Transforming Undergraduate Science Education With Learning Assistants: Student Satisfaction in Large Enrollment Courses

By Robert M. Talbot, Laurel M. Hartley, Katrina Marzetta, and Bryan S. Wee

Large enrollment undergraduate science courses are often seen as "gatekeepers" and tend to support less-than-ideal pedagogical approaches. Student satisfaction with teaching and learning and gains in student conceptual understanding in these courses is often limited at best. At University of Colorado Denver, the Learning Assistant (LA) Program supports the transformation of these large-enrollment science courses to include more interactive teaching strategies and learning opportunities. We find that students in these LA-supported courses are satisfied with these courses in part because of their use of LAs, primarily during the lecture meeting time. Students do not report using LA support as much outside of course lecture meetings. Further, students in an LA-supported General Biology course also exhibited much larger gains in conceptual understanding. We suggest that future work should investigate cross-group comparisons of cognitive and affective gains by factors such as ethnicity; class; gender; and interactions among students, LAs, and faculty.

Student satisfaction in large-enrollment "gatekeeper" introductory courses is one of the key indicators of whether a student will continue as a science major in college (Baldwin, 2009; Bok, 2006; Seymour & Hewitt, 1997) or even continue at an institution (Twigg, 2003). Large-enrollment science courses are difficult environments for both students and faculty (Allen & Tanner, 2005). These courses tend to be taught in large, stadium-style auditoriums with much distance between the instructor and most students (Geske, 1992). Additionally, the sheer number of students, most of whom do not interact with one another, creates an impersonal setting (Geske, 1992). These physical difficulties tend to support the enactment of suboptimal pedagogical strategies that may contribute to poor student performance and satisfaction. These large enrollment courses tend to be taught using a traditional lecture format and tend to focus on memorization of factual details rather than conceptual understanding and the development of higher order reasoning skills (National Research Council, 2003). Large class sizes in general also reduce the frequency and quality of the interaction with and feedback to students, limit the breadth and depth of course objectives and assignments, and reduce student satisfaction (Cuseo, 2007). More often than not, large-enrollment science courses end up acting as filters, "weeding out" students who are unable to succeed in them (Baldwin, 2009).

Course transformation is clearly needed in undergraduate science education to address these issues. We propose that the use of Learning Assistants (LAs) can support these transformation efforts. LAs are students who have recently (and successfully) completed the course in which they provide support, and they have an interest in teaching or helping others. They are "near-peers" who have experienced the same struggles and successes as the students in these courses (Otero, Finkelstein, McCray, & Pollock, 2006). LAs support student-centered instruction and peer interaction in a way that, we suggest, leads to greater student satisfaction and achievement in introductory science courses.

Consistent with this need for course transformation, Froyd (2008) suggested a set of practices including cooperative group work, frequent formative assessment, facilitated active learning in class, use of electronic communication among groups outside of class, and use of pedagogically trained teaching assistants. Several studies have pointed to the value of adopting peer interaction and active learning strategies for increasing student learning and grade performance (Beichner, 2008; Freeman et al., 2007; Hake, 1998; Knight & Wood, 2005; Ruiz-Primo, Briggs, Iverson, Talbot, & Shepard, 2011; Smith et al., 2005; Udovic, Morris, Dickman, Postlethwait, & Wetherwax, 2002). Although many of these approaches show much promise, they are difficult to implement in large undergraduate science courses because of high student-to-faculty ratios, rigid architecture of classrooms, and possible student resistance to instructional approaches that do not mimic traditional practices (Allen & Tanner, 2005; Felder & Brent, 1996). Using LAs can help support the implementation of these approaches.

Although other studies have incorporated the use of LAs as one part of their transformative efforts (Chasteen, Perkins, Beale, Pollock, & Weiman, 2011), in this article we mainly discuss the effects of LAs on undergraduate students' perceptions of teaching and learning in large enrollment science courses. Research has shown that student affect is an important predictor of student recruitment and retention in science (Osborne, Simon, & Collins, 2003). However, indicators of student success in undergraduate science courses are typically only cognitive in nature and do not often include students' perceptions of teaching or their satisfaction with the course. Although we also present some learning gains data from LA-supported and non-LA-supported courses, our main goal herein is to provide insight into undergraduate science education reform using an affective measure of student experiences in LA-supported, large-enrollment science courses.

The Learning Assistant Program

The Learning Assistant Program was started at the University of Colorado–Boulder in 2003 and has since been replicated at over 55 institutions around the country (Learning Assistant Alliance, n.d.). The LA program at University of Colorado Denver began in the spring of 2012. The goals of our LA program are threefold: (1) to improve student learning in undergraduate science courses, (2) to support reform efforts in undergraduate science courses, and (3) to give high-performing science students an opportunity to learn about science teaching as a career choice.

LAs are recruited by faculty in science and science education. Selection of LAs is competitive, and LAs are paid a monthly stipend for their work. LAs support course transformation by facilitating more student-centered methods of teaching and learning. At University of Colorado Denver, the courses that LAs support are usually large-enrollment, lecture-based courses. During lecture, LAs are often used to facilitate interaction and discussion among groups of students during breakout problem-solving sessions or clicker questions (e.g., during think-pair-share activities) and to support "flipped" class sessions. As specific examples, LAs in General Biology II (enrollment ~275) are used to facilitate student interaction during clicker question discussions, answer student questions during in-class activities, and help to develop student-centered learning resources and activities to be used during lectures. LAs also facilitate learning outside of class by holding drop-in office hours, answering e-mails from students, moderating discussion boards, and helping students to develop study skills. Although faculty who do not use LAs can certainly implement some of these same strategies, the LAs facilitate and support the incorporation of such approaches. They often suggest active learning strategies that they have researched or developed, and LAs provide instructors with insight about what concepts students are struggling with, which often becomes a target of an active learning strategy. Further, in LA-supported courses, students have more interaction with an active learning facilitator, which does not always occur in a class with less support.

LAs are different from teaching assistants (TAs), who might work in the same course, in that they focus on supporting the student in his or her learning, rather than supporting the instructor in his or her teaching. LAs do not grade or have input in evaluating students and are therefore meant to be in a more "trusted" position. A typical LA-to-student ratio is 1:30, though our largest enrollment courses (~275) generally have a maximum of seven or eight LAs. Faculty at our institution find that larger groups of LAs make coordination and planning more difficult.

The foundations of any LA program are content, pedagogy, and practice. These three elements shape the experience for LAs, faculty using LAs, and students in supported courses:

- *Content*: LAs meet weekly with their lead faculty to reflect on the past week's activities, plan for the next week's lesson, discuss the content under study, and analyze student work. These meetings help the LAs to deepen their own content knowledge, and they help to provide a richer content-based context for the students in the supported course.
- *Pedagogy:* First-time LAs take a pedagogy seminar in which they discuss learning theory, teaching strategies, formative assessment, promoting discourse, and students' conceptions, all in the context of their specific content and their LA work. The seminar serves as a place to learn about teaching and learning through reflecting on their LA experience (to see the syllabus for this course, go to www.nsta.org/college/connections.aspx).
- *Practice:* An LA's primary role is to facilitate discourse and interaction among students in the supported course. Although our LAs work primarily in the large lecture environment, they also work in help rooms, in study sessions, and online (in course management systems, outside discussion boards, e-mail, etc.).

Since beginning in the spring semester of 2012, our LA program has grown steadily to impact more students. Not only has the total number of science courses, students, and LAs increased, but representation of women and ethnic minorities has also increased over time (Table 1). This is encouraging, considering the relative absence of diversity in science, where women, ethnic minorities, and persons with disabilities continue to be marginalized (National Science Foundation, National Center for Science and Engineering Statistics, 2013). It also better reflects our student population at the university, which is approximately 33% students of color.

The use of LAs is generally well received by students in supported courses. Research has shown that learning gains of students in LA-supported courses are significantly higher than those of students in non-LA-supported courses (Otero et al., 2006) and that using LAs has an impact on curricular change in these courses (Pollock & Finkelstein, 2013). Although there is some data on students' attitudes toward learning science in LA-supported courses (Chasteen et al., 2011; Pollock, 2006), little has been done to investigate students' perceptions about teaching and their own learning in these courses. Further, almost all research on the use of LAs has been done within the context of physics, but LAs are used in other disciplines as well. Our work focuses on LA use in biology and chemistry and therefore helps to fill in the discipline gap with respect to LA research.

Student satisfaction survey results

We administered a survey to students enrolled in five LA-supported science courses at our university during spring semester 2013. The purpose was to investigate the impact of LAs on students' satisfaction with the course. The survey was comprised of both open-ended and constrained-response items. In this discussion we focus primarily on the results from the constrained-response items. The courses surveyed were General Biology I, General Biology II, General Chemistry I, General Chemistry II, and Organic Chemistry I. All faculty teaching these courses had used LAs at least once before, and some had used LAs for each semester the program has been in existence at our university. The survey that was administered at the end of the semester was voluntary, anonymous, and administered on paper in class. Total number of respondents was $n_r = 534$, which represents a response rate of 63%, based on the end-of-semester enrollment total in these courses ($n_T = 848$).

Three of the following Likert-scale items are of particular interest to the present discussion: (1) having LAs helped you learn in this course, (2) having LAs increased your overall satisfaction with this course, and (3) having LAs increased your satisfaction with the teaching of this course. There were five response categories for each of these items, ranging from *strongly disagree* to *strongly agree*, including a neutral option of *neither agree nor disagree*. Further, respondents were prompted to "explain" after choosing a response.

Four other constrained-response items were all related to how students used LA support. These items were as follows: (1) Did you seek help from

TABLE 1

Growth of the Learning Assistant Program at University of Colorado Denver.

	Spring 2012	Fall 2012	Spring 2013	Fall 2013
Number of LAs	15	18	42	41
Number of LAs from ethnic minority groups	6	3	15	22
Female/Male	6/9	10/8	24/18	31/10
Number of students impacted	555	805	1,400	1,600
Courses that used LAs	General Bio II General Chem II Organic Chem I	General Bio I Genetics General Chem I *General Chem II	*General Bio I *General Bio II *Genetics *General Chem I *General Chem II (2 sections) *Organic Chem I Organic Chem II (2 sections)	+General Bio I (2 sections) *Genetics *Chem Foundations *General Chem I *General Chem II *Organic Chem I *Organic Chem II Biochemistry

Note: LA = Learning Assistant.

*denotes course taught by a faculty member with previous experience using LAs.

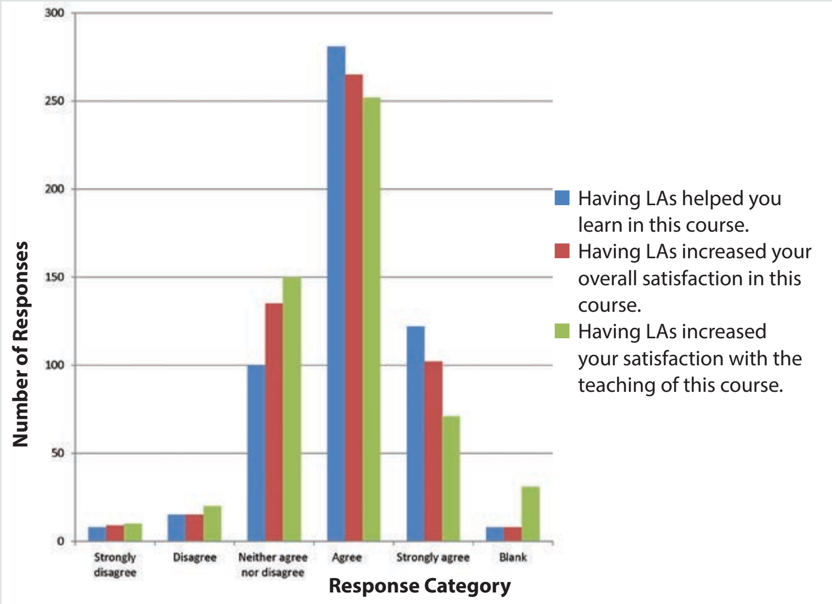
+denotes one section taught by faculty with experience using LAs, and one section taught by faculty with no experience using LAs.

an LA during class? (2) Did you ever email an LA for help? (3) Did you ever attend LA office hours? and (4) Did you ever attend an LA-run exam preparation session? Response categories for each item were *never*, *less than once a month*, *once per month*, and *more than once per month*.

In analyzing student responses to the three satisfaction items, we first examined the frequency of category choice and then examined relationships between responses to these Likert-scale items and to the other items pertaining to use of LAs. Because the response patterns were very similar across all courses surveyed, we aggregated all 534 responses into a single pool for analysis and presentation in this article. Also, because we are not comparing student satisfaction in LA versus non-LA courses, we are assuming that students are basing their responses on their previous course experiences at our university, which are largely in non-LA-supported courses. One limitation of this research is that we did not have comparable non-LA supported courses to survey.

FIGURE 1

Frequency of responses to Likert scale satisfaction items. LA = Learning Assistant.



The majority of students agreed that having LAs helped them learn, increased their satisfaction with the course, and increased their satisfaction with the teaching of the course (see Figure 1). Taken together, responses to these three items seem to characterize a general response of student satisfaction. The fact that response distributions to each question

TABLE 2

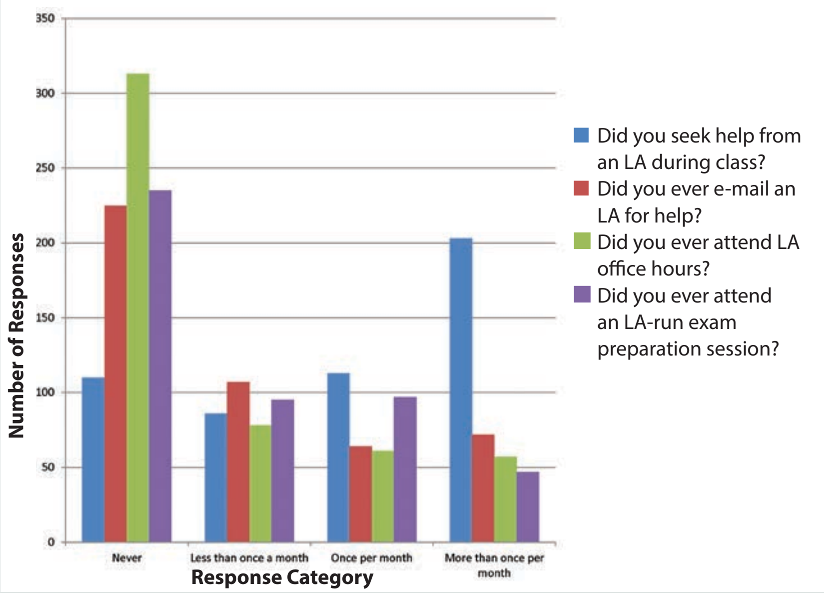
Representative open-ended comments from students in LA-supported courses.

Comments representative of student satisfaction with LAs	Comments representative of student use of LAs
"It gives a more personal feeling to a giant lecture class and it almost feels like a smaller class because it's so much easier to ask one-on-one questions." [General Biology II student]	"Having LA[s] provided more attention to individual students. In a class of 200+ students, it was easy to get our questions answered and addressed fast and easily!" [General Biology II student]
"They make the class much more interactive and engaging." [General Chemistry II student]	"They help explain thing that Dr. [faculty name] just doesn't have time to explain to us individually in class while working on something or doing clicker questions." [General Biology II student]
"[LAs] Helped me but made me understand why I was solving a problem the way I was. [They] Didn't just give an answer." [General Chemistry II student].	"Having people about to answer question during class was amazing. I may have personally not used them much, but they made class much smoother. To reiterate: even if you don't' use them personally they are good overall." [General Biology II student]
"Doing group work in class and getting individual help from LA[s] is the only reason I got a firm grasp on some concepts." [General Chemistry I student]	"In a big class the prof cannot be everywhere to answer all the questions. It was extremely nice to have people who can come and answer our question or explain a point." [Organic Chemistry I student]

Note: LA = Learning Assistant.

FIGURE 2

Frequency of responses to Likert scale LA utilization items. LA = Learning Assistant.



were very similar supports this notion of a more general trend. Open-ended comments from students also support this finding (see Table 2).

When asked about how they use LA support, students reported that they mainly use LAs during class meeting times. Far fewer students e-mail their LAs for help or attend LA-run office hours or exam prep sessions. Frequencies of responses to the four items about how students use LAs are shown in Figure 2. Also, comments from the students' open-ended responses were mainly focused on LA use during class time (see Table 2).

Cross-tabulating responses from the items about student satisfaction with those about how students used LAs shows that responses are indeed related. Specifically, chi-squared tests show that the dependence of student satisfaction on how LAs were used is statistically significant. However, note that for the questions related to LA uses outside of class, some expected cell counts in the contingency tables were quite low. This is due to the distribution of responses to the item related to course satisfaction (see Figure 1). There were relatively few responses in the *strongly disagree* and *disagree* categories to this item; therefore, expected cell counts in more than 20% of the cells in the contingency tables were less than 5 (see contingency tables at www.nsta.org/college/connections.aspx). Because of the very low numbers, the assumptions underlying chi-squared tests in these cases are likely not valid. Therefore, we only infer a significant relationship between LAs impacting student satisfaction in the course and the frequency with which students reported using LAs in class ($\chi^2 = 110.57$, 12 *df*, $p < .000$).

Student learning gains

Although not the primary focus of this study, we do present student learning gains data to support the effect of LAs on Biology course transformation. In our General Biology II courses, the Conceptual Inventory of Natural Selection (CINS; Anderson, Fisher, & Norman, 2002) is administered pre- and postsemester's instruction. Table 3 and Figure 3 present comparative CINS gain data between two separate Biology II sections: one with LA support and one without. Although taught by

TABLE 3

Learning gains data from General Biology II courses using the Conceptual Inventory of Natural Selection (CINS).

Semester/ LA use	Instructor overall rating	Course overall rating	n_{pre}	n_{post}	pretest *M* (*SD*)	posttest *M* (*SD*)	*Average normalized gain (<g>)	+Effect size
Fall 2012/ no LAs	4.9	4.7	133	92	12.31 (4.24)	11.63 (3.66)	–0.08	–0.17
Spring 2013/ LAs	5.0	4.9	220	197	11.01 (3.69)	15.46 (3.83)	0.49	1.18

Note: LA = learning assistant.

*<g> = (post_mean – pre_mean)/(Total_possible – pre_mean) (Hake, 1998)

+Effect size = (post_mean – pre_mean)/SD_pre different instructors, these courses each have very similar "course overall" and "instructor overall" ratings on the standard university measure, the Faculty Course Questionnaire. Further, each course used the same textbook as a curricular resource. The gains and effect sizes presented are based on all available responses but are essentially the same when only matched pre- and postresponse sets are used. The LA-supported course incorporated active teaching strategies, and the LAs and course instructor collaboratively examined research literature on student conceptions of natural selection. LAs were given question prompts to help students identify and address problematic thinking.

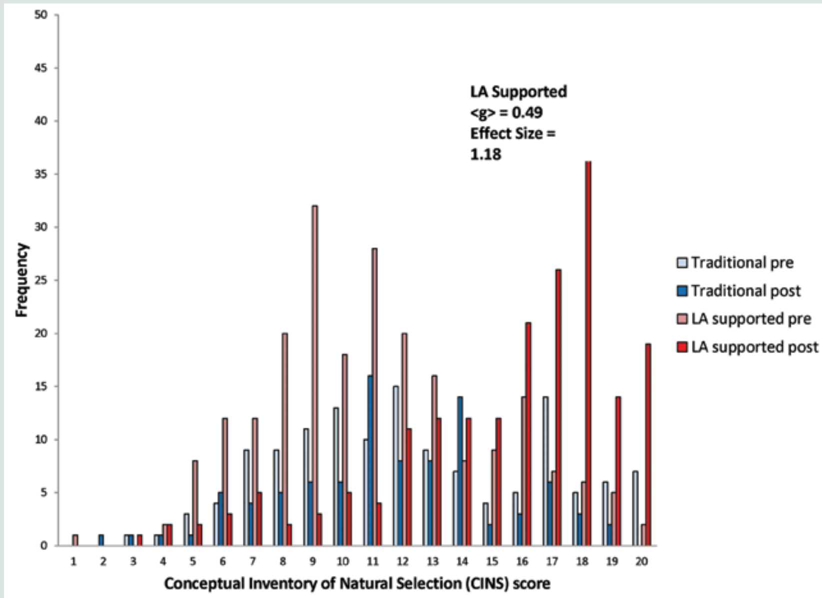
Compared with CINS gains from other research, the gains observed in our LA-supported course are very high (Andrews, Leonard, Colgrove, & Kalinowski, 2011). Andrews et al. (2011) reported learning gains on an abbreviated version of the CINS from 33 instructors across the United States who used active learning strategies to varying degrees. They observed effect sizes range from –0.11 to 1.26, with a mean effect size of 0.49 (*SD* = 0.31) and a mean average normalized gain of 0.26 (*SD* = 0.17). Our LA-supported course is at the very top of this range, whereas our non-LA-supported course is at the bottom.

Discussion

It is important to remember that LAs are not TAs in terms of their roles in undergraduate science classes (e.g., LAs do not grade). In fact, some LA-supported courses concurrently had "traditional" TAs for these purposes. Perhaps this is why students did not show much preference for using LAs outside of class time, as these may be responsibilities more commonly associated with TAs. Another possible explanation is that the LA faculty primarily encourage LA use during the lecture time in the course. Faculty encouraging and supporting LA use

FIGURE 3

Comparison of learning gains on the Conceptual Inventory of Natural Selection (CINS) in General Biology II, LA-supported and Traditional (non-LA-supported) sections. LA = Learning Assistant.



outside of lecture time (e.g., holding study sessions, etc.) is a more recent development. Our findings from the survey highlight these differentiated roles for TAs and LAs. Specifically, students perceive the face-to-face learning environment (during lecture time) as a place where the "near-peer" LAs are most supportive of their learning. Consequently, even though students reported fewer interactions with LAs outside of class, they still reported increased satisfaction with the course because of the LAs. Follow-up research related to the nature of these interactions between LAs and students would help to elucidate the types of learning that occur in these settings.

In addition to student satisfaction, another critical indicator of success in undergraduate science courses is student achievement. Although we present only limited comparative learning gains data from our Biology II course, the results are very encouraging, especially when compared with other published data using the same instrument. Students in our LA-supported Biology II course are clearly achieving much higher gains than those in non-LA-supported Biology II courses. Other research (Otero et al., 2006) has also shown the positive impact of LAs on the conceptual understanding of students in LA-supported physics courses, but to our knowledge such data from LA-supported biology courses has not heretofore been published. Future research exploring the relationships between student satisfaction and achievement could provide a more nuanced understanding of teaching/learning processes in these large courses.

Earlier we noted that a challenge facing undergraduate science educators is not only attracting more students into science, but also transforming the way we teach science in large-enrollment undergraduate classes. Using LAs supports these transformative efforts and has a positive impact on students' attitudes about the course and their learning in those courses. Future studies that allow for cross-group comparisons of cognitive and affective gains by factors such as ethnicity; class; gender; and interactions among students, LAs, and faculty would provide critical insight into the role of the LA program in course transformation and institutional change. ■

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