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Integrating Lecture and Laboratory in Health Sciences Courses Improves Student Satisfaction and Performance

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By Kevin Finn, Kathleen FitzPatrick, and Zi Yan

Students often struggle in introductory health sciences courses; some students have difficulty in upper level classes. To address this, we converted three lecture/lab courses, traditional first-year Anatomy and Physiology (A&P I), upper level Biomechanics, and upper level Microbiology to an integrated studio model. We used the Student Assessment of Learning Gains perceptual survey to assess student and instructor reactions to the change and analyzed rates of unsatisfactory grades and quiz performance. Reaction (220 students, 15 instructors) to the new model was highly positive, and performance improvement was seen. Student perceptions were consistent across courses and agreed closely with instructor perceptions. Performance improvements were seen in reduced C–, D, F, W (Withdrawal) rates in A&P. There was no clear pattern in quiz performance, despite reduced in-class time. With typically high grades in upper level courses, we saw no change in performance in biomechanics, while student satisfaction was high in biomechanics and in microbiology. These results, with increased efficiency in staffing time and scheduling, have led us to convert all department lecture-lab courses to the studio format.

Traditionally, college science courses include one or more large lecture sections, supplemented by many smaller laboratory sections. Students might have one instructor for lecture and have lab at a time separate from lecture with a different instructor. Content integration, teaching style, and expectations with multiple instructors might vary across sections. To address these issues and improve student performance, the physics education community created an integrated instructional experience. In this studio model, longer class periods integrate lecture and lab within the same class sessions, which include small classes; group collaboration; close interaction between instructors and students and among students; minimized didactic instruction; and incorporation of learning activities, group work, problem solving, and investigative/experimental work. A group of students work with the same instructor for the entire term, and the same concepts are addressed in multiple ways within the same class time (see Laws, 1991 [Workshop Physics]; Cummings, 2008, and Cummings, Marx, Thornton, & Kuhl, 1999 [Studio Physics]; Beichner, 2008, and Beichner et al., 2007 [Student–Centered Active Learning Environment for Undergraduate Programs, or SCALE-UP]).

In scientific teaching (Handelsman et al., 2004), it is important to evaluate the effectiveness of the studio model. Assessments of student performance with this method often use the Physics Force Concept Inventory (FCI; Hake, 1998; Hestenes, Wells, & Swackhamer, 1992) and other standardized tests. These calculate a gain factor comparing pretest to posttest performance in the studio format with traditional instruction. Cummings et al. (1999) did not see better FCI gains in studio sections and emphasized that simply incorporating traditional activities in studio courses is not sufficient to improve performance; the specific curriculum and activities used were critical. Concept gains were not worse, despite a reduction in overall in-class time. Cummings (2008) also suggested increased efficiency of studio courses because of reduction of faculty administrative time, consistency and use of technology, and web-based instruction and homework, with immediate feedback to students.

Data on 16,000 students comparing SCALE-UP to traditional physics showed improvements in concept understanding, problem-solving ability, attitudes, and attendance, along with reduced failure rates, especially for women and minorities. Students preferred the SCALE-UP sections, recommended them to peers, and attended at a high rate. D, F, W (withdrawal) rates were much lower and evaluations were very positive

(Beichner et al., 2007, Beichner, 2008). Several others reported improved physics student performance and positive student reactions to the integrated model (Gaffney, Richards, Kustusch, Ding, & Beichner, 2008; Gatch, 2010; Gok, 2011; Hoellwarth, Moelter, & Knight, 2005; Kohl, Kuo, & Ruskell, 2008). Yoder and Cook (2014) noted an increase in number of students completing the course with A, B, C grades; reduced withdrawal rates; and increased student satisfaction.

In general chemistry, performance on some, but not all, exams improved in studio sections, whereas other exams showed no difference. Traditional students did better on the first course exam (Oliver-Hoyo, Allen, Hunt, Hutson, & Pitts, 2004). Student response to an integrated model in general chemistry was highly positive (Bailey, Kingsbury, Kulinowski, Paradis, & Schoonover, 2000). In introductory Microbiology, when the session began with lab activities followed by directly related lecture concepts, retention rates increased from 47%–52% in the traditional format to 80% (Lux, 2002). Statistically higher pre–post gain factors of .75 were seen in studio sections of genetics and evolution, compared with .42 traditionally (Roy, 2003). Gain factors were significantly higher in studio sections of evolution and ecology (Cummings, 2008; McDaniel, Lister, Hanna, & Roy, 2007). Burrowes and Nazario (2008) saw significantly higher midterm exam scores in studio zoology and botany, compared with controls of both small and large lectures, and a higher percentage of A and B grades and fewer failures. Students expressed a desire for more of the activities used in the studio sections, and control students wished to have studio instruction.

These studies uniformly support the finding that studio instruction improves student performance and that student response to the format is highly positive, although the disciplines, the metrics for assessing performance and perception, and the finer details of organization of instruction differ. In response to these findings, our Physics Department successfully converted all sections of introductory physics to the studio format, offering more possibility of hands-on work and interaction with instructors, a factor considered to improve the college experience (Astin, 1993). With this example, we implemented the integrated model in our foundational Anatomy and Physiology (A&P) course in our health sciences curriculum.

We enroll 419 undergraduates preparing for graduate education and careers in health professions. Interest in health professions careers is rising, driven by positive employment predictions. According to the Bureau of Labor Statistics (2016), "Employment of healthcare occupations is projected to grow 19 percent from 2014 to 2024, much faster than the average for all occupations, adding about 2.3 million new jobs. Healthcare occupations will add more jobs than any other group of occupations." Two semesters of A&P, taken in the freshman year, are required of all department majors. Many students struggle with the course, and approximately 25% of students received unsatisfactory grades (C– or less) in A&P I, as seen elsewhere (Harris, Hannum, & Gupta, 2004; Sturges & Maurer, 2013; Sturges, Maurer, Allen, Gatch, & Shankar, 2016). These students must repeat the course, delaying their movement through the curriculum, requiring summer school with added expense, and generating frustration and dissatisfaction. Students may struggle with A&P because of the nature of the discipline, the volume and level of detail involved, student readiness for college level work, unproductive study strategies, and instructional techniques (Michael, 2007; Sturges & Maurer, 2013). We demonstrated to the administration that a studio A&P course (Appendix A) would be cost-effective (Appendix B), and they committed resources to create a studio classroom (Appendices A and B available at http://www.nsta.org/college/connections.aspx).

Our objective was to improve student success and the student experience in A&P I by integrating the former lecture and lab into a studio model. This goal was assessed by comparison of rates of C–, D, F, W grades and course quiz grades in the integrated model to traditional control semesters, and by means of the Student Assessment of Learning Gains (SALG) perceptual survey (Seymour, Wiese, Hunter, & Daffinrud, 2000), taken by both students and instructors. We predicted improved performance and positive student and instructor reaction to the integrated model. Both were supported by the data. Based on the positive response to the integrated model in A&P, the lecture and lab portions of two upper level courses, Microbiology for Health Professions and Biomechanics, were each integrated. Older students who experienced the traditional model previously might resist such a change, but response in these courses was consistent with the positive reactions in A&P.

Methods

Context of the study

We are a private, comprehensive, residential college with 2,700 full-time undergraduate and 400 graduate students, representing 22 states and 17 countries. The population is about 50% male and 50% female, of traditional college age. Our department enrolls 419 majors (25% athletic

training, 45% exercise science, 30% health sciences). Three master's degree programs enroll 38 students; many hold fellowships as teaching assistants (TAs). The college's Institutional Review Board approved this study.

A&P I course

A&P is a two-semester course required for all freshman majors. The traditional course had three sections of a 75-minute biweekly lecture, each enrolling up to 60 students, taught by two instructors, and seven separate weekly 150-minute laboratory periods enrolling up to 16 students, taught by five instructors, including both lecture instructors (in-class time of 300 minutes). Part I includes musculoskeletal anatomy and the nervous system.

The studio course was offered as seven sections capped at 30 students, meeting for 110 minutes, twice a week, each staffed by one faculty instructor and one graduate TA (maximum teacher to student ratio of 1 to 15). The two lead instructors had taught both lecture and lab of the traditional course for many years and the other instructors had previously taught lab sections of the traditional course. Grading policies appear in Table 1; demographics appear in Table 2. Course activities and time during a typical class appear in Table 3. See Appendix A for details on both formats and Appendix B for cost analysis (available at http://www.nsta.org/college/connections.aspx).

TABLE 1

Comparison of Anatomy and Physiology I grading policies.

2015 Grading policy—integrated		2012–2014 Grading policy—traditional		
		LECTURE (70% of final grade)		
Quizzes/Final exam	40%	Quizzes/Final exam	85%	(60% of total)
Preclass reading quizzes	5%	Preclass reading quizzes	5%	(3.5%)
Connect assignments	15%	Connect assignments	10%	(7%)
In-lab assessment	5%	**LAB (30% of final grade)**		
Practical exams	15%	Practical exams	50%	(15%)
WARI assignments	20%	Weekly WARI assignments	50%	(15%)

TABLE 2

Demographic profile of Anatomy and Physiology I enrollments.

	2012% *N* = 130	2013% *N* = 136	2014% *N* = 186	2015% *N* = 174
Male	39.2	36.8	31.7	32.2
Female	60.8	63.2	68.3	67.8
Freshman	79.2	86.0	79.0	75.9
Sophomore	11.5	11.8	10.8	14.9
Junior	4.6	1.5	5.4	3.4
Senior	4.6	0.7	4.8	5.7
Health sci. majors	74.6	72.8	74.2	76.4
Other majors	25.4	27.2	25.8	23.6

Data collection and analysis

At the end of term, students received instructions and due dates to complete the SALG (Seymour et al., 2000), a web-based instrument developed for assessing student perceptions of the degree to which various course aspects improved their learning and gains they made in various areas from the beginning to the end of the course. Faculty developed 12 additional numerical questions on the integrated model (Table 5) using a 5-point Likert scale. A box for narrative responses was added. Responses were anonymous. After submission of final grades, survey data were downloaded for analysis. The same questions were sent to instructors and TAs through a Google form, and responses were not anonymous.

To assess changes in performance resulting from the integration, numbers of C–, D, F, W grades in A&P from traditional years (2012, 2013, 2014) were compared with the integrated semester (2015) using chi square analysis with posttest comparing each year to every other year. Chi-square analysis was used to determine whether the numbers of students who received C–, D, F, W grades were significantly higher or lower than the expected values that were calculated on the basis of the proportion of the students compared with other years.

TABLE 3

Integrated 2-hour class session on anatomy of the brachium.

Learning goals	Activities	Time (min)	Assessments
Understand the muscular anatomy of the brachium	Lecture—introduce the muscles, where they are and what they do	20	Instructor asks review questions to check understanding
Identify the brachium anatomy	Lab—students identify muscles on models and 3D BodyViz software	30	Students complete lab activity assignment in class
Understand the anatomy in practical manner	Lecture—explain how anatomy is applied in clinical and injuries	20	Students complete case study activity
Application of anatomical structures	Lab—palpation of structures in brachium	40	Students complete oral quiz palpating structures

Quiz grades from traditional years were also compared with the integrated semester using analysis of variance (ANOVA) with Tukey's posttest. The content and format of the quizzes was very similar across the 4 years. All analysis was performed using SPSS, and alpha was set at $p < .05$.

In spring 2016, the integrated model was implemented in upper level Microbiology for Health Professions and in Biomechanics. Both courses met in the same format as A&P (twice a week, for 2 hours each) and the general model for the use of time as in A&P was followed. The same SALG questions used for A&P were given to the students and instructors at the end of term. Rates of unsatisfactory grades were examined. Overall course averages for Biomechanics were examined for 2013, 2014, 2015, and 2016 and compared using ANOVA with posttest, with alpha set at $p < .05$. No comparative grades were available for the new Microbiology course. Demographics for the three courses appear in Table 4.

Results

One hundred forty-eight (148) of the 174 students (response rate 85%), all five instructors, and six of seven TAs completed the A&P SALG survey.

Numerical student perception responses

On the numerical questions for A&P (Table 5), item averages and modes were quite high (>4) for both students and instructors; a two-tailed, unpaired *T* test indicated no significant difference ($p = .221$) between the average of the average ratings of the 12 questions for students and for instructors. Students and instructors were in close agreement in their positive perceptions of the integrated model.

In Microbiology (Table 5), the average of the average ratings of the 12 SALG questions for the instructor was higher than for students, with modes of 4 and 5 for both groups. Thus the instructor had a more positive response than the students, yet both groups had a positive perception of the model.

On the numerical questions for Biomechanics (Table 5), item averages and modes were also quite high (>4) for both students and instructors. Two items had the most divergent responses among instructors ("way to study for exams" and "feedback

TABLE 4

Demographic profile of studio course enrollments.

	A&P 2015 % (*N* = 174)	Biomechanics 2016 % (*N* = 54)	Microbiology 2016 % (*N* = 20)
Male	32.2	31.5	30
Female	67.8	68.5	70
Freshman	75.9	0	0
Sophomore	14.9	0	0
Junior	3.4	64.8	5.0
Senior	5.7	35.2	95
Health sci. majors	76.4	96.3	100
Other majors	23.6	3.7	0

Note. A&P = Anatomy and Physiology

TABLE 5

SALG survey numerical results on integrated studio model for fall, 2015, spring, 2016.

Lecture–lab integration SALG survey 220 Students, 15 Instructors	**HSC1122 Anatomy & Physiology FA2015**				**HSC3320 Microbiology SP2016**			**SME3308 Biomechanics SP2016**			
	Students		**Instructors**		**Students**		**Instructor**	**Students**		**Instructors**	
	***N* = 148**		***N* = 11**		***N* = 19**		***N* = 1**	***N* = 53**		***N* = 3**	
How much did the following aspects of the class help student learning?	Mean (*SD*)	Mode	Mean (*SD*)	Mode	Mean (*SD*)	Mode	Response	Mean (*SD*)	Mode	Mean (*SD*)	Mode
Integration of lecture and lab activities	4.3 (0.98)	5	4.6 (0.52)	5	4.00 (1.00)	4	5	4.6 (0.8)	5	5 (0)	5
Presence of graduate teaching assistants in class	4.2 (1.01)	5	4.6 (0.69)	5				4.3 (1.0)	5	4.3 (0.47)	4
As a result of the integration of lecture and lab, what gains did you make in each of the following?											
Engaging in active learning	4.2 (.97)	5	4.4 (0.67)	5	3.8 (0.90)	4	5	4.4 (0.72)	5	5 (0)	5
Increasing participation and involvement in class	3.9 (1.01)	4	3.9 (0.83)	4	3.5 (1.02)	4	5	4.3 (0.95)	5	4.3 (0.47)	4
Maintaining attention during class	4.0 (1.02)	5	4.1 (0.70)	4	3.6 (0.96)	4	5	4.3 (0.87)	5	4.3 (0.47)	4
Applying material immediately during class	4.3 (0.91)	5	4.7 (0.47)	5	3.6 (1.01)	4	5	4.6 (0.63)	5	5 (0)	5
Providing feedback about understanding of material	4.1 (0.94)	5	4.0 (0.77)	4	3.7 (0.93)	4	4	4.4 (0.76)	5	4 (0.82)	3,4,5
Encouraging participation	4.0 (1.11)	5	4.2 (0.87)	4	3.8 (0.96)	4	5	4.4 (0.75)	5	4.7 (0.47)	5
Encouraging class attendance	4.2 (1.02)	5	4.1 (0.70)	4	4.0 (0.88)	4	5	4.5 (0.86)	5	4.7 (0.47)	5
Providing a way to study for exams	4.2 (1.03)	5	4.0 (0.77)	4	3.6 (1.12)	4	4	3.9 (1.16)	5	4 (0.82)	3,4,5
Promoting discussion/ collaboration with instructors and peers	4.2 (0.93)	5	4.5 (0.93)	5	4.0 (0.75)	4	5	4.4 (0.86)	5	5 (0)	5
Improving understanding of material and performance	4.3 (0.96)	5	4.3 (0.79)	5	3.8 (0.71)	4	5	4.3 (0.84)	5	4.7 (0.47)	5
Mean (*SD*) of means	4.2 (0.13)		4.3 (0.27)		3.76 (1.17)		4.82 (0.40)	4.4 (0.18)		4.6 (0.39)	
Response rate	85%		92%		95%		100%	98%		100%	

Note. Students were asked to respond to the question: "As a result of . . . , what gains did you make in each of the following?" 1 = *no help/gains*; 2 = *a little help/gain*; 3 = *moderate help/gain*; 4 = *much help/good gain*; 5 = *great help/great gain*. SALG = Student Assessment of Learning Gains.

about understanding"). The response of both students and instructors to the integrated model was highly positive.

Narrative student perception responses

The SALG narrative comments were all read, and coding categories were established for similar comments that were seen repeatedly. These were classified into major themes and as positive or negative (Table 6A, B). In A&P, 95 students (64% of the 148 students completing the survey) offered 110 comments that could be classified; some represented more than one theme. Eleven instructors offered 21 comments. Student comments were 69% positive and 31% negative, a more than 2 to 1 positive ratio. The main themes from students related to immediate application of the material, nonspecific positives such as liking the format, the ability to work hands-on with models and palpation, and the ability to use these to visualize structures. Some comments did identify insufficient time devoted to some topics and/or a pace that seemed too fast. Instructors also noted immediate application and hands-on work as positive, but also identified lack of time, poor motivation of some students, and problems with technology (see Table 6B and Appendix C [available at http://www.nsta.org/college/connections.aspx]). Again in these narratives, there was good agreement between the groups.

Eleven of 19 students in Microbiology (58%) provided eight positive comments (73%) based on the ability to immediately apply what was being learned in a lab situation. One student commented negatively on the class length; two comments did not relate to the integrated model (see Appendix C, available at http://www.nsta.org/college/connections.aspx).

Biomechanics student and instructor comments were also highly positive (85%), mostly relating to the immediate application of material, hands-on nature of the learning, and the helpfulness of the presence of TAs during class. Two were negative, both related to the longer length of the class, and three were not relevant (see Appendix C, available at http://www.nsta.org/college/connections.aspx).

Student performance and grades

The rate of unsatisfactory grades (C–, D, F, W) in A&P in the integrated semester was compared with each of 3 years of the traditional model (Tables 7 and 8). The studio model resulted in the lowest rate of unsatisfactory grades seen in 4 years. Although these rates had dropped steadily from 2012 to 2014, the 8.8% drop for 2015 was larger than any previous declines and the rate for 2015 was the lowest ever noted. This is especially clear in the sharp drop in withdrawal rate in 2015 to 2.3%, compared with a high of 12.8% in 2013, when the C or better requirement was instituted. When the three studio sections taught in 2015 by the lead instructors, who had taught all lecture sections in each prior year, were calculated separately, the 2015 unsatisfactory rate was 8.3%, compared with 14.9% when all seven sections were included.

The chi-square test for grade distributions showed that the distribution was significantly different from the expected value, $\chi^2(12, N = 646) = 39.32$, $p < .001$. The post hoc chi-square test showed that the percentage of students who received C and above grades in 2015 was significantly higher than

TABLE 6

Narrative survey comments by students and instructors for Anatomy and Physiology I, fall 2015.

A. Student comment analysis Total comments = 110	**# Comments**	**%**
Immediate application	25	22.7
Nonspecific positive	21	19.1
Hands on with models	13	11.8
Too little time	13	11.8
Ability to visualize	8	7.3
Total positive	76	69.1
Total negative	34	30.9
B. Instructor comment analysis Total comments = 21	**# Comments**	**%**
Too little time	7	33.3
Immediate application	5	23.8
Hands-on with models	4	19.0
Poor motivation	2	9.5
Technology issues	2	9.5

Note. The students and instructors were asked to 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).

the expected values, $\chi^2(1) = 14.44$; the percentage of students who withdrew in 2015 was significantly lower than the expected value, $\chi^2(1) = 16.0$, both p values <.0025 (compared with adjusted p value of .0025). No other significant differences were found (Table 8).

Table 9 illustrates A&P quiz scores and ANOVA analysis was performed to examine the differences across years 2012–2015 on five content areas. Results showed that there were significant differences across different years among all quizzes, with all p values <.001. Post hoc test results showed that, for the muscle physiology quiz, the average score for 2015 was significantly higher than for 2012, 2013, and 2014, p <.001, with effect size (i.e., Cohen's d) from .65 to .66. For upper extremity, the score for 2013 was significantly higher than 2012, 2014, and 2015, p < .001, with Cohen's d from .43 to .49. For the nervous system quiz, the score for 2012 was significantly higher than 2013, 2014, and 2015, p < .001, with Cohen's d from .21 to .56. For the other two quizzes, no particular year had significantly higher scores than the other years.

Typically, grades in upper level major courses are rather high, mostly A and B. In Biomechanics, no unsatisfactory grades were reported in 2016 or in the three previous years, and virtually all course grades were A and B for 2013–2016. There were no significant differences in averages for 2013, 2014, and 2016. The 2015 year had higher grades than any of the other years (all p < .001). In 2015, the instructor offered a very large number of extra credit assignments, which resulted in a higher average than any previous year, but in 2016, these options were returned to previous levels. Thus reduced class time did not seem to have a negative effect on performance. The Microbiology course was new in 2016. There were 2 C– grades among 20 students (10%).

TABLE 7

Rates as percentage of unsatisfactory grades for Anatomy and Physiology I, fall 2012–2015.

	C–, D, F, W %	C–, D, F	W
2012 T (N = 130)	32.3	23.1	9.2
2013 T (N = 156)	26.9	14.1	12.8
2014 T (N = 186)	23.7	16.7	7.0
2015 I (N = 174)	14.9	12.6	2.3

Note. The requirement for a C or better grade was instituted with the 2013 class. T = traditional model, I = integrated model.

TABLE 8

Numbers of students receiving satisfactory and unsatisfactory grades in Anatomy and Physiology I, fall 2012–2015.

	A, B, C	C–	D	F	W	Total
2012 T	88	12	11	7	12	130
2013 T	114	6	9	7	20	156
2014 T	142	6	15	10	13	186
2015 I	*148	1	15	6	*4	174
Total	492	25	50	30	49	646

Note. The requirement for a C or better grade was instituted with the 2013 class. T = traditional model, I = integrated model. *Indicates significant difference in 2015, p < .05.

Discussion

The objective of this study was to evaluate the effects of the integration of lecture and lab experiences in A&P and in two additional upper level courses; we predicted improved performance and positive student and instructor reaction to the integrated model. The data presented here support the hypothesis. Overall, these data are consistent with previous studies cited earlier indicating that integrating the lecture and lab experience is viewed positively by students and instructors and can result in improved learning.

Perceptual data

In this study, SALG survey results for 220 students (89% of students in the courses) supported both quantitatively (Table 5) and qualitatively (Table 6 and Appendix C, available at http://www.nsta.org/college/connections.aspx) the hypothesis that students viewed the integrated model quite positively, across class years and across courses. Question means were generally around 4, with virtually all modes of 4 or 5, indicating that students perceived good to great gains, from the beginning to the end of each of the three

courses, in increased engagement, participation, application of material, useful feedback about applying material immediately, and the promotion of discussions with instructors and students. Responses did not vary greatly across courses or levels of students, and the narrative comments are quite consistent with the numerical ratings; positive comments predominated and expanded on the same features in the numerical questions. Clearly, students feel engaged and active in the integrated classroom. Similarly, the instructors of the three courses expressed positive perceptions of the studio approach. Item averages ranged from 4 to 5, with most mode responses of 5. Instructors also noted immediate application and hands-on work as positive outcomes. In the narratives, there was good agreement between the students and instructors. The student and instructor perceptions were fairly consistently positive across all three courses and class years.

Performance data

Data were also examined to determine if student performance improved in the integrated course. The rate of unsatisfactory grades (C–, D, F, W) was compared for three years of the traditional model and the integrated semester in A&P I. The studio model resulted in the lowest rate of unsatisfactory grades in 4 years. These results are similar to others who have seen an increase in number of students completing the course with A, B, C grades and reduced withdrawal and unsatisfactory grade rates with the studio model (Beichner, 2008; Beichner et al., 2007; Burrowes & Nazario, 2008; Yoder & Cook, 2014). Our data on quiz grades were not consistent. In one content area, muscle physiology, significant improvement in performance was seen; interestingly, this area had the consistently lowest quiz average across years. The effect size for 2015 was higher than other effect sizes, indicating that students in 2015 were doing quite well on this quiz compared with other years. In other quizzes, there was no consistent pattern. Performance on the first course quiz did not differ across years, which may indicate similar student ability coming in to the course. Others have reported mixed results on quiz performance (Burrowes & Nazario, 2008; Oliver-Hoyo et al., 2004). Performance needs further investigation, using pre–post testing, to determine the effect of the integrated model.

In Biomechanics, there was no difference in final course averages between the integrated year and 2 prior years, with the exception of 2015 when extensive extra credit opportunities were offered. These grades were virtually all in the A, B range in both formats.

Advantages

The advantages of this study include perceptual sampling of multiple courses with multiple instructors at several levels of progression within our major curriculum over one year of the integrated approach. Instructors found that the studio approach created an interactive classroom that promoted immediate application of the material. Students also expressed positive reactions to being able to immediately apply lecture and lab content to make the connection between theory and application.

Initially there was concern about less classroom time (4 hours/week) compared with the traditional lecture and lab format (5 hours/week). The data showed that content can be implemented in less total weekly time, while improving performance in certain areas, with little evidence of a consistent reduction in student performance, along with positive instructor and student response to integration. Traditionally students often complained about inconsistencies between lecture and lab. It was often difficult to match

TABLE 9

Quiz grade comparison in Anatomy and Physiology I, fall 2012–2015.

	Terminology	Muscle physiology	Upper extremity	Lower extremity	Nervous system
2012	21.15 (3.12)	16.73 (3.93)	15.92 (3.85)	18.47 (4.06)	20.53 (3.49)
2013	22.99 (2.39)	16.76 (4.32)	18.66 (4.32)	20.55 (4.45)	18.88 (3.30)
2014	22.34 (3.33)	16.79 (4.02)	18.65 (4.26)	18.48 (4.3)	18.46 (3.12)
2015	21.21 (3.4)	*19.19 (3.40)	18.13 (3.84)	18.71 (4.75)	19.76 (3.67)

Note. All quiz scores represent mean (*SD*) of the adjusted full score of 25. In some years, two quizzes were given on certain content areas. Number of students for 2012 = 130; 2013 = 156; 2014 = 186; 2015 = 174. *Indicates that 2015 average was greater than any other year, $p < .001$ with effect size (i.e., Cohen's *d*) from .65 to .66.

lecture content to lab activities every week because of timing and other factors. The lecturer was often not the same person as the lab instructor. Students felt it was difficult to have two instructors with different teaching styles. In the integrated approach, students felt that having the same instructor for all aspects of the course was positive and created consistency. The integrated approach eliminated the large, impersonal lecture halls where students were often disengaged and instructor pedagogy was limited because of the physical space. Here, with TAs, instructor-to-student ratios were held at 1:16. As the student responses and instructor experiences were positive in these courses, we have decided to implement the studio model in all of our traditional lecture/lab courses. Successful implementation of integration requires instructor, department, and higher administration buy-in, along with physical, financial and scheduling resources. The time investment for planning and coordination is also considerable.

Limitations

In studies like these, it is difficult to control the many independent variables affecting student performance. Each class year enrolls a different student cohort; this is perhaps the most significant uncontrolled variable. Our institution does not require SAT scores.

Overall, 89% of the students completed the SALG survey. Even though not all students provided comments, there was still a large majority of students in all courses that had positive views on the approach, combined with overwhelmingly positive responses from instructors. In A&P, where 31% of comments were negative, it is important to note that only 64% of students completing the survey provided narratives. Although 31% may seem inconsistent with the high numerical ratings, it may be that students with negative impressions were more motivated to comment and that the 36% who did not comment had positive impressions captured by their numerical responses.

The courses did not have students take pre–post tests to determine the student knowledge of the content prior to the course and course gain. Even if background on entering the course is similar, pretests cannot quantify intangibles such as work habits, study skills, and commitment, which vary greatly across students within a given class and across classes. When scores on the first quiz for students in A&P I were compared, grades in 2015 were not different from the other years. We have compared different years and assumed that students have similar knowledge, work habits, and academic ability. Prior academic success was not addressed in the Biomechanics or Microbiology courses.

When moving to the integrated approach, the instructors in A&P and Biomechanics slightly changed the grading weights of assignments (Table 1), which may have impacted final grades. The introduction of required use of iPads in A&P was unique to the integrated year, although course materials were the same as prior years. The iPads were used simply to make those materials more easily available. It is not clear to what degree this may have affected outcomes; no student comments addressed iPad use. The use of TAs in A&P and Biomechanics was also new in the studio format. This allowed us to maintain the 1:16 instructor-to-student ratio used in the former lab sections. Faculty instructors presented all didactic material as before, while TAs assisted with lab activities.

Conclusions and future directions

These positive results motivated us to integrate additional courses next year. Feedback from students and instructors and the experience gained in this first year will be very valuable in designing the new courses and modifying and improving those described here for their second offering. Future courses will incorporate pre- and posttesting so gains achieved in these courses can be compared over time and to literature reports. ■

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