Are Learning Assistants Better K-12 Science Teachers?

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Abstract. This study investigates how the undergraduate Learning Assistant (LA) experience affects teachers' first year of teaching. The LA Program provides interested science majors with the opportunity to explore teaching through weekly teaching responsibilities, an introduction to physics education research, and a learning community within the university. Some of these LAs are recruited to secondary science teacher certification programs. We hypothesized that the LA experience would enhance the teaching practices of the LAs who ultimately become teachers. To test this hypothesis, LAs were compared to a matched sample of teachers who completed the same teacher certification program as the LAs but did not have the LA "treatment." LAs and "non-LAs" were compared through interviews, classroom observations, artifact packages, and observations made with Reformed Teacher Observation Protocol (RTOP) collected within the first year of teaching. Some differences were found; these findings and their implications are discussed.

Keywords: Physics Education, teacher preparation, teacher observations.
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INTRODUCTION

Teachers are always learning especially in their first year of teaching, recent research has stressed the need for teachers who are prepared to be effective immediately following their certification program [1]. Coupled with the need for teachers with strong content preparation is the need for teachers with strong pedagogical preparation. Currently, two out of three high school physics teachers in the U.S. have neither a major nor a minor in the subject [2]. Most research universities produce very few physics teachers and tend to send an implicit (and often explicit) message that secondary science teaching is not a worthy career for talented physics majors. Meanwhile, research shows that among the factors within policy control, the most significant predictor of student success is the proportion of teachers in a school who have full teacher certification and a major in the subject being taught [3]. Physics departments can no longer consider physics teacher preparation the sole responsibility of schools of education, rather physics departments must play a key role in the process [4, 5]. The Colorado Learning Assistant (LA) model addresses these issues by engaging both the schools of education and physics departments in the recruitment and preparation of future physics teachers [6].

The Colorado Learning Assistant (LA) program [7] began at the University of Colorado (CU) in 2003. The program is focused on recruiting talented math and science teachers and improving the quality of math and science education for all undergraduates.

The program has been implemented in nine science, math, and engineering departments at CU and is currently being emulated by over twelve four-year institutions. Each semester the program hires 80-90 LAs. These LAs are talented undergraduates hired to assist instructors in transforming their undergraduate courses to be more student-centered and interactive. LAs lead "learning teams" in which students articulate and defend their ideas and analyze authentic scientific data. While most LAs are not considering careers in teaching when they first apply to the LA program, many express an interest in teaching following their experience. Common reasons given for this shift are encouragement and support from science and mathematics faculty members and recognizing teaching as an intellectually challenging endeavor. Approximately 12% of undergraduates who participate in the LA program go on to enroll in a teacher certification program [7]. This recruitment has led to a dramatic increase in the number of secondary math and science teachers certified at CU and across the state [6].

The LA program not only recruits undergraduates to help in science and math courses but also prepares them (through a three-pronged experience shown in figure 1) to facilitate student learning in these transformed courses.

First, LAs further their content understanding in weekly meetings with the lead instructor of the course in which they work. Second, LAs develop their pedagogical knowledge through a weekly science and mathematics education seminar that is co-taught by an education faculty member and a master high school teacher. This class is attended by LAs from all departments and addresses practical techniques as well as readings from science and physics education research. Finally, LAs engage in actual practice as they lead learning teams of 6-20 students. While the LA program introduces undergraduates to pedagogical theories and strategies, it is not a teacher preparation program. LAs interested in a teaching career later enroll in a teacher certification program.

Although previous research has already shown that

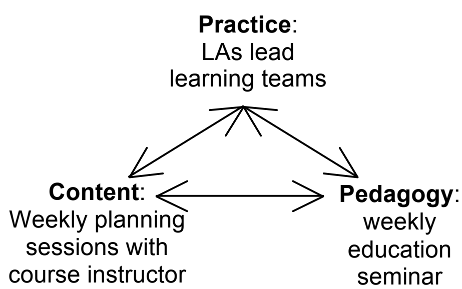

FIGURE 1. The three pronged learning experience

the LA program is increasing the number of science majors entering the teacher certification programs [6] and that LAs have more advanced views of cooperative learning [8], it is still unclear whether these former LAs (who are now first year middle and high school teachers) engage in more effective teaching practices than their colleagues who did not participate in the LA program as undergraduates. The purpose of the research reported in this paper was to investigate the teaching practices of these former LAs using a quantitative observation protocol.

METHODOLOGY

Data Collection

Former LAs who completed a teacher certification program in secondary science were recruited to participate in the research study during their first year of teaching. A matched sample of first year teachers who had completed the same teacher certification programs but had not participated in the LA program were also recruited. Teachers were matched based on their degree area (math, physical science, or biological science), teacher preparation program (licensure only or licensure with masters), and school context such as ethnic diversity, and school location (urban, rural, or suburban). This matched sample served as a "control" for this study and helped us evaluate whether there are indeed differences between former LAs and those who did not have the LA experience as undergraduates. During their first year of teaching these teachers were interviewed and observed two to three times during the course of the school year. The number of teachers and the number of observations are shown in Table 1 and are broken down by LAs (the former LAs who are now teaching) and NonLAs (the control teachers who did not have the LA experience but are matched on other experiences).

For each of the two to three observations a member of the research team observed one of the teacher's class periods. Each teacher was observed by at least two different researchers throughout the year. The observing researcher took notes and then rated different aspects of inquiry oriented classroom practice using the Reformed Observation Teaching Protocol (RTOP) [9].

The RTOP is made up of 25 statements about the lesson design, content, classroom relationships, and classroom dialogue which are in line with the National Standards for Science Teaching. Each statement is rated on a scale from zero to four.

Scoring reliability was established by reaching agreement (within 80%) among the entire team when scoring videos of several different teachers engaged in a variety of teaching activities [10]. Subsequently, researchers observed teachers in teams of two for the entire first year to check reliability in live settings and to negotiate differences. In the following years of the study researchers met periodically to ensure scoring consistency using video cases. New researchers were brought onto the project and were not informed about who was and was not a former LA. New researchers conducted observations with experienced observers and discussed their scores, after establishing reliability among the larger group with video cases.

Data Analysis

RTOP results can be broken down into subsets of statements using two methods: the category method and the factor groups method. The category method uses the categories as they are organized in the RTOP (i.e. Lesson Design and Implementation, Content, and Classroom Culture) which were developed from the research literature on reformed teaching. The second and third categories are broken down further into two subcategories each (Propositional Knowledge, Procedural Knowledge, Communicative Interactions,

TABLE 1. Number of Observations Done and Teachers Observed Grouped by LA and NonLA Groups.

	Observations	Teachers
LA	19	7
NonLA	20	7

and Student/Teacher Relationship). This grouping encompasses all the statements on the RTOP. This organization of the statements is also the more familiar of the two methods.

The second method for organizing RTOP responses is to disaggregate subscores based on the factors described in the RTOP reference manual [10]. These factors were found using an exploratory factor analysis performed by the creators of the RTOP using the results from 153 classroom observations. Their analysis led to five factor groups which were named and described in the manual. These factor groups include: Inquiry, Content Propositional Knowledge, Content Pedagogical Knowledge, Community of Learners, and Reformed Teaching. All but two of the RTOP statements (# 8 and 23) are included in these factor groups. The factors do not correspond to the categories used on the RTOP survey. The factor groups present an interesting grouping of the RTOP statements since they separate out the statements specifically related to inquiry teaching such as respecting students prior knowledge, and to creating a community of learners such as encouraging student to student dialogues.

FINDINGS

An analysis of the RTOP scores for the first year science LAs and NonLAs shows that the classroom practices of LAs were rated higher on the RTOP and most of the subsets of statements and that most of these differences were statistically significant. The first year Science LAs show a statistically significant result when compared to NonLAs on the overall RTOP score ($p = 0.02$) as shown in Table 2.

The analysis of the RTOP scores by categories and subcategories also shows statistically significant results with the LAs outperforming the NonLAs in four categories: Content ($p < 0.01$), Propositional Knowledge ($p = 0.03$), Procedural Knowledge ($p = 0.02$), and Classroom Culture ($p = 0.05$). These results are shown in Figure 2,

TABLE 2. Average Overall RTOP Score and Standard Deviation Grouped by LA and NonLA Groups.

	Average	SD
LA	57.6	20.7
NonLA	43.1	18.0

The first year LA Science teachers also outperformed their counterparts in three of the five factor groups: Inquiry ($p = 0.02$), Content Propositional Knowledge ($p = 0.02$), and Content Pedagogical Knowledge ($p = 0.03$). These results are shown in Figure 3.

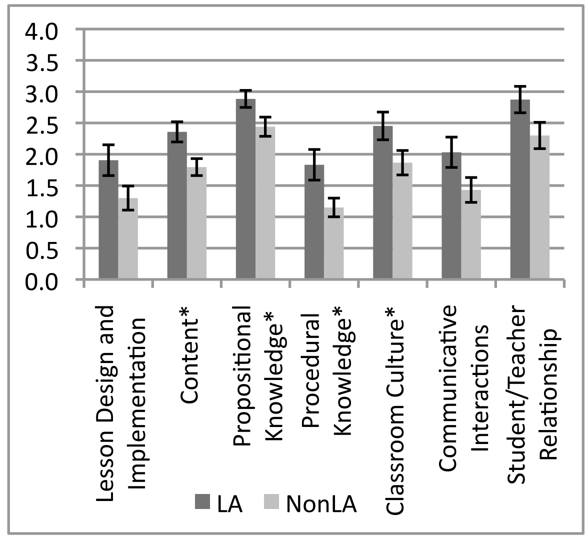

FIGURE 2. Average response for each category and subcategory of the RTOP. Error bars represent the standard error of the mean. * = Statistically different means.

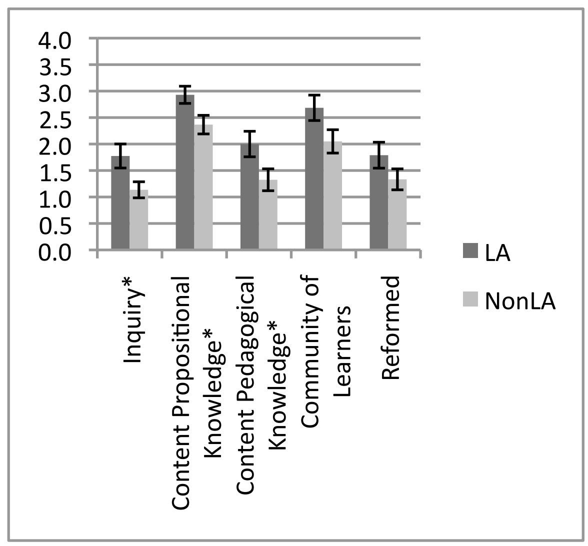

FIGURE 3. Average response for each factor group of the RTOP. Error bars represent the standard error of the mean. * = Statistically different means.

DISCUSSION

Based on the analysis presented above the teaching of the former LAs tends to be more aligned with the national standards and research on teaching. More specifically, the LAs tend to present the content of their courses in a more organized way using real-world examples, multiple representations, and appropriate levels of abstraction (as indicated by their higher score in the content categories of the RTOP). The former LAs tend to use their students' ideas as starting points for their lessons and to encourage them to challenge ideas and generate alternative solutions (as indicated by their higher score in the Content Pedagogical Knowledge group of RTOP statements). As one former LA explains when asked why she assesses her students, "I have to know where they are in order to help them go to where I'm trying to get them. In order for them to hit the target, I have to know what direction they're pointing, to help them hone in on the bull's eye." The former LAs' higher score in the Inquiry group suggests the LAs tend to involve their students in more inquiry-based learning practices such as creating hypotheses, practicing constructive criticism, and being reflective about their learning. Finally, the LAs tend to create a classroom culture that better promotes dialogue, argumentation, and respect for others as indicated by their higher scores in classroom culture. These differences are not surprising since the LA experience emphasizes eliciting, respecting, and using students prior ideas; facilitating group discussions; and coaching students in argumentation and metacognition skills. As explained by one of the first year LAs during an interview,

> *The biggest thing, and it's just second nature, is, I know how to ask students more open-ended guiding questions because of being an LA. I cannot fathom giving a student an answer when they ask me a question. [laughs] And my mentor last year was like, How do you know how to do that? It's because it's instilled in you as an LA. You ask guiding questions to get them to understand the process. It's not about the answer as much as the process. That's the biggest thing. And all of that was all [the LA program]*

IMPLICATIONS AND CONCLUSION

The results of this study suggest that the LA program is effective in preparing first year science teachers in both content and pedagogy. Although a matched sample of the type we used cannot serve as a perfect control, the findings make clear that former LAs exhibit more aspects of reformed teaching than first year teachers who did not serve as LAs. Though no causal claims can be made regarding the LA program specifically, the data strongly suggest that fomer LAs are better first year teachers than their peers. Former participants in the LA program were observed to be better able to teach as recommended in the national standards, specifically in the more coherent way they organize the content, the inquiry skills they encourage their students to develop, and the type of learning community they create in their classes. These improved practices may be the result of the opportunity LAs are given to learn about research-based teaching practices while engaging in an opportunity to explore these ideas while leading their own students in cooperative learning, inquiry-based activities. These weekly opportunities to try out the new ideas LAs have been studying and to gain new knowledge and experiences to apply to their readings and seminar discussions may allow the LAs to create a robust personal understanding of research-based teaching. The difference in RTOP scores may also be a result of a selection effect. For example, since students must be selected to serve as LAs, perhaps they were already different in important ways from the matched sample of teachers. We took great care to find a matched set of teachers who care about their students, and are in similar school contexts, though we were up against many contextual variations such as grade level, subject matter, and level of administrative support. However, we believe that there is something in the LA experience that prepared them for their first year of teaching. We have confidence that the matched sample of teachers will continue to grow as teachers. Future work will provide qualitative case study examples of differences in the nature of LA and non-LA's classroom practice.

ACKNOWLEDGMENTS

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REFERENCES

1. Darling-Hammond, L. and Bransford, J., *Preparing Teachers For a Changing World: What Teachers Should Learn and Be Able to Do*, Jossey-Bass, San Fransisco, 2005.
2. Neuschatz, M., McFarling, M., and White, S., *Reaching the Critical Mass: The Twenty Year Surge in High School Physics, Findings from the 2005 Nationwide Survey of High School Physics Teachers*, AIP, College Park, MD, 2008, Fig. 14, p. 17.
3. Darling-Hammond, L. and Youngs, P., *Educational Researcher* 31, 13-25, (2002).
4. National Task Force for Teacher Education in Physics, Report Synopsis (February, 2010).
5. Hodapp, T., Hehn, J., and Hein, W., *Phys. Today* 62 (2), pp. 40-45, 2009.
6. Otero, V., Pollock, S., Finkelstein F., *American Journal of Physics*, (in press).
7. Otero, V., Finkelstein, N., Pollock, S., and McCray, R., *Science **313***(5786), 445-446 (2006).
8. Gray, K.E. and Otero, V.K., 2009 PERC Proceedings, AIP **1179**, 149-152 (2009).
9. Sawada, D., Piburn, M.D., E. Judson, E., Turley, J., Falconer, K., Benford, R., and Bloom, I., *School Science and Mathematics* 102, 245-253 (2002).
10. M. Piburn and D. Sawada, http://physicsed.buffalostate.edu/AZTEC/rtop/RTOP_full/PDF/RTOP_ref_man_IN003.pdf..