

Initial Replication Results Of Learning Assistants In University Physics

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Abstract. West Virginia University recently began a learning assistants (LA) program in its introductory calculus-based physics course targeted at increasing course effectiveness and recruiting future STEM teachers. The LA program was modeled after the Colorado Learning Assistant model. This paper describes the setting and initial results from the implementation including changes in learning gains (measured with the Force and Motion Conceptual Evaluation) and attitudes (measured with the Colorado Learning Attitudes about Science Survey). These data are combined with demographic data about the individual students and compared to baseline data collected prior to the implementation of the LA program.

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INTRODUCTION

At West Virginia University (WVU), we have recently begun a learning assistants (LA) program based on the model developed at the University of Colorado [1]. The initiation of this program serves to address two challenges not unique to West Virginia: a shortage of well-qualified physics teachers in our state and the need to improve our introductory physics courses in our department.

Our institution is in many ways typical; it is a public, land-grant university that serves a broad population. The physics department seeks to increase its research funding and its number of majors but has no plans to add physics education research (PER) as a major research focus. Student groups underrepresented in physics nationally are also underrepresented here. In this sense, it is an ideal setting to replicate a program that has had successful results elsewhere [2].

IMPLEMENTATION CONTEXT

West Virginia University in Morgantown is the flagship land-grant, doctoral degree-granting research university in the state of West Virginia. It had an enrollment of 29,617 in the fall of 2011, with minorities comprising approximately 10% of the total. The PhD-granting Department of Physics consists of 18 tenure-track or equivalent faculty, five research faculty, and three temporary faculty working in a

newly renovated building. It currently has approximately 70 graduate students and 100 undergraduate majors.

At WVU, physics teacher certification takes place in the College of Human Resources and Education. There are three established paths for physics teacher education. The first is a 5-year dual-degree program, in which students obtain a bachelor's degree in integrated science and a master's degree in education with teaching certification in physics and general science. The other two paths to certification are post-baccalaureate models. One is the Master of Arts with Certification, while the other is a certification-only path.

Despite these options, only one physics education graduate has completed the program over the last six years. West Virginia had 20 job postings in physics for the two-year period 2007-2009. Ten of these were unfilled. Of these unfilled positions, 3.5 were awarded [3] to permit holders not classified as "professional educators." These data are typical for the state.

Our introductory calculus-based physics courses (4 credit hours) meet for four 50-minute lectures and one two-hour lab per week. The first semester course uses a standard text [4] and serves approximately 700 students per year. Of these students, 82% are engineering majors and 13% are other STEM majors. Although non-lecture-based structures have proven effective for learning physics in other settings (see [5] for one recent example), our department does not have

a space that would accommodate such a change. Because of this, we have focused on the lab as a setting for the LA implementation, and have used part of the lab time to insert the University of Washington tutorials [6], with LAs performing the tutorial instruction under weekly guidance from a faculty member.

The labs themselves were non-reformed prior to the LA program and remain so. Before the LA implementation, students completed lab reports in a graded lab notebook and completed weekly quizzes on content or lab preparation. The laboratory exercises could be accurately described as “cookbook.” There was little interaction between lecture instructors and lab teaching assistants (TAs), and lab students would often complete their work and leave early. Considering the fact that some scheduled time was unused, the lab situation was seen as an opportunity to insert learning assistants into a research-based activity while holding essentially the same labs. This approach allowed the lab-based aspect of the course, which is a part of many students’ general education program, to stay in place during the first steps of our course transformation.

Experiment lengths were adjusted to ensure that the two-hour “lab” time allowed both tutorial and experiment time (approximately evenly split), with the TA and LA working together during contact time. LAs took the lead for the first part (the tutorial), and the TA led the (scaled-down) experiment. Lab expectations of students were adjusted to replace lab notebook and weekly quiz requirements with tutorial homework and lab calculations, so that changes in student workloads were zero sum but more research-based. Lab expectations of TAs also remained zero sum because quiz grading and most lab book grading was removed when tutorial homework grading was added.

Serving as an LA is an early teaching experience which is contextualized by the requirement that LAs enroll in the science pedagogy course. At WVU, we offer a science-specific version of a required education course (EDUC 200: Professional Inquiry) that serves as the LA seminar. This course, taught by one of the authors (JSC), is modeled after the Colorado course and modified slightly to meet the requirements of our education program. Each of our LAs is required to take it, but it is also open to anyone on campus to make it more sustainable. In our first year, we had five LAs and ten non-LAs enrolled in the pedagogy course.

In addition to the pedagogy course, each LA is assigned three tutorial sections for which they attend a weekly training session. In order to receive their stipend (\$1500/semester), LAs hold “office hours” in a central tutoring location in addition to their scheduled tutorial labs and the pedagogy course. In the Colorado model, the essential elements of LA program implementation briefly summarized are (1) that it

serve as an experiential learning program for the LAs themselves, (2) that LAs attend a special seminar designed to help them integrate content, pedagogy, and practice, (3) that teacher recruitment be a focus, and (4) that the program is evaluated [7]. We have recreated each of these aspects at WVU.

METHODOLOGY

This study employs a quasi-experimental design using pre- and post-testing with control and experimental groups. The test of conceptual understanding utilized in the course was the Force and Motion Conceptual Evaluation (FMCE) [8] while the attitudinal survey was the Colorado Learning Assessment in Science Survey (CLASS) [9]. The FMCE and CLASS were administered in each section during the semester prior to the LA program implementation (the baseline semester) and to all sections in the first two semesters after LA implementation (the LA1 and LA2 semesters). A total of 725 students took both pre and post FMCE surveys, with a similar number taking the CLASS.

The survey approach was selected as the most practical choice for our site, since we have no formal physics education research program. While more finely-grained data collection might provide clues to separate the effects of using learning assistants from using tutorials, we do not claim to distinguish these effects. We selected the tutorials because they have been shown to be effective, and we were only able to use them *because* of the structure provided by the implementation of the learning assistants.

Because combined lab/tutorial sections (hereafter referred to as “lab”) are not paired with lecture sections, each lab section contains a mix of students from all lecture sections. This means that a lecture instructor may choose not to interact with LAs who are working with his or her students in lab. In the LA2 semester, only students who were enrolled in the small section designated for honors program students and physics majors had a lecture instructor who did not interact with the LAs.

In the LA1 semester, due to a last minute change in the teaching schedule, no lecture instructor met regularly with the LAs. Instead, LAs met weekly with another faculty member. Because frequent communication between LAs and lecture instructors is a vital part of the LA model, students in this situation do not experience an authentic replication of the LA program. Further, since no baseline data was collected for these instructors, the effect of using a different instructor cannot be separated from the LA implementation. Therefore, the LA1 semester is not considered in the survey comparison.

TABLE 1. Normalized content gains (average of matched pair gains) on the FMCE before and after implementing the LA program at WVU. LAs were used in two consecutive semesters, but lecture instructors in the LA1 semester did not have baseline data and did not meet with LAs (see text). Data from boldfaced sections are highlighted in the figures.

Semester	Section	Instructor	Enrollment	# Pretests	# Pairs	Normalized gain (%)
Baseline	7:30 AM section	A	72	61	41	24
	Honors/majors section	B	46	45	33	37
	Regular section	A	115	111	96	32
	Regular section	C	116	205	47	6.4
	Summer section	A	55	55	46	32
LA1	7:30 AM section	D	120	99	57	19
	Regular section	E	122	94	51	13
	Regular section	E	124	119	54	12
LA2	Honors/majors section	F	23	24	21	42
	Regular section	A	178	171	143	48
	Regular section	A	181	168	136	47

To get the most valid comparison between the control and experimental sections for this study, we have selected one section of the baseline semester and two sections of the LA2 semester. These sections shared the same instructor and (besides the building change) only differed in that the LA program was fully implemented in the latter. The instructor used clicker questions and the same lecture notes and homework assignments during lecture both before and after LA implementation. Note that this instructor also taught a 7:30 AM section in baseline semester. This section is not included in the baseline data since this section had an unusually early time slot and has since been retired.

RESULTS AND DISCUSSION

Table 1 shows the FMCE results for all students tested in all three semesters. The average normalized content gain for each section was determined by averaging all FMCE matched pair gains for that section. The overall average normalized gain on the FMCE for the five sections (including a summer section) taught before the LAs were used was 32.4 (for $N = 263$ exam pairs) and for the six sections taught after was 35.8 (for $N = 462$ exam pairs). Gains are determined using the scoring method described in [10]. For the reasons described above, these average numbers do not isolate the effect of the LA implementation, but are provided for completeness and establish that students' experiences are highly dependent on the instructor.

When the focus is narrowed to the sections shown in boldface in the table and the instructor variable is eliminated, the effect of the LA-led tutorials is highlighted. The baseline section has a normalized gain of 32, compared to a gain of 47 for the two sections taught with LAs and tutorials.

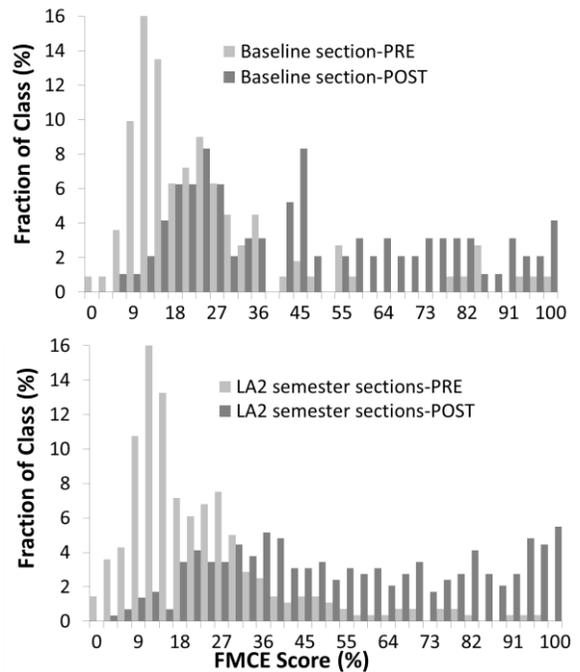


FIGURE 1. Pre- and post-FMCE score distributions for students in the baseline section ($N = 96$ pairs) of the first semester physics course compared to the LA2 semester sections ($N = 279$ pairs).

The distribution of scores is shown in Figure 1 for these sections. The average pretest (posttest) scores for these sections in 2011 and 2012 were 25.6% (48.5%) and 22.4% (56.1%) respectively.

A two-way factorial analysis of variance was conducted to detect any significant gender-specific differences in FMCE scores between the baseline semester section and the LA2 semester sections. While there was a significant difference in the

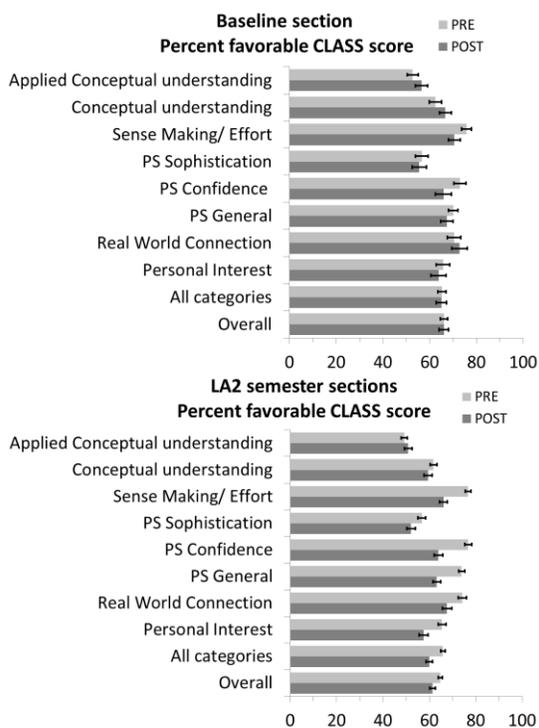


FIGURE 2. CLASS survey results in the baseline semester ($N = 88$ pairs) compared to the LA2 semester ($N = 261$ pairs).

normalized content gains from control to experimental groups as a whole (mean difference = 0.13, $t = -3.42$, $df = 346$, $p < 0.01$), and for men (mean difference = 0.16, $t = -3.38$, $df = 275$, $p < 0.01$), there was no significant change in normalized content gains for women. Additionally the sample size was too small to show significant differences between genders or between first generation and non-first generation students from the baseline semester to the comparison semester.

CLASS data was analyzed utilizing the standard scoring sheet resulting in a percent favorable score for each category investigated. Students who selected the incorrect choice on the screening question (statement 31) [9] were eliminated. The survey results by category from the sections indicated in boldface in the table are presented without comment; further analysis is ongoing.

As of now, none of our five LAs have transitioned to the teaching pipeline, but three have chosen to continue as LAs. One stated the following in her portfolio for the pedagogy course: “I know that without this program I never would’ve considered education as a possible career option.” This remark is encouraging. Meanwhile, we are working on streamlining the path to teacher certification so that we can better accommodate interested students.

We have shown that student learning gains can be achieved at a non-PER university through the replication of an LA program structure using LA-led, research-based instructional methods. We have already begun to expand the implementation to the second semester introductory course, and have additional LAs coming on board to help us.

Finally, in addition to improving the education of students in LA-supported courses and recruiting future teachers, the goals of the Colorado model of the learning assistant program also include engaging tenure-track faculty more in teacher education and discipline-based educational research [1]. While this study shows some improvement in student learning gains over baseline with LA-led tutorials, we expect that we could see additional improvement if instructors who are not actively using the LAs to their advantage could be convinced to do so. This broader transformation is still a work in progress.

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