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Does it Matter if Students Have the Same Instructor for Lecture and Lab Sections? An Analysis of Introductory Biology Students

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Abstract: With the goal of increasing the immediacy of the relationship between tenure-track professors and students, science departments in liberal arts colleges may try to arrange their curriculum so that students have the same professor in both the lecture and the lab section of introductory courses. While this goal seems laudable, empirical data are currently lacking to justify the logistical hurdles and professional sacrifices likely required to match professors to students in both lecture and lab sections of large courses. To address this data gap, I analyzed student evaluations and grades from three years of an introductory biology course that included separate lecture and lab sections. There was no evidence that matching a student's lecture and lab instructor had any benefit on either the students' perception of the effectiveness of the labs, or on the students' performance in their lab or lecture sections. In addition, there was no consistent pattern in students' perceptions of the relative effectiveness of tenure-track professors, visiting professors, and adjunct instructors. Finally, I discuss why students may even benefit from having different instructors in their lecture and lab, whether they are tenured professors, visiting professors, or part-time adjuncts.

Keywords: contingent faculty, student performance, student evaluations, laboratory staffing, liberal arts college

Introduction

The traditional approach for teaching introductory science courses is to split the course into one or a few large lecture sections and multiple small laboratory sections. In research and comprehensive universities, the lectures are likely to be taught by tenure-track professors, while the lab sections are handled by a team of graduate students (Kendall & Schussler, 2012, 2014). Smaller liberal arts colleges generally follow a similar model of a large lecture and small lab sections; however, without graduate teaching assistants, both the lecture and lab sections must be taught by faculty (Kezar, Maxey, & Eaton, 2014; Sundberg, Armstrong, & Wischusen, 2005). To meet the large teaching demand required to cover multiple lab sections, liberal arts colleges tend to use a combination of tenure-track professors and contingent instructors (i.e., visiting professors, instructional staff, and part-time adjuncts) (Baldwin & Wawrzynski, 2011; Benjamin, 2002).

In liberal arts colleges as well as research universities, there has been a movement away from the traditional lecture-lab split toward a "studio" approach (a.k.a., blended, integrated, self-contained, or active learning) in which class meetings consist of short lectures that are interspersed with hands-on, student-centered activities (Beichner & Saul, 2003; Gonzalez, 2014; Hoellwarth, Moelter, & Knight, 2005). One purported advantage of the studio approach is that it enables students to forge a closer, more immediate relationship with their professor than they can as passive

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audience members in a large lecture (LeFebvre & Allen, 2014; Todd, Tillson, Cox, & Malinauskas, 2000; Wildermuth, French, & Fredrick, 2013). There is a growing body of evidence suggesting that not only do students tend to be more engaged in studio-style courses, but their performance on a variety of assessment metrics also tends to improve (Beichner & Saul, 2003; Burrowes & Nazario, 2008; Gonzalez, 2014; Hoellwarth et al., 2005).

Despite the promise that studio courses hold in improving introductory science courses, the traditional lecture-lab model does have some pedagogical and practical advantages. A well-designed and effectively delivered lecture is a very efficient method of conveying large amounts of content (Klionsky, 2004; Krontiris-Litowitz, 2009; Lodish & Rodriguez, 2004; Lumpkin, Achen, & Dodd, 2015), and a weekly two- or three-hour lab experience can be very effective in helping students master specific techniques and appreciate what "doing" science is like (Lents & Cifuentes, 2009; Sundberg et al., 2005). Furthermore, converting a lecture-lab course into a studio course introduces a range of logistical challenges that may prove prohibitive, including retraining professors, renovating classrooms, purchasing new equipment, creating new lessons, and coordinating the schedules of students and instructors (Knight & Wood, 2005). Thus, it is likely that even in liberal arts colleges, many of the introductory science courses will continue to consist of separate lecture and lab sections (Allen & Tanner, 2005; Sundberg et al., 2005).

Short of adopting the studio structure whole cloth, science departments in liberal arts colleges may attempt to schedule a professor to teach the same group of students in his or her lecture and lab sections. For instance, in a course with 120 students, three professors may each teach a lecture section of 40 students and two lab sections of 20 students. Students would presumably benefit from a more immediate relationship with their professor because they can interact with him or her in both lecture and lab. Likewise, professors would get to know their students better and would be able to anticipate areas in which they need more help. Overall, a more positive, effective pedagogical experience may be expected to result from this matching lecture-lab scenario. However, empirical data to address this expectation is lacking.

Accomplishing this matching scenario in a liberal arts college requires logistical finesse and perhaps professional sacrifices. It can be difficult enough finding openings in lab sections that can accommodate students' schedules. Restricting the available lab sections for a student to those sections that his or her lecture professor also teaches would magnify this logistical challenge. In addition, a participating professor may have to be solely dedicated to teaching introductory courses, thus foregoing the teaching of favored upper-level courses. The matching scenario may be further restricting to a department because it may not be feasible (or desirable) to have visiting instructors or adjuncts teach as many sections or play such a large role that the matching scenario would require (Kezar et al., 2014; Umbach, 2007). Thus, to make the matching scenario work, a department may have to assign several tenure-track professors to the introductory courses.

Before going through the difficulties of attempting this matching scenario, it would be good to know whether there is any evidence that it is actually beneficial to students to have the same professor for both lecture and lab sections in introductory science courses. In order to address this question, I analyzed three years of evaluation and performance data for an introductory biology course at Roanoke College. I compared students who had the same professor for lecture and lab versus students who had different instructors for their lecture and lab sections. The comparisons were made in three ways to assess student perceptions and performance: 1) students' evaluations of the effectiveness of lab activities; 2) students' grades in lab sections; and 3) students' grades in lecture sections. In addition, I examined the data for potential differences in perceived effectiveness among tenure-track professors, visiting professors, and adjunct instructors.

Methods

Course Description

BIOL 120 (Principles of Biology) was populated mainly by future Biology majors in the first semester of their freshman year, though there were a few sophomores, juniors, and seniors, as well as Psychology, Health, and Environmental Studies majors in the course. The main topics of the course include basic biochemistry, cell structure, energetics, Mendelian genetics, and molecular genetics. In the three years included in this study, lecture sections ranged from 30 to 57 students, with three or four sections taught per year (Table 1). The syllabi were nearly identical for all lecture sections, with the same topics and textbook sections covered, and each with five mid-term exams and one comprehensive final exam making up the bulk of the lecture grade.

All BIOL 120 students were also enrolled in a separate lab section, which met once weekly for a three-hour block for twelve weeks. Eight or nine lab sections were taught per year, and the section sizes ranged from 13 students (for the one honors section) up to 22 students (Table 1). The activities and assignments for each lab meeting were spelled out explicitly in the in-house lab manual, which was used in every lab section and which varied little over the three years of the study. Students' grades in labs were based on preparation for and participation during lab (20%), as well as worksheets, questions sets, and short reports produced outside of lab (80%).

In the three-year duration of this study, seven different faculty members taught lecture sections and eleven different faculty members taught lab sections. The lecture instructors included five tenure-track and two visiting professors, while the lab instructors included three tenure-track professors, four visiting professors, and four adjunct faculty (two of whom held a doctoral degree). Four of the professors taught both lecture and lab sections in the same semester.

Table 1. Lecture and lab instructors, coded by capital letters, for BIOL 120 sections

Year	Enrollment	Lecture Instructors	Lab Instructors
Year 1	146	A, B, C	C*, D(2), E, F, G(2), H(2)
Year 2	155	A, E, H	G(2), H(3), I(2), J
Year 3	159	C, E, F, K(2)	E, G(2), H(2), K, L, M

Note: If more than one section was taught by an instructor in a semester, the number of sections is indicated in parentheses. Underscores represent instructors who taught both lecture and lab sections in the same semester. The enrollment includes only students who completed both the lecture and lab sections of the course. * indicates an "honors" lab section, taken by students pre-identified as "high achieving."

Assessment of Student Perceptions of Lab Effectiveness

In the lab manuals, the first page for each of the twelve lab activities (i.e., weeks) included a list of up to five intended learning outcomes. During the final lab meeting, students were asked to complete a survey evaluating how effectively and efficiently each of the twelve lab activities (*not* the instructor) met its intended learning outcomes. The evaluation included written comments as well as a score ranging from 1 to 5, with 1 = "little value"; 2 = "needs improvement"; 3 = "neutral"; 4 = "effective"; and 5 = "very highly effective." The evaluations were anonymous (did not include student names), but each student was instructed to identify his or her lecture professor (by circling the professor's name in a list). In total, 436 surveys were completed. However, in 85 of these, the student neglected to identify the lecture professor; thus these 85 surveys could not be used in the analyses involving lecture grades.

Means and standard errors of the effectiveness ratings across the twelve labs were calculated for each lab instructor for each year he or she taught a lab section. An analysis of variance (ANOVA) was run to compare mean evaluation scores among lab sections. A separate ANOVA was run to assess whether a student's *lecture* professor had any influence on the student's perception of the effectiveness of the labs.

Further analyses were performed for the four instructors who taught both lecture and lab sections in the same semester (underlined letters in Table 1). Student surveys were sorted based on whether students had the same lecture instructor as lab instructor versus whether their lecture instructor was different from their lab instructor. Surveys in which students failed to indicate their lecture instructor were not included. In total, that left 85 surveys for students with different instructors and 29 surveys for students with the same instructor for lecture and lab.

For each of these four instructors, two mean-evaluation scores were calculated for each of the twelve lab activities—one set of means for students who also had the instructor for lecture, and one set for students who had a different instructor for lecture. An ANOVA was run with the evaluation score as the response variable, and with instructor, lab activity, and whether the lab and lecture instructors matched as explanatory variables. The ANOVA also included all two-way interactions and the three-way interaction. In total, there were 1282 individual scores (up to 12 per student) included as variates in the ANOVA. In addition, two overall evaluation-score means and standard errors were also calculated across the twelve lab activities for each instructor (one for matching, and one for non-matching students). For each instructor, the number of lab activities for which the mean score was higher for students who had the same lecture instructor was compared with the number of lab activities for which the mean score was lower if the lab and lecture instructor were the same.

Analysis of Student Performance in Laboratory

I analyzed lab grades to see whether students with the same instructor for lecture and lab had higher lab grades than students who had a different instructor for lecture and lab. Again, this analysis involved only the four instructors who taught both lectures and labs in the same semester. First, subjective differences in mean scores among instructors had to be accounted for. (For instance, one instructor's "A-" paper may be another professor's "B" paper.) To account for such subjective differences, student lab grades (final numerical scores) were standardized for each instructor to a mean of zero and a standard deviation of one by subtracting from each student's final score the mean score for that instructor, then dividing by the standard deviation for that instructor.

I then ran an ANOVA with standardized lab grades for each student as the response variable, and lab instructor, whether the lab and lecture instructors matched, and the interaction between lab instructor and matching as predictor variables. (The "lab instructor" main effect should not be significant because standardized grades were used.) The "matching" main effect would suggest in general whether having the same instructor for both lecture and lab would help the lab grade. The interaction term was included to indicate whether the effect of matching differed depending on the identity of the instructor.

Analysis of Student Performance in Lecture

I also analyzed lecture grades to see whether students who had the same instructor for lecture and lab had higher lecture grades than students who had a different instructor for lecture and lab. As with the lab grades described above, the lecture grades (final numerical scores) were standardized for each of the four instructors to a mean of zero and standard deviation of one to factor out any subjective differences in grades among lecture sections. An ANOVA was then run with standardized lecture grades for each student as the response variable and with three predictor variables: lecture instructor, whether the lab and lecture instructors matched, and the interaction between lecture instructor and matching.

Instructor C was left out of this analysis because Instructor C's lab section was an "honors" section that included only students pre-identified as high achievers. Therefore, the students in Instructor C's lecture section that also had Instructor C for lab would be a biased sample of students with higher abilities compared to those students who did not have Instructor C for lab. Such a bias was not relevant for the analysis of lab grades because the students in Instructor C's lab section were allocated randomly across lecture sections; that is, there was no analogous honors lecture section.

Results

Assessment of Student Perceptions of Lab Effectiveness

The average effectiveness of the lab activities, as judged by students, differed significantly among lab sections (and thus among lab instructors) over the three-year evaluation period ($P < 0.0001$, Table 2; Figure 1). For individual instructors, the perceived effectiveness sometimes changed significantly across years; for example, there was a significant improvement for Instructor H from the first to second year (Figure 1). In contrast, the perceived effectiveness of Instructor E dropped substantially ($P = 0.03$, unplanned pairwise contrast).

The title (or type) of instructor did not consistently affect the students' perception of the effectiveness of the lab activities. For instance, the three highest means included one tenure-track professor (E), one visiting professor (I), and one adjunct lecturer (G). Similarly, the three lowest means included one instructor from each of the same three categories.

Table 2. Results of ANOVA assessing the difference among 24 lab sections in effectiveness at meeting their intended learning outcomes, as measured by student evaluations.

Source of Variation	df	Mean Square	F-ratio	P-value
Lab Section	24	0.533541	2.6088	< 0.0001
Error	411	0.204519		

In addition to the influence of the lab instructor on a student's perception of the effectiveness of the labs, whom the student had for lecture also had a significant, though smaller, influence on how effective the student perceived the labs to be ($P = 0.02$, Table 3; Figure 2).

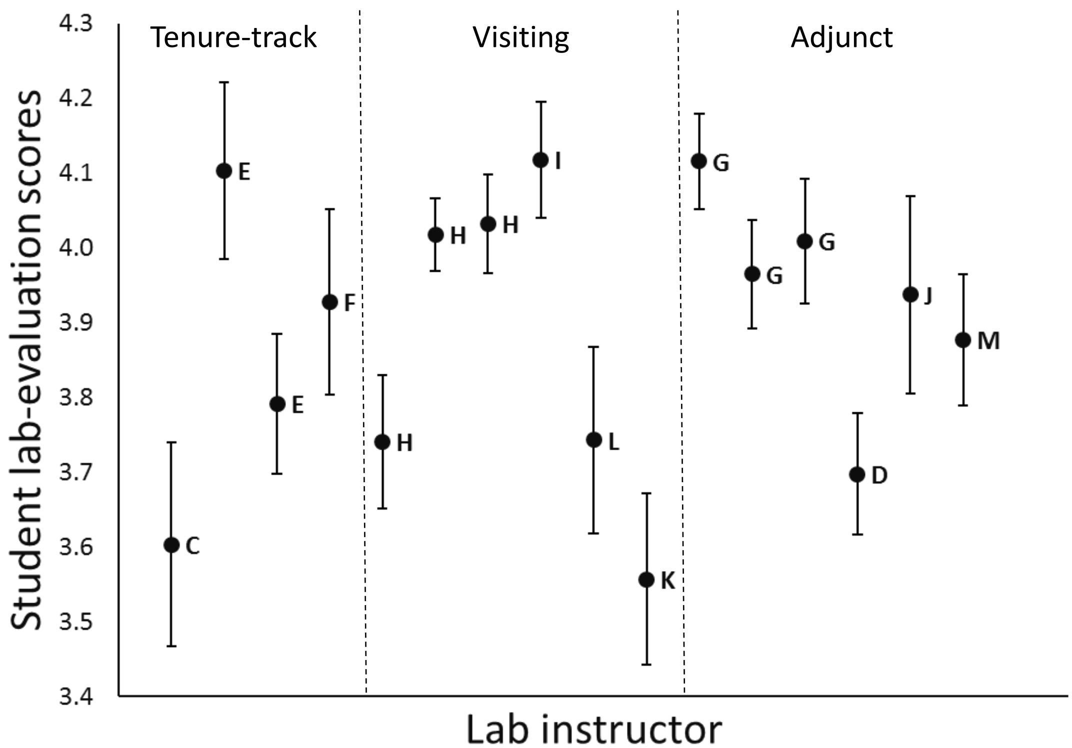

Figure 1. Comparison of the perceived effectiveness of lab sections of BIOL 120, grouped by lab instructors. Points and bars represent means ± one standard error of the student evaluation scores across all lab activities and sections taught by an instructor in one semester. For those instructors (E, H, and G) who taught in more than one semester, the means are presented in chronological order.

Table 3. Results of ANOVA assessing the influence of lecture instructors on student assessments of the effectiveness of the lab activities.

Source of Variation	df	Mean Square	F-ratio	P-value
Lecture Instructor	6	0.519335	2.4662	0.024
Error	344	0.210578		

With 12 lab activities (weeks) and four instructors who taught both lectures and labs in the same semester, there were 48 different lab-activity-by-instructor combinations, and thus 48 comparisons between mean effectiveness scores of lab activities when the lecture and lab instructor matched for students versus when the lecture and lab instructor were different. In 22 of these comparisons, the mean effectiveness score was greater when the lab and lecture instructors matched, in 23 comparisons, the mean effectiveness score was greater when the lab and lecture instructors did not match, and in three comparisons, the mean scores were equal (Table 4). While these overall numbers could hardly be more equal, there were substantial differences among instructors. For instance, students were three times more likely to consider a lab activity to be more effective when the lab and lecture instructor were the same—but only if they had Instructor H (Table 4). At the other end of the scale, students with Instructor C for lab were 3.5 times more likely to consider a lab activity to be *less* effective if they also had Instructor C for lecture than if they had a different lecture instructor.

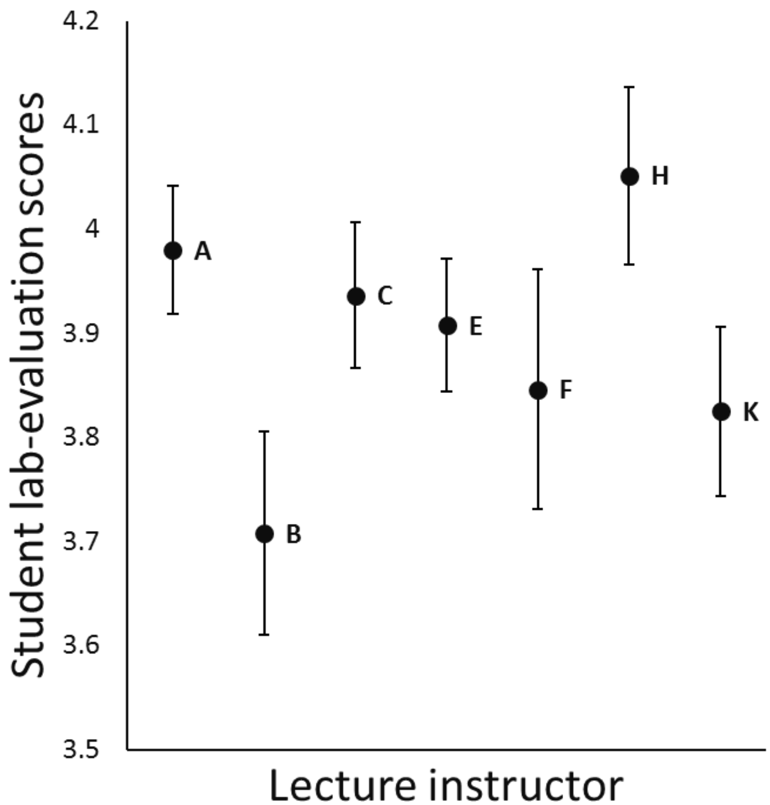

Figure 2. Comparison of the perceived effectiveness of lab activities, grouped by the instructors of the *lecture* sections. Points and bars represent means ± one standard error of the student evaluation scores across all lab activities for students enrolled in a lecture-instructor's section(s).

Table 4. Comparison of student evaluations of the 12 lab activities for each lab instructor.

	Number of labs judged more effective if the lab instructor was the:	
Lab Instructor	same as the lecturer	different from the lecturer
C	2	7
E	5	7
H	9	3
K	6	6

The ANOVA for the effect of instructor matching on perceived effectiveness of labs tells a similar story: On average, whether there was a match between lab and lecture instructor did not influence how effective students perceived the lab activities to be (Table 5). Only if a student had Instructor H for lab did the pairwise comparison show that students perceived the labs as more effective if the students also had Instructor H for lecture as opposed to a different instructor for lecture ($P = 0.047$; Figure 3). However, this difference was not statistically significant after adjusting for the fact that multiple pairwise comparisons were made (i.e., one for each instructor).

Table 5. Results of ANOVA for student-lab-evaluation scores. "Match" is a nominal variable indicating whether a student had the same instructor for lecture as for lab. (Match was set to "one" if the student had the same instructor, and "zero" if the student had a different instructor for lecture and lab.)

Source of Variation	df	Mean Square	F-ratio	P-value
Lab Activity	11	19.98423	24.6065	< 0.0001
Lab Instructor	3	20.52104	25.2675	< 0.0001
Match	1	0.01492	0.0184	0.89
Lab Activity x Lab Instructor	33	2.85521	3.5156	< 0.0001
Lab Activity x Match	11	0.81695	1.0059	0.44
Lab Instructor x Match	3	1.21937	1.5014	0.21
Lab Activity x Lab Instructor x Match	33	0.86721	1.0678	0.37
Error	1186	0.81215		

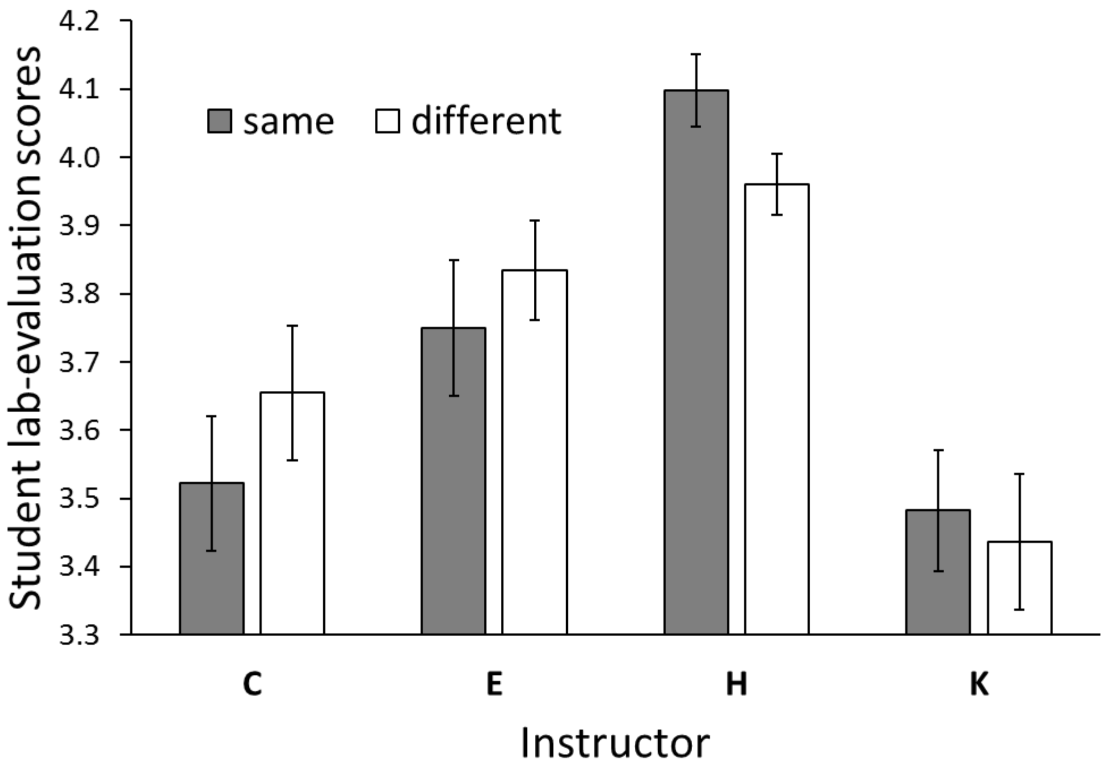

Figure 3. Comparison of the perceived effectiveness of the lab activities for instructors who taught both lab and lecture sections. Columns and bars represent means ± one standard error of the student evaluation scores across all lab activities and sections taught by an instructor. The filled bars represent means for students who had an instructor for both lab and lecture, while the white bars represent students who had a different instructor for labs and lectures.

Analysis of Student Performance in Laboratory and Lecture

Students' grades in lab were not significantly influenced by whether the students had the same instructor for lecture as they did for lab (Table 6). Specifically, there was less than a two-point difference for students in labs with Instructor H, less than three-point difference for students in labs with Instructor C, or K, and less than four-point difference for students in labs with Instructor C depending on whether the students had the same or different instructor for lecture. The largest differences in terms of standard deviations were for students in the lab of Instructor C (0.61 std *higher* grade if students also had Instructor C for lecture) and for students in the lab of Instructor E (0.46 std *lower* grade if students also had Instructor E for lecture). Neither of these differences was statistically significant, however (P = 0.32 for both pairwise comparisons of same versus different lecture instructor) (Figure 4A).

Table 6. Results of ANOVA for standardized lab grades. "Match" is a nominal variable indicating whether a student had the same instructor for lecture as for lab.

Source of Variation	df	Mean Square	F-ratio	P-value
Lab Instructor	3	0.10734	0.1059	0.96
Match	1	0.08499	0.0838	0.78
Lab Instructor x Match	3	0.82818	0.8168	0.49
Error	106	1.01390		

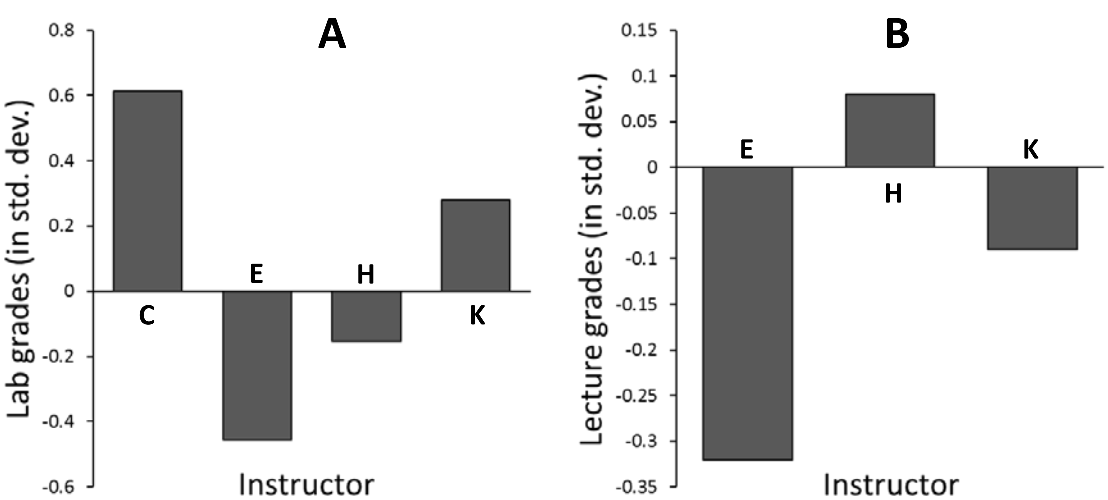

Figure 4. Effect of instructor-matching on student grades in lab (Panel A) and grades in lecture (Panel B). The columns represent the number of standard deviations by which the mean grades of students with matching instructors differed from students with different instructors. Positive values indicate that the grades were higher for students who had the same instructor for both lecture and lab, while negative values indicate that grades were lower for students who had the same instructor for both lecture and lab. (Instructor C is left out of Panel B because all of the Instructor C's lab students were in the Honors lab section, and thus they would not represent a random sample of lecture grades.)

Students' grades in lecture were also not significantly influenced by whether the students had the same instructor for lab as they did for lecture (Table 7). Specifically, for students who had Instructor H or K for lecture, there was less than a one-point difference in lecture grades for students who had the same versus different instructor for lab. This difference is less than a 0.1 standard deviation in lecture grades (Figure 4B). Students with Instructor E for lecture had a 3-point lower grade in lecture if they also had Instructor E for lab (a 0.3 standard deviation difference), but again, this difference is not statistically significant (P = 0.46 for pairwise comparison).

Table 7. Results of ANOVA for standardized lecture grades. "Match" is a nominal variable indicating whether a student had the same instructor for lab as for lecture.

Source of Variation	df	Mean Square	F-ratio	P-value
Lecture Instructor	2	0.08728	0.1059	0.92
Match	1	0.22577	0.0838	0.64
Lecture Instructor x Match	2	0.26767	0.8168	0.77
Error	138	1.01692		

Discussion and Conclusions

For the three years of this study on the introductory-level Principles of Biology course at Roanoke College, there was no general trend indicating that students had a better experience when they had the same instructor for both lecture and lab than when the lecture and lab instructors differed. Specifically, neither the students' assessments of the pedagogical effectiveness of the lab activities nor the students' performance (judged by grades in both lab and lecture) depended significantly on whether their lecture and lab instructors were the same person. These negative results run counter to the common assumption that students will benefit from the closer relationship with one instructor that results from encounters in both lecture and lab settings (LeFebvre & Allen, 2014). After all, it seems reasonable that if an instructor gets to know students well in lab setting, he or she ought to be able to communicate more effectively to these students in lecture. Moreover, if the lecturer knows exactly what the students are experiencing in lab, there should be fewer opportunities for gaps in information, or worse yet, contradictions in explanations about concepts in lab versus lecture sections.

Despite the lack of a general pattern, some benefits may have occurred for a subset of students in the course who had the same instructor for lecture and lab. Nevertheless, the relatively large differences in effectiveness among lab instructors seemed to outweigh any advantages of matching instructors between lecture and lab sections. Obviously, students would be better off having a single particularly effective instructor for both lecture and lab than they would be if they had a less effective instructor for both. Having a different instructor for lab and lecture thus can serve as a sort of bet-hedging strategy against the worst-possible case scenario.

Allowing exposure to different instructors may have other advantages as well. In particular, students with different learning styles get a chance to have concepts explained from instructors with different backgrounds or teaching styles, even if there is a potential risk of some contradictory information. With two different instructors, there is a better chance that a student will "click" with at least one of his/her instructors.

One of the more surprising results of this study was that the identity of a student's lecture instructor could have a measurable impact on how effective the student judged the lab activities to be (Table 3; Figure 2). At least two factors probably played a role in this result. The first is entirely subjective: If students had an overall bad (or good) experience in their lecture sections, then they might carry a negative (or positive) attitude with them to their lab section. Their attitudes toward the course as a whole would then color their impressions of how effective the lab activities seemed to be. The second factor has to do with the lecture professors' level of involvement in the labs. The more that the lecturer knows about what students are experiencing in labs, and the more explicit connections that the lecturer makes for the students between the topics in the lecture and the activities in the labs, the more relevant and effective the lab activities are likely to be perceived.

Because of the large enrollment in introductory science classes, the use of contingent instructors to cover lecture and lab sections has steadily increased, and liberal arts colleges are certainly not immune to this trend (Kezar et al., 2014). The issues related to using temporary and part-time instructors are myriad and potentially serious (Benjamin, 2002). The particular issue germane to the current study is whether contingent instructors teach students as effectively as tenure-track professors. Past studies have shown that students tend to have different expectations of instructors based on their rank (Kendall & Schussler, 2014), and full-time professors tend to use different teaching strategies and spend more time with students than part-time adjuncts (Benjamin, 2002; Umbach, 2007). However, there is a paucity of empirical data regarding whether any of these factors translate into differences in effectiveness among instructors of different rank (Baldwin & Wawrzynski, 2011).

The results of the current study suggest that instructor rank did not have a consistent influence on students' judgment of the effectiveness of the labs. Notably, the three lowest and the three highest effectiveness evaluations both included a tenured professor, a visiting professor, and a part-time adjunct instructor. While there are certainly other dimensions to consider when judging the success of the practice of relying heavily on contingent instructors, this study at least shows that the experience of our students in this course did not suffer in terms of perceived effectiveness of the labs.

The equal success of the contingent instructors relative to the tenure-track professors in this course was likely due to several factors. First was certainly good fortune in that the Biology Department consistently had pools of highly qualified applicants for the visiting and adjunct positions. The contingent instructors were generally very dedicated, enthusiastic, and motivated toward career advancement. Second, the lab activities were carefully planned and coordinated, and the instructors met at least weekly to ensure that the new instructors were up to speed, and that all instructors used the same teaching and assessment practices. While the tenure-track professors certainly had more academic experience in general, and more experience with this course and the student culture in particular, they have influences that may not apply to contingent instructors. For instance, tenure-track professors face additional time demands of teaching other classes, keeping a research program going, advising students, and serving on committees. Finally, one cannot ignore fear as a motivating factor. Tenured professors may have less to worry about if they let their attention to a single lab section slide than does an adjunct teacher whose career advancement may depend heavily on proving that he or she can teach his or her only lab section effectively. Notably, there was only one instance in which a professor's perceived effectiveness in the labs dropped, and this drop occurred the year after the professor was granted tenure.

In conclusion, a careful analysis of three years of data from a relatively large introductory-biology course at a liberal arts college showed that some of the common practical concessions or "shortcuts" to instructor staffing did not have a measurable detrimental effect on students. Specifically, students' evaluations of the effectiveness of the lab activities did not depend on whether they had the same or different instructors for their lecture and lab sections. Moreover, student performance (grades in labs and lectures) was not significantly influenced by whether students had matching lab and lecture instructors. Finally, the heavy reliance on contingent instructors to teach lab sections did not have a negative impact on students' perceptions of the effectiveness of the labs. In fact, exposure to talented visiting professors and adjunct instructors likely improved the diversity of the learning experiences for students in this course.

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