculum by students aspiring to careers in the health professions. For several reasons, such as the integrative nature of physiology, the large volume of detailed material, inadequate preparation and study skills, as well as difficulties with the transition to college, many beginning students find this course to be quite challenging (Michael, 2007; Sturges & Maurer, 2013). In our program, as seen elsewhere, prior to 2015 approximately 25% of students received unsatisfactory grades (C- or less) in A&P I (Harris, Hannum, & Gupta, 2004; Sturges & Maurer, 2013; Sturges, Maurer, Allen, Gatch, & Shanker, 2016). These students must repeat the course, delaying their movement through the curriculum, requiring additional courses and expense, and generating frustration and dissatisfaction.

We originally collected performance and perception data for a single semester of integrated A&P I (Finn, FitzPatrick, & Yan, 2017). Student and instructor perceptions of the integration were gathered using the Student Assessment of Their Learning Gains (SALG) instrument. This online survey tool collects both quantitative and narrative responses regarding perceptions of the helpfulness of various aspects of the course to student learning and of the gains made in various skills and learning (Seymour, Weise, Hunter, & Daffinrud, 2000). The SALG results were quite positive in that both students and instructors identified immediate application of theoretical didactic material in the lab activities and the ability to learn through hands-on activities as important positive features of the new model. This study showed some performance gains in reduced rates of unsatisfactory grades. Nevertheless, it is possible that the positive student responses and improved performance were, in part, a function of the novelty of the instructional change or were unique to the particular courses or groups of students or instructors. Therefore, it is crucial to determine whether the integrated model is sufficiently robust to continue to generate positive and consistent student/instructor responses and improved performance, despite the involvement of different groups of students and instructors with varying levels of experience with the model.

To establish the model's long-term success and, thus, continue our commitment to ongoing assessment of pedagogical changes (Handelsman et al., 2004), we analyzed student and instructor perceptual responses and performance to the integrated approach in three semesters of A&P I and two semesters of A&P II. This analysis included five semesters over a three-year period, with 843 SALG surveys completed by students and 56 surveys by instructors. It allowed us to address three primary questions: Did the positive student response to integration persist within a course over time? Were the positive perceptions of integration consistent between students and instructors over repeated offerings of each course? Were the themes raised in narrative responses consistent across time, and between students and instructors? The results reported here support the consistency of positive perceptions of the model.

In regard to student performance, we addressed additional research questions: Did integration result in better performance, as measured in several ways? Did the reduction in weekly instructional time have a negative impact on student performance? Did performance improvements in A&P persist for repeated offerings over time? Our results support the positive effect of integration for reducing rates of unsatisfactory grades and mixed results for course quizzes and practical exams.

Method

Context of the Study

Merrimack College is a private, comprehensive, residential college with ~3200 full-time undergraduate and ~600 graduate students, currently representing 34 states and 35 countries. The population is ~ 47% male and 53% female, most of traditional college age. The School of Health Sciences enrolls 501 majors (22% in athletic training, 23% in exercise science, 35% in health sciences, 15% in nutritional sciences/public health/rehab sciences, and 5% in undeclared health sciences). Three master's degree programs enroll 99 students; many graduate students hold fellowships as teaching assistants (TAs). The College's Institutional Review Board approved this study.

Studio Model Courses

A&P is a two-semester course (A&P I and A&P II) required for all students in the School of Health Sciences. A&P I covers basic material on cells and tissues and the integumentary, musculoskeletal, and nervous systems, while A&P II covers the endocrine, cardiovascular, respiratory, digestive, lymphatic, and urinary systems. The traditional model course sections met for 75 minutes twice per week, with each section enrolling up to 60 students. The separate laboratory sections met for 150 minutes once per week and enrolled 16 students each (total student in class time = 300 minutes per week).

A&P I was first offered as an integrated studio course In fall 2015 and remained integrated in fall 2016 and 2017. The studio courses were offered in multiple sections capped at 30 students each and met twice per week for 110 minutes (total in class time = 220 minutes per week). Each section was staffed by one faculty instructor and one graduate TA (with a maximum teacher-to-student ratio of 1 to 15). A&P II adopted the studio model format in spring 2017 and 2018. Demographics appear in Table 1; grading policies appear in Table 2.

Assessments and Measures

Student and Instructor Perceptions

At the end of each integrated semester, students completed the SALG survey (Seymour et al., 2000). Faculty developed and included 12 additional quantitative questions related to the integrated studio model

Table 1
Student Demographic Distribution by Course for Traditional and Integrated Years (%)

	A&P I			A&P II	
	Traditional (2012, 2013, 2014)	*Integrated (2015, 2016, 2017)*		*Traditional (2012, 2013)*	*Integrated (2017, 2018)*
No. of Students	426	549		197	294
Male	34.7%	30.3%		36.1%	30.8%
Female	65.2%	69.7%		63.9%	69.2%
Freshman	81.7%	75.8%		77.6%	67.5%
Sophomore	11.3%	13.4%		10.1%	19.2%
Junior	3.3%	4.9%		4.0%	7.3%
Senior	2.8%	5.3%		8.1%	4.5%
Health Science	75.1%	81.3%		76.7%	85.3%
Other Majors	24.8%	18.7%		21.3%	14.7%

Note. A&P I = Anatomy & Physiology I; A&P II = Anatomy & Physiology II

Table 2

Comparison of A&P I and A&P II Grading Policies in Traditional and Integrated Years

A&P I

	Traditional - 2012, 2013, 2014	Integrated - 2015, 2016, 2017
Quizzes/Final Exam	60%	40%
Pre-Class Reading Quizzes	3%	5%
Connect™ Assignments	7%	15%
Lab Practical Exams	15%	5%
Weekly Lab Assignments	15%	15%
Writing Assignments		20%

A&P II

	Traditional - 2012, 2013	Integrated - 2017, 2018
Quizzes/Final Exam	60%	40%
Pre-Class Reading Quizzes	3%	5%
Connect™ Assignments	7%	15%
Lab Practical Exams	15%	5%
Weekly Lab Assignments	15%	15%
Writing Assignments		20%

Note. A&P I = Anatomy & Physiology I; A&P II = Anatomy & Physiology II

using a 5-point Likert scale. A box for narrative responses was added for additional qualitative comments on integration (see Table 3). Instructors and TAs responded to the same questions through a Google form. Student responses were anonymous; instructor and TA responses were not.

To compare perceptions over time when only two integrated semesters were analyzed (A&P II), we used the Mann Whitney U test to compare two independent samples. To compare perceptions across time when three or more semesters were analyzed (A&P I), we used the Kruskal Wallis H tests. To compare student versus instructor perceptions in A&P I and II, we used Mann Whitney U to compare two independent samples. Following significant findings using Kruskal Wallis, we performed *post hoc* testing. For narrative responses among students and instructors, all three researchers read and categorized the narrative comments for all courses as positive, negative, or unrelated, and then assigned them to major themes. The relative frequencies of the appearance of the major themes were then calculated.

Student Performance

To assess changes in performance resulting from integration, numbers of unsatisfactory grades (C-, D, F, W) from traditional years (A&P I in 2012, 2013, 2014; A&P II in 2012, 2013) were compared with the integrated years (A&P I in 2015, 2016, 2017; A&P II in 2017, 2018). For the traditional years, 2012 and 2013 were chosen for analysis for A&P II because they were taught by the same instructor, who had taught the course in a consistent traditional manner for several years. During the years 2014-16, there was considerable turnover in pedagogy and instructors, resulting in many inconsistencies across sections. In 2017 and 2018, the course was integrated and was taught by the same instructors. Chi-square analyses were used to determine whether the number of students who received grades of C-, D, F, W was significantly higher or lower than the expected values, which were calculated based on the proportion of the students compared to other years.

Grades on quizzes, each covering a different body region, from traditional years were compared with grades for the integrated years for A&P I using independent group *t* tests. Independent group *t* tests were also used to compare midterm and final practical exam grades from traditional years, compared with the integrated years for both A&P I and II. The content and format of the in-class quizzes in A&P I were very similar across both models. Practical exams in both semesters were based on timed identification of structures and functions. The content and the format of the practical exams were similar, but not identical, across models. All statistical analysis was performed in SPSS, and alpha was set at $p < 0.05$.

Table 3
Lecture/Lab Integration SALG Survey

How much did the following aspects of the class help student learning?
- Integration of lecture and lab activities
- Presence of graduate teaching assistants in class

As a result of the integration of lecture and lab, what gains did you make in each of the following?
- Engaging in active learning
- Increasing participation and involvement in class
- Maintaining attention during class
- Applying material immediately during class
- Providing feedback about understanding of material
- Encouraging class participation
- Encouraging class attendance
- Providing a way to study for exams
- Promoting discussion/collaboration with instructors and peers
- Improving understanding of material and performance

Please provide any additional comments on the advantages/disadvantages of integrating lecture and lab activities, compared with separate lecture and lab periods (as experienced in other college science classes)

Note. 1 = no help/gain; 2 = a little help/gain; 3 = moderate help/gain; 4 = much help/gain; 5 = great help/gain

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Results

Student and Instructor Perceptions

Numerical Responses

Data on the mean and median scores for the average ratings of the 12 instructor-added SALG survey questions for students and instructors are shown in Table 4. On the numerical questions for A&P I and A&P II, median scores of the average ratings of the 12 questions were quite high (>4 [out of 5], indicating much help/good gain) for students across all semesters. Kruskal-Wallis H tests indicated no statistically significant differences ($p > 0.05$) between the median scores for students across repeated offerings for A&P I. In A&P II, Mann-Whitney U tests indicated no statistically significant differences ($p > 0.05$) between the median scores for students for the two integrated semesters.

For A&P I, the positive perceptions of integration were consistent over repeated offerings over time, as indicated by non-significant Mann-Whitney U tests ($p > .05$). On average, students and instructors had positive and similar perceptions across repeated course offerings. For A&P II (spring 2017 and 2018), median scores were statistically higher ($p < .05$) for students than for instructors, indicating that student perceptions of the integrated model were more positive than instructor perceptions.

Narrative Responses

The SALG narrative comments for all studio courses were read, coded as positive, negative, or not applicable, and classified into major themes; some comments represented more than one theme (see Tables 5 and 6). Comments on other themes unrelated to the model are not represented in the tables. In A&P I (2015, 2016, and 2017), student comments were ~83% positive and ~17% negative, a more than 4-to-1 positive ratio across three integrated semesters. Student comments on integration remained positive when A&P II became integrated in spring 2017, aligning almost identically with comments for A&P I. Positive comments related to immediate application of material. One student commented, "when we finished the lecture we applied this knowledge in lab [for]identifying the landmarks, which helped me better understand the content."

The ability to work hands-on with models and to visualize structures was also identified by students as a positive theme, for example, "the learning piece was intensified because after I learned about a bone or muscle I could look at a model and move it to see its actions." Some comments did identify that insufficient time was devoted to some topics and/or that

Table 4
Lecture/Lab Integration SALG Survey for A&P I and A&P II (2015, 2016, 2017, 2018)

	N	*Median of Means*	*M, SD*	*Response Rate*
A&P I				
F2015	S = 174 I = 13	S = 4.4 I = 4.3	S = 4.2±0.1 I = 4.3±0.3	S = 85% I = 92%
F2016	S = 182 I = 12	S = 4.4 I = 4.4	S = 4.2±0.1 I = 4.3±0.3	S = 76% I = 100%
F2017	S = 193 I = 13	S = 4.1 I = 4.1	S = 4.0±0.1 I = 4.2±0.2	S = 63% I = 100%
A&P II				
S2017	S = 154 I = 9	S = 4.4* I = 3.9	S = 4.2±0.1 I = 3.9±0.13	S = 64% I = 100%
S2018	S = 140 I = 9	S = 4.5* I = 3.8	S = 4.2±0.1 I = 3.7±0.4	S = 84% I = 100%

Note. N = sample size; S = students; I = instructors
*In A&P II, student perceptions were significantly higher ($p < .05$) than instructor perceptions in 2017 and 2018.

Table 5
Narrative Survey Comments by Students in Integrated A&P I and II

	A&P I *(2015, 2016, 2017)*	*A&P II* *(2017, 2018)*
Total Number of Contents	199	90
Total Positive%	83.9%	86.7%
Immediate Applications%	33.6%	21.1%
Nonspecific Positive%	30.1%	51.1%
Hands-on with Models%	14.1%	13.3%
Ability to Visualize%	6.1%	1.1%
Total Negative%	16.1%	13.3%
Too Little Time%	13.5%	6.7%
Nonspecific Negative%	2.6%	2.2%
Too Long%	0.0%	4.4%

Note. A&P I = Anatomy & Physiology I; A&P II = Anatomy & Physiology II

Table 6
Narrative Survey Comments by Instructors in Integrated A&P I and II

	A&P I *(2015, 2016, 2017)*	*A&P II* *(2017, 2018)*
Total Number of Contents	38	18
Total Positive%	71.0%	72.2%
Immediate Applications%	42.1%	44.4%
Nonspecific Positive%	15.8%	22.2%
Hands-on with Models%	13.1%	5.6%
Total Negative%	29.0%	27.8%
Too Little Time%	26.3%	16.7%
Nonspecific Negative%	2.7%	11.1%

Note. A&P I = Anatomy & Physiology I; A&P II = Anatomy & Physiology II

the pace seemed too fast. In both courses, instructors noted immediate application and hands-on work as a positive. An instructor stated, "the ability to teach content and then immediately facilitate an activity that promotes student engagement and direct hands on experience is a key asset to content understanding and retention." Some instructors also identified there being too little instructional time as an issue and there were a few comments on poor motivation of some students.

Student Performance

Unsatisfactory Grades

The rate of unsatisfactory grades (C-, D, F, W) in A&P I and II in the integrated years were compared to unsatisfactory grade rates for each traditional year (see Table 7). Students who receive a C- or lower grade must repeat the course and earn a C or better to move on to the next course in the sequence. In A&P I, results showed the lowest rates of unsatisfactory grades in the integrated years. The studio model years had a mean unsatisfactory grade rate of 17.3% compared to 27.6% in the traditional years, a greater than 10% decrease. While these rates increased 5.7% from 2015 to 2016, unsatisfactory rates remained lower across all integrated years compared to any year in the traditional model. This is especially clear in the reduction in withdrawal rates in 2015 (to 2.2%) and 2017 (to 5.2%), compared with a high of 12.9% in 2013, when the C or better requirement was instituted.

The chi–square test for grade distributions in A&P I showed that the distribution was significantly different from the expected value, χ^2 (10, 32.79, $p < .001$). The *post hoc* chi-square test showed that the percentage of students who received C and above grades in 2015 and 2017 was significantly higher than the expected values. The percentage of students who withdrew in 2015 and 2017 was significantly lower than the expected value, with both p values < 0.003 (compared to an adjusted p value of .003). The withdrawal rate was slightly higher in 2016 than in 2015 and 2017.

In A&P II, the rates of unsatisfactory grades were less consistent between traditional and integrated years compared to A&P I. Unsatisfactory rates dropped to 5.2% and 4.3% during the integrated semesters. The withdrawal rate was 1.9% in 2017 and 1.4% in 2018, compared with a high of 5.6% in 2013 using the traditional model. The chi-square test for grade distributions in A&P II showed that the distribution was significantly dif-ferent from the expected value, χ^2 (6, 55.50, $p < .001$). The *post hoc* chi-square test showed that the percentage of students who received an unsatisfactory grade (C-, D, W, F) in 2012 and 2013 was significantly higher

Table 7
**Rate as (%) of Satisfactory/Unsatisfactory Grades
During Traditional & Integrated Semesters**

	A,B,C	C-,D,W,F	C-,D,F	W
A&P I				
F2012(Tr)	68.5%	31.5%	23.1%	8.5%
F2013(Tr)	72.9%	27.1%	14.2%	12.9%
F2014(Tr)	76.2%	23.8%	16.7%	7.0%
F2015(In)	84.8%⁺	15.2%	12.9%	2.2%⊥
F2016(In)	79.1%	20.9%	9.9%	10.9%
F2017(In)	85.0%⁺	15.0%	9.8	5.2%⊥
A&P II				
S2012(Tr)	74.3%	25.8%*	20.8%	5.0%
S2013(Tr)	70.1%	29.9%*	24.3%	5.6%
S2017(In)	94.8%^	5.2%	3.2%	1.9%
S2018(In)	95.7%^	4.3%	2.8%	1.4%

Note. Tr = traditional model; In = integrated model. The requirement for a C or better grade was instituted with the 2013 class.
⁺In A&P I, the percentage of students who received C and above grades in 2015 and 2017 was significantly higher than the expected values indicated by *post-hoc* chi square tests; both p values < 0.003 (compared to adjusted p value of .003).
⊥In A&P I, the percentage of students who withdrew in 2015 and 2017 was significantly lower than the expected value; both p values < 0.003 (compared to adjusted p value of .003).
*In A&P II, the percentage of students who received an unsatisfactory grade (C-, D, W, F) in 2012 and 2013 was significantly higher than the expected values.
^In A&P II, the percentage of students who received C and above grades in 2017 and 2018 was significantly higher than the expected values; both p values < 0.004 (compared to adjusted p value of .004).

than the expected value. The percentage of students who received a C an above in 2017 and 2018 was significantly higher than the expected values, with both p values < 0.004 (compared to an adjusted p value of .004).

Quiz and Practical Exam Grades

Table 8 illustrates A&P I and II average midterm and final lab practical exam grades between the traditional and integrated years. In A&P I, average midterm practical grades were significantly higher in traditional

years compared to integrated years, whereas in A&P II, midterm practical grades were higher with integration, $p < .05$. No differences were reported for final practical grades between traditional and integrated semesters for A&P I; however, final practical grades were significantly higher for A&P II during integrated years ($p < .05$). While average midterm practical grades in A&P I were higher in traditional years compared to integrated years, and no differences were observed with final practical grades between the two models, students' performance improvement (measured as the % gained from the midterm to final practical) was highest in all integrated years.

Table 9 illustrates A&P I average quiz scores between the traditional and integrated years for five content areas. Results showed significant differences between the two models with all p values <.001. For muscle physiology and upper extremity content areas, average quiz scores during the integrated years were significantly higher than during the traditional years, $p < .001$. In contrast, average quiz scores for the terminology and the nervous system content areas were significantly higher in the traditional years, $p < .001$. There were no differences for the lower extremity content areas.

Discussion

Previously, we reported positive student and instructor perceptions of integration and reduced rates of unsatisfactory grades in one semester of first-year A&P I (Finn et al., 2017). To determine whether these positive responses and performance improvements were intrinsic to the pedagogy of the model, and persisted over time, we collected data from two subsequent semesters of integrated A&P I as well as data from two semesters of integrated A&P II.

Student and Instructor Perceptions

In the area of perceptions, we addressed three research questions: Did the positive student response to integration persist within a course over time? Were the positive perceptions of integration consistent between students and instructors over repeated offerings of each course? Were the themes raised in narrative responses consistent across time, and between students and instructors?

A&P I and II vary in content and lab activities. Nevertheless, in the 843 student surveys and 56 instructor surveys there was consistency in the quantitative ratings of the model. All student median and mean ratings were 4.00 (out of 5.00) and above. In comparing student responses across

Table 8
Comparison of Midterm and Final Practical Grades Between Traditional and Integrated Years in Anatomy & Physiology, 2012-2018

	Midterm		Final		Gain
	M	SD	M	SD	
A&P I					
2012, 2013, 2014 (Tr)	70.40%*	15.40%	68.80%	17.98%	-2.11%
2015, 2016, 2017 (In)	60.26%	17.40%	71.26%	16.26%	18.13%
A&P II					
2012, 2013 (Tr)	70.10%	12.02%	72.68%	11.48%	3.68%
2017, 2018 (In)	81.56%⁺	16.40%	80.14%	14.00%	-1.74%

Note. A&P I = Anatomy & Physiology I; A&P II = Anatomy & Physiology II; Tr = traditional model; In = integrated model.
*indicates average midterm practical grades in A&P I were significantly higher when the traditional model was implemented compared to the integrated $p < .001$.
⁺Indicates average midterm and final practical grades in A&P II were, on average, significantly greater when the integrated model was used compared to the traditional model, $p < .001$.

Table 9
Quiz Grade Comparison in A&P I, 2012-2017

	Term		MP		UE		LE		NS	
	M	SD	M	SD	M	SD	M	SD	M	SD
2012, 2013, 2014 (Tr)	88.6**	14.8	66.9	16.6	71.6	18.2	77.4	13.6	75.4**	16.7
2015, 2016, 2017 (In)	78.9	13.7	74.7*	15.1	74.5*	12.1	74.1	15.4	67.2	22.9

Note. Term = terminology; *MP* = muscle physiology; *UE* = upper extremity; *LE* = lower extremity; *NS* = nervous system. 2012-2014 (n) = 470; 2015-2017 (n) = 553; Tr = traditional model; In = integrated model. All quiz scores represent means (*SD*). In some years, two quizzes were given on the same content areas.
*indicates average quiz grades were significantly higher during the integrated years compared to the traditional years.
**indicates average quiz grades were significantly higher during the traditional years compared to the integrated years.

repeated offerings of the same course, there were no statistically significant differences, indicating consistency in student responses.

The narrative comments gathered from both students and instructors in the integrated courses were predominantly positive. Most frequently noted was the ability to apply theoretical material immediately in hands-on laboratory activities. Negative comments were less frequent (mostly less than 20%) and related primarily to lack of instructional time. Within a given academic year, the comments for A&P II were quite similar to those for A&P I, given that the same students constituted the sample.

A&P II students rated the integrated course model more highly than instructors did in both spring 2017 and 2018; the primary issue for instructors seemed to be insufficient instructional time. One graduate TA commented, "I know when I took A&P II we covered so much more detail than we did this semester, and I feel this gap of 2 hours plays a major role and can't be overlooked." Another instructor noted, "I think that the separate lecture and labs gives the students more time with the material. I feel as though the combined lecture and lab makes the class feel rushed." Comments about lack of time or the pace of the course being too fast are a regular feature of student teacher course evaluations overall. It is always a challenge to address this issue in a way that the majority of students are comfortable, both accommodating those who are struggling while still holding the interest of the higher-performing students. Although some students mentioned the lack of instructional time, this seemed to be outweighed by the ability to apply material immediately, which many students connected to improved learning and understanding. One approach to address this issue may be to offer regular weekly optional open lab times, staffed by instructors or TAs, instead of offering these only around the time of practical exams.

This study includes a large sample size (843 students and 56 instructors) over a three-year period of A&P I and II course offerings. Other than the large-scale evaluations of integrated physics courses (Beichner, 2008; Cummings, 2008), our sample size exceeds that in most studies and deploys the same survey completed by both instructors and students. Both numerical and narrative perception data are consistently positive for both groups. Students' narrative comments were extensive and helped to clarify their numerical ratings, allowing us to identify major themes. Overall, 74-75% of students completed SALG surveys for A&P I and II, a high response rate for online out-of-class surveys and considered valid for these total class sizes (Chapman & Joines, 2017). Virtually all course instructors (97-100%) completed surveys.

This study is one of few analyses of integration in health sciences

courses involving students preparing for careers in the health professions. Lux (2002) noted increased retention rates in an integrated Microbiology course, but did not report on student perceptions. Round and Lom (2015) stated that 24 of 28 students (86%) in Developmental Neurobiology preferred a fused course format to the traditional lecture/lab split.

It is possible that some of the positive student reactions to integration were a result of students working with a single instructor for all components of the course, a factor that could be independent of the integrated feature. Ghanat et al. (2018a, b) reported positive student responses to paired scheduling, in which students had the same instructor for both lecture and lab components of electrical engineering courses, although these were scheduled at different times in the traditional manner. They also noted some performance improvements in paired courses. In this study, only 5 of 289 total narrative comments across courses (1.4%) noted having the same instructor for both parts of the course as a noteworthy positive feature of the integrated studio model. This comment was greatly outnumbered by comments on immediate application (33.6% in A&P I; 21.1% in A&P II) and hands-on active learning (14% in A&P I; 13.3% in A&P II), features that seemed much more significant to students. While it is possible that in some of their non-specific positive comments students had this feature in mind, it was not articulated in the study results.

A second possible confounding issue may involve positive student response to spending less total time in class. Only 8 of 289 (2.3%) narratives identified less instructional time as a positive, with 3 of these based on the ease of scheduling two 2-hour blocks in comparison to scheduling three hour-long lectures and one 2.5-hour lab. It was much more common to see comments about insufficient lab time, which was considered a negative. A&P I students were experiencing integration for the first time and were not taking other science courses in the same semester; thus, they had no traditional courses for comparison. There were, however, upper-class students in the sample who may have experienced traditional biology and chemistry courses and studio physics.

Student Performance

In the area of performance, we addressed three additional questions: Did integration result in better performance, as measured in several ways? Did the reduction in weekly instructional time have a negative impact on student performance? Did performance improvements in Anatomy and Physiology persist over repeated offerings over time?

The assessment of performance or academic success is complex. York,

Gibson, and Rankin (2015) noted that grades and GPA are the most common measures used, in addition to student satisfaction, persistence, and retention, as well as other long-term outcomes such as career success. This study addressed satisfaction through the SALG survey and performance through grades (unsatisfactory grades, practical exams, and quizzes). Additionally, satisfactory/unsatisfactory grades relate to retention and persistence within the major. Students receiving unsatisfactory grades may repeat the course to seek a satisfactory grade (C or better), but they may not move on in the curriculum until they do so. Other students may leave the major and seek a field in which they can be more successful. Our data indicated that rates of unsatisfactory grades were lower, and satisfactory grades higher, in most integrated years, thus allowing more students to continue on in the sequence. The data from A&P I in 2016 were something of an anomaly, with higher withdrawal rates than in 2015 and 2017. The reasons for this are unclear. Other researchers have reported reduced failure rates and increased A, B, and C rates in integrated courses (Beichner, 2008; Beichner et al., 2007; Burrowes & Nazario, 2008; Lux, 2002). This study reports mixed results on lab practical exams; midterm grades were higher in traditional years in A&P I, but final grades did not differ between models. Interestingly, midterm practical grades in A&P I, though lower in integrated years, increased considerably from the midterm to the final exam in integrated years (an 18% gain) compared to traditional years (a -2% loss). In A&P II, both midterm and final grades were higher in integrated years. Generally, we would expect better performance in A&P II, because the lower-performing students from A&P I are not taking the class, and all enrolled students have completed one semester of college courses. A&P I quiz grade results were also mixed, with students performing significantly better on muscle physiology and upper extremity content areas in integrated years and significantly better on terminology and nervous system content areas in traditional years, with no difference for lower extremity content areas. In A&P I, quiz content was very consistent across both traditional and integrated years, as were the instructors for the course. Typically, students find the muscle physiology content more challenging than the anatomical content. A&P II in-class quiz grades were not available due to changes in instructor, several of whom were part time and/or taught for only a year or two.

The trend toward course integration began in the physics education community (Laws, 1991). Student performance is typically assessed using standardized concept-based tests such as the Force Concept Inventory (Hake, 1998; Hestenes, Wells, & Swackhamer, 1992). These tests are administered at the beginning (pre) and end (post) of the course, and a gain

factor is calculated and compared between traditional and integrated courses. Many of these studies show increased gains in integrated courses (Beichner, 2008; Cummings, 2008; Gatch, 2010; Hoellwarth et al., 2005; Kohl et al., 2008; Yoder & Cook, 2014). Some other fields have also seen increased gain factors on pre-post concept tests in evolution and ecology (Cummings, 2008) and genetics and evolution (Roy, 2003). In other cases, studies have compared performance on typical course exams. Gok (2011) reported that studio physics student scores on course exams (70% average) were lower than scores for online learning activities, but this finding was not compared to exam scores for traditional courses. Hoellwarth et al. (2005) noted increased concept understanding in studio physics sections, but similar or worse scores on quantitative final exam problems. Burrowes and Nazario (2008) reported higher scores on midterm exams in zoology and botany for students in studio sections. Oliver-Hoyo et al. (2004) noted better performance by students in studio chemistry sections on two of four course exams and worse performance on the other two exams. It seems that, as in our data, performance improvement was seen most clearly on pre/post standardized concept testing and overall satisfactory course grades, while results on course exams were more mixed. Freeman et al. (2014) noted that concept tests aim to identify misconceptions and typically are assessed for validity and reliability, while course exams designed by individual instructors tend to emphasize detail mastery and may vary greatly.

In their meta-analysis of 225 studies, Freeman et al. (2014) noted that active learning ". . . engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work" (pp. 8143-8144). Active learning was found to increase student performance in STEM courses when compared with those taught using traditional lecture style, as seen by improved student performance on exams and concept inventories and reduced failure rates in courses that used at least some active learning. In the integrated classroom experience, reduced and shortened periods of didactic presentation are interspersed with laboratory activities and discussion, generally performed in groups, all within the same class period. Thus, the integrated model described here for A&P fits the active learning definition. The students surveyed responded quite positively to the integrated experience; their narrative comments cited the major positive features of the model to be immediately applying course material in hands-on activities, allowing visual and kinesthetic interaction, and engaging in group work and discussion. The result was reduced rates of unsatisfactory grades and improved performance

on some assessments. Thus, the results of this study are consistent with the studies analyzed by Freeman et al. (2014).

Limitations

We report that unsatisfactory grade rates were lower in integrated A&P I and II courses across three years. Measuring student performance across different courses is challenging. Grades may be based on different criteria, with different weighting of graded assignments. Some courses rely heavily on content knowledge, while others prioritize skills and abilities. There are no national standardized concept tests for A&P. While we did encourage instructors to administer their own pre/posttests, we found that various factors around the posttests varied so much as to make the results inconclusive. These factors included the time of administration of the posttest, the setting (face-to-face or online), and whether the test score was included in the course grade, thus affecting students' motivation to prepare for the posttest. Additionally, in some cases the test content was altered over the three years. If pre/post testing is to be useful in evaluating student performance in the future, it is crucial to emphasize to instructors the need to standardize these factors across courses and to develop a standard conceptually based test for A&P, rather than designing exams based on detailed recall of basic information.

In a study such as this, each class enrolls a different group of students. Our institution does not require SAT scores for admission, and because high schools vary in their grading profiles, students' entering GPAs may not be comparable. This makes it difficult to assess whether the traditional and integrated year student groups differed in ability.

The demographic distribution of students by class year does differ slightly, by 8-10%, between traditional and integrated years in A&P II, with a higher percentage of upper-class students and a lower percentage of first-year students in integrated years. It is possible that older students with more experience in college may have done better on assessments, which affected the final grade profile. However, first-year students do constitute at least two thirds of the study population in both cases.

There were some differences in the grading schemes between traditional and integrated years, with the weight of quizzes/final exam reduced and the weight of online and writing assessments increased in the integrated years. This may have contributed in some way to the overall course grade differences. The lab practical exams (see Table 8), however, were weighted equally across both models. Clearly, students differ in their abilities, with some excelling in test taking, others in writing, and others in concrete lab

activities. The distribution of these types of abilities in different courses may interact with the weighting of different assessments across years, but this is very hard to control for.

There were also differences in this sample with instructor experience with course content, with the mode of implementation of the model, and with the degree to which instructors supported making a pedagogical change. Several instructors had taught A&P for many years, while others were new to the courses. The same variables apply to the graduate TAs. In order to approach consistency, each course had a coordinator who met regularly with instructors. Course materials and activities were common in all sections; exams were similar but not identical. Importantly, these instructor differences did not seem to drastically alter the positive student perceptions and performance in most cases. To make a pedagogical change like lecture/laboratory integration successful, however, attention must be devoted to instructor mentoring and support in order to implement the model as consistently as possible within the constraints of the different subject matter. Graduate TA training is also important, because these students may not have experienced integration in their own undergraduate careers.

Future Directions

In the future, we hope to investigate the optimum method for evaluating student performance. We plan to focus more on faculty and graduate TA instructor preparation, mentoring, and support so that these instructors can apply the integrated model more efficiently, effectively, and consistently, thus addressing some of the issues with lack of instructional time. These study results encourage us to continue to integrate these courses and to apply the model to more of the department's courses.

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