

# Developing Undergraduate Learning Assistants' Skills in Guiding Science Learning

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## ABSTRACT

This concurrent triangulation mixed method design study describes the influence of a science education seminar (SES) on the learning assistants' (LAs) perceptions of their roles in the classroom. The SES was developed to train undergraduate students as LAs at a Southern liberal arts college in the USA. The focus of the seminar was teaching the LAs how to guide students through the learning process. Using the LAs perception survey, a pre and post-survey was administered to a conveniently sampled nine LAs to observe changes in their perceptions of their role. An interview was given to eleven LAs at the end of the seminar to investigate their perception of the seminar and any changes that had occurred in their perceptions of their role as LAs. A test of the significance of the quantitative data was done using the Kruskal–Wallis Chi-square and the qualitative data were analyzed using Atlas software. The pre- and post-survey results indicated that the LAs' perceptions about their roles changed during the semester. During an interview conducted at the end of the seminar, LAs indicated that their views on how to approach students' problems had changed mainly due to the seminar. The interview also showed that the LAs felt that the seminar was valuable because it changed the way they viewed themselves in their role. Results from this study inform colleges of the importance of training LAs.

**KEY WORDS:** Interviews; learning assistants; perceptions; science education seminar; survey

## INTRODUCTION

The paradigm of teaching has slowly shifted from telling students to actively engaging them in the learning process (MacIsaac and Falconer, 2002). Active learning techniques require students to engage with the material for effective learning (Chi, 2009). Research has shown that students who engage in their learning process retain the information (Kvan, 2000), perform better (Aji and Khan, 2019; Freeman et al., 2014), have better critical thinking skills (Kim et al., 2013), and are less likely to drop their classes than those involved in a traditional lecture. In active learning, students are encouraged to engage in activities that help them construct meaning to the activities (Chi, 2009). According to Chi (2009), students must have an opportunity to engage with both teachers and peers to effectively understand the classroom material. This is done by ensuring that students are properly guided through proper questioning techniques, effective group discussions, and providing challenging activities for the students (Burke, 2011; Chi, 2009). MacIsaac and Falconer (2002) indicated that students must be encouraged to involve in dialog in their classes. According to Warfa et al. (2018), dialog in classes has the potential to improve conceptual understanding.

Teaching students actively has its challenges, especially when different groups are created during class discussions. Some groups may be silent, while in other groups, very few individuals speak. Sometimes, students in some groups

will go off-topic while the class is in session (Burke, 2011). Faculty must ensure that they are paying attention to the group dynamics as classes are in session. Sometimes watching these dynamics may be difficult for a single individual. Another set of eyes may help observe these group dynamics. Team teaching approaches have been used to alleviate these problems. In some cases, graduate students have been used as teaching assistants (TAs). In undergraduate institutions, learning assistants (LAs) have taken that role.

Faculty in colleges are finding ways to effectively engage their students in the learning process through various active teaching and learning techniques. One proposed teaching technique for active learning is the use of undergraduate peer mentors called LAs (Crowe et al., 2014). However, LAs require training to ensure that they can effectively engage students in the classroom. This article describes a semester-long seminar for LAs and reports results on the assessment of the seminar's effectiveness on the LAs.

### LAs

LAs are undergraduate students who work with faculty either in lecture or laboratory classes to assist in the student learning process. Barrasso and Spilios (2021) define LAs as near-peer instructors because these are students who help other students to learn. According to Barrasso and Spilios (2021), LAs are different from TAs because they have two different roles. While TAs are graduate students who help faculty in teaching responsibilities

such as grading, evaluation, and preparing assignments, LAs aid students in the learning process. Their job is to assist the students to learn better. LAs are usually students who took the class a semester or two semesters previously. Therefore, they understand what their peers are going through in specific classrooms.

LAs have been used as a conduit for faculty to adopt evidence-based instructional techniques (Barrasso and Spilios, 2021; Otero et al., 2010; Van Dusen et al., 2015). For instance, faculty who are overwhelmed with group or inquiry activities in their classes can benefit from the presence of LAs who are there to help the students learn better. Specifically, student–teacher ratios can be overwhelming for large classrooms. This ratio can be reduced with the help of the LAs. The LA model has also been used for teacher K-12 teacher recruitment and transforming science departments to increase learner-centered approaches in their teaching (Otero et al., 2010).

The LA model is characterized by the following (Barrasso and Spilios, 2021): (1) LAs interact with students in either lecture, laboratory, or recitation sessions, (2) LAs attend scheduled meetings to plan for future activities or reflect on past activities, and (3) LAs attend a seminar to teach them how to interact with students. A seminar is important for the LAs because it provides the skills to navigate working with students and clarify their roles in the classroom (Sana et al., 2011). For instance, in large science classrooms, LAs can lead small group discussions by encouraging students' engagement through guided questions and by elaborating on course material (Sana et al., 2011; Woltering et al., 2009;). Further, Franklin (2018) indicated that classes that use LAs must adopt evidence-based approaches where the LAs are not there to replace teachers but to complement what teachers do by working with individual groups. Franklin (2018) also emphasizes the need for the training of the LAs to properly carry out their roles.

Research on the impact of LAs on students' outcomes has come with mixed results. A study by Sellami et al. (2017) found that classes with LAs performed significantly better on higher-order skills. However, no statistically significant difference was observed when lower-order skills were tested between classes with LAs and those without. Another study in multiple institutions by White et al. (2016) showed that classes with LAs had significantly higher effect sizes than classes without LAs. This was attributed to inquiry activities that the use of LAs promoted. A study was also carried out to investigate the influence of LAs on science, technology, engineering, and mathematics (STEM) recognition and persistence in other STEM courses (Philipp, 2013). This study found that students with LAs had higher STEM recognition and persistence in subsequent STEM courses.

Rassouli and Ríos (2020) used a semi-structured interview to investigate the importance of weekly content meetings between LAs and instructors. Most of the LAs felt more prepared when they knew beforehand what would be in the classes through the weekly meetings. They also found that the weekly meeting gives the LAs the time to reflect upon their interactions with

students. Another study by Cochran and Brookes (2013) investigated LAs' reflective practice in their classes. The LAs interviewed reported being frustrated by the struggles students faced, and this resulted in them making changes to deal with the struggles. For instance, some LAs changed the way they approached problems and others used multiple ways to deal with the same problems. It is not clear what type of training the LAs were given in this study. In another perception survey (Becker et al., 2016), LAs felt that they were more relatable to students than graduate TAs and faculty. Cao et al. (2018) also found out that LAs believe that they understand the students better than their TA counterparts. This is because the LAs just passed the classes they are working in and thus understand the dynamics of these classes. The LAs from this study mentioned understanding and communicating course content to students as important, although facilitating group discussions was not seen as very important to the LAs. Jeong (2021) found that LAs believed that their goals were to help students as they reason through their classroom problems without giving outright answers. However, some of the LAs in the study advocated outright confirmation of an answer to avoid confusing students. The LAs believed that not giving an outright answer could lead to distrust between them and the students they are helping.

LAs' training can address issues such as their roles in the classroom, the way they communicate with the students, and how to deal with group dynamics. A study by Philipp (2013) found that LAs can practice the skills they learn during seminars when they work with students.

In this study, we created a STEM education seminar (SES) to train LAs on evidence-based approaches to working with undergraduate students in both lecture and laboratory sessions. The SES aimed at acquainting LAs with effective teaching methods for conceptual understanding, and familiarizing them with effective assessment methods, including self-assessment, instructor evaluation of student progress and learning, and assessment of course efficacy. We further wanted to demonstrate the value of interactive strategies for teaching in the college classroom, provide students with experience reading primary literature in STEM education, and allow them to put teaching strategies into practice in their labor assignments. This article evaluates the influence of the SES on the perceptions of the LAs. It specifically evaluates the impact of the SES on LAs' sophistication in using active approaches to help students, the perception of LAs on the SES, and how the SES influenced how the LAs approached students' questions.

## METHODOLOGY

This research followed a concurrent triangulation mixed method design where the quantitative and qualitative data were collected within the same time frame and were analyzed separately. To be involved in this study, a student was supposed to be a LA in the following STEM disciplines: chemistry, physics, biology, mathematics, and computer sciences. Therefore, a convenient sampling procedure was used for the participants.

The SES had six LAs in the spring 2015 semester and eight LAs in the fall 2015 semester. The SES was team-taught by two of the authors of this article. The meeting time was a weekly 2-h session. The two instructors selected papers for students to read each week in preparation for the in-class meeting. These papers focused on theories of education, learning styles, how to work with student groups, how to effectively guide students through various questions, and how to use prior knowledge to help students. The instructors developed questions to guide the students through each of the given readings. The class session was focused on discussing the outside readings. During class, the LAs also discussed how they were applying the readings with their students.

### The Participants

Participants in this study came from a southern liberal arts college. The participants were undergraduate students working as LAs in various science disciplines. The disciplines comprised physics, biology, chemistry, mathematics, and computer science (Table 1). Most of the participants were in their junior year of college. Internal review board approval for human subjects and consent process was duly carried out for this research. All participants gave informed consent and voluntarily participated in the project.

### The Instruments

To develop the instrument, we considered what the literature said about the role of LAs. According to Gordon et al. (2022), LAs work to “facilitate student engagement by modeling successful intellectual practices and offering assistance to students with coursework” (p. 104). Furthermore, Fingerson and Culley (2001) brand LAs as “collaborators in teaching and learning” (p. 299). However, due to an initial lack of expertise and experience, the LAs may be unsure about their roles and skills (Sana et al., 2011). We also looked at websites of different universities and colleges involved with LA programs and found that common among them is that LAs assist with instruction, lead discussions, provide feedback on assignments, facilitate discourse among students, and help make a course more students centered. The above considerations provided a pathway for the type of questions to be included in the instrument. The survey, LAs’ perception survey (LAPS), was created by two of the three researchers to investigate how the LAs viewed their role in the classrooms, what they viewed as the roles of students, and what they believed an effective faculty would teach like. One of the researchers is a chemistry educator, while the other is a curriculum developer focused on STEM education. Both researchers have experience in science education research. One of the researchers had created validated science education instruments before. Thus, the researchers used both literature and expert judgment to create the instrument. To create the survey, the two researchers agreed to come up with items individually. Through a series of meetings, the items were examined to see which fit with our objectives. After brainstorming, some of the items were removed. The final survey had 12 items (see Appendix). The survey was used for the quantitative part of the study.

A semi-structured interview protocol was created to support the quantitative sections. The protocol was aimed at investigating the LAs’ perception of the SES and changes that occurred due to attending the seminar. To create the interview questions, all the researchers met several times and discussed what they needed to get from the interviews. In this meeting, several questions were suggested. After this series of meetings and brainstorming, the final interview protocol was created (see Appendix).

### Data Collection

We collected data to investigate changes in LAs’ understanding of their role and the role of faculty in the classes they were assigned. We also collected data to determine their perceptions of the SES. The participants were given a survey as a pre- and post-test at the beginning and end of each semester. Then, volunteers were requested for interviews. In total, nine participants completed both pre- and post-test surveys, and eleven LAs participated in the interview.

### Data Analysis

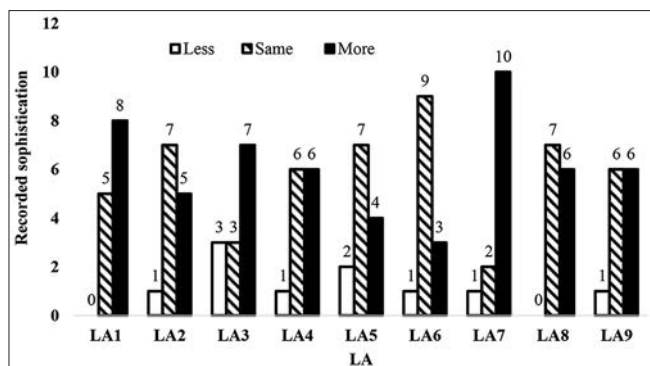
The researchers read the pre- and post-test responses from the survey. After reading the responses to each question, the researchers decided whether the response had shown an improvement in perception or not. Three columns were made for each individual, representing reduced sophistication, the same level of sophistication, and improved sophistication. After the analysis of each survey, a score on each level of sophistication was determined for an individual. Kruskal-Wallis’s Chi-square was used for statistical analysis. For the qualitative section, the researchers analyzed the data independently using the Atlas qualitative analysis data. The researchers discussed and agreed on the codes developed through the analysis process.

## RESULTS

### Level of Sophistication for Each Participant

Figure 1 shows changes in the sophistication of the LAs within a single semester before and after taking the science education seminar course.

Of the thirteen questions individuals answered on the survey, the figure shows how many of those responses indicated less, same, and more sophistication, respectively. The figure shows that LAs 1, 3, and 5 showed the most improvement in their sophistication in understanding inquiry guidance in their classes. The LAs 2, 5, 9, and 7 had no changes in 7 or more of the 13 questions on the survey. Further, six of the nine LAs had improvement in 6 or more of the 13 questions on the survey, and all of them had an improvement in sophistication in at least 3 of the 13 questions. The data shown in Figure 1 was ranked to make sense of it using nonparametric tests. Kruskal–Wallis (KW) Chi-square test was carried out on the ranked data to detect whether significant variations in the ranks of participants’ responses existed. The null hypothesis, in this case, was that the mean ranks of sophistication (less, same, or more) for individual LAs are the same. The KW chi-square is



**Figure 1:** Changes in the sophistication of students' responses after taking the SES course

calculated using the following equation (Lane, n. d.):

$$H' = -3(N+1) + \frac{12}{N(N+1)} \sum_{i=1}^k \frac{T_i^2}{n_i} \quad (1)$$

In (1),  $N$  is the total number of observations,  $T_i$  is the sum of ranks for the  $i^{\text{th}}$  group,  $n_i$  is the sample size of the  $i^{\text{th}}$  group, and  $k$  is the number of groups. When tied ranks are present,  $H$  adjusted for tied ranks is given as follows:

$$H = H' / (1 - 0.111) \quad (2)$$

Using the KW test for the column mean ranks, the following statistics were calculated:  $H = 16.6$ ,  $df = 2$ ,  $p = 0.000$ . This  $p$ -value is greater than the alpha level of 0.05. This indicates that the null hypothesis has been rejected. Therefore, we can conclude that the difference of at least one mean rank of sophistication is big enough to be statistically significant. Using Bonferroni posthoc analysis, no significant difference was observed in the number of responses that remained at the same sophistication and the number of responses that showed improved sophistication. Table 2 shows sample quotes depicting observed changes in LA's perceptions.

### Level of Sophistication for Each Question

We tested to determine changes in sophistication for each of the 13 questions on the pre-posttest survey. Figure 2 shows responses to the 13 questions by the LAs.

We defined large improvements when 5 of the 9 LAs showed more sophisticated understandings of that question. By that definition, there was a large improvement in sophistication from the LAs in five of the thirteen questions (questions 1, 5, 8, 10, and 11). Questions that had an improvement of sophistication between 3 and 4 LAs were regarded as a medium improvement. Based on that definition, seven questions of the 13 resulted in a medium (questions 2, 3, 4, 6a, 6b, 7, and 8). A small improvement was defined as only one or two LAs indicating an improvement in that question. By that definition, a small improvement was observed only on question 12.

A KW Chi-square was also carried out to make sense of the data. The null hypothesis, in this case, was that the mean ranks

of sophistication (less, same, or more) for different questions on the survey are the same. The calculated KW test  $H$  was as follows:  $H = 21.6$ ,  $df = 2$ ,  $p = 0.000$ . Therefore, we can also conclude that the difference of at least one mean rank of sophistication for different questions is big enough to be statistically significant. Using Bonferroni post hoc analysis, no statistically significant difference was observed between questions that had no change in sophistication and those that had an improved sophistication. However, the number of responses that indicated a decrease in sophistication was significantly less than the other two levels of sophistication.

### LAs' Perceptions of the SES

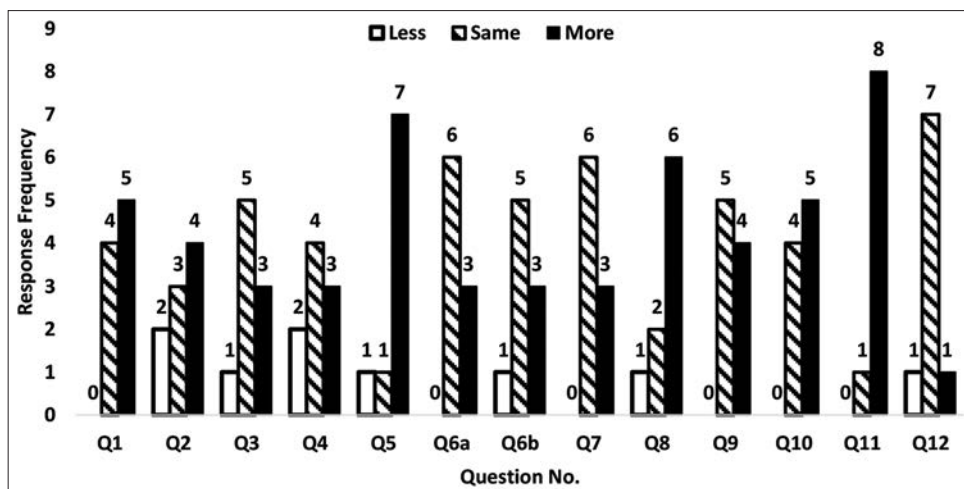
A semi-structured interview was given at the end of each semester to determine the perception of the LAs of the SES. The first question asked the LAs to talk about their experience with the SES course. The most common thing they thought the seminar was beneficial was teaching the LAs to involve students in the learning process to improve their understanding. For instance, one LA1 indicated that he learned about providing necessary tools to the students instead of just giving facts. Another LA (LA2) indicated that the seminar taught her to help students gain a deeper understanding of the material that they are learning. The LAs also felt that the SES helped them understand the broader nature of their roles as LAs. For instance, LA3 indicated that the seminar made him reflect on his role as an LA, while LA4 indicated that at first, she thought she was just there to help with minor issues in the class but through the SES, she realized that she could do more to help her faculty. When asked about her experience with the SES, LA4 said:

*At first, I thought it's gonna be a class that helps the TA but it taught me more. It got me in-depth into what teaching is actually like...I imagined to be more off, these are responsibilities for TAs and these are like the only responsibilities you have. But it showed me that there are many levels of actual learning and teaching that we can both apply to ourselves and to the students we teach.*

In general, the LAs indicated that the seminar had taught them to be effective LAs who could approach students' work in a different way from what they were used to. The LAs liked the fact that they learned various teaching techniques that would help them with their roles as LAs. When asked about his experience with the SES, LA5 said:

*I think after reading all these articles and going to class and discussing them, I realized that teaching is a little bit more complex than what I thought it was. So, I think I've learned more myself as a student by just taking that class and by being a better TA. So, some of these things that I'm learning in class I'm able to apply then myself as a student. I've been applying them as a TA or..., so which is their objective, but I have learned.*

When asked about how the class affected their perspective, most of the LAs indicated that the SES had changed the way they



**Figure 2:** Changes in the sophistication of LAs' responses to individual questions

felt about their roles in the classrooms. For instance, before the SES, LA6 felt that her role was just to help students catch up with whatever the faculty was saying, but after the seminar, she felt that her role was more than that. The SES helped her learn questioning techniques that could help her students understand the material better. This was echoed by LA1 who said that at first, he thought he was just the right-hand man to the faculty, but after the SES, he thought that he was a collaborator with the teacher and somebody who could ask questions to students. When asked about his changed perceptions, LA1 said:

*To begin with, I sort of thought of myself as the right-hand man of the teacher, right? You know, something needs grading, I am gonna grade it. If he or she needs something in her office, I am gonna get it. I just thought of myself as somebody who was there to help. Now I am starting to realize that it's more than that. You have to be somebody that's gonna ask those questions in order to deduce what students are struggling with and what they are having a hard time with... and to collaborate with the teachers in order to get those tools that we learned in order to explain those concepts to the students. Anything that they might be struggling with.*

In general, the LAs felt that they were passive observers in their classes before the SES. After the SES, most of the LAs felt that their role was that of active participants as they supported the faculty in their classes. For instance, LA7 felt that he was almost the second faculty in the classroom because he was supposed to understand the background of students as he was helping them. After all, instructors may not be able to assess the background knowledge of every student in their classes. LA2 felt that she had a bigger role in helping students with different learning styles, which she did not think of before the SES. LA8 thought of himself as a passive tool in the classroom, but with the SES, he was able to talk with the faculty about the class to be taught so that he could assist better during the discussion sessions.

### Changes in the Way LAs Assist Students

The LAs were asked to determine if the SES had changed their view of assisting or the way they assisted students in their

classroom. Responses from the LAs indicated changes in the way the LAs assisted students. For instance, before the seminar, LA3 would just explain whatever question he received from the students. After the seminar, he changed how he approached students' questions. When asked how he assisted students after the seminar, LA3 said that he first asked the students to provide their explanation from which he could get a better picture of their understanding. He ensured that the students understood the basic concepts involved in the questions and would look for effective ways to explain the question to the students. One approach he used was concept mapping. This is what LA3 said:

*So, what I would generally kind of do is try to give them. So, first thing is, we will try to make sure that we have the basics. Then what I tend to do is try to get them to explain the idea to me so that they, if they can explain it which means they understand it. And sometimes, you ask your students to explain a question and as they are explaining it begins to make sense, and then all of a sudden, they don't need your help anymore. Sometimes when they explain the idea and they are still not quite able to make that connection, we, so I try to sort of bring up things like concept maps so to make sure that they know what the information they have, the information they need. They know how it's related to the overall structure of information they gain.*

Another LA (LA6) would also just explain to her students, but this time she uses guiding questions, which help her access the students' prior knowledge. This was echoed by LA8, who after the seminar, started investigating his students' background knowledge as he helped them. He further avoided giving answers but instead walked the students through the problems using guiding questions. LA9 also changed his approach to assisting students. Before the seminar, LA9 was more worried about his reputation if he failed to answer a student's question. After the seminar, he became more confident, and instead of just answering the questions, he was asking the students more questions to gauge their conceptual understanding. When asked about how helped students, LA9 said:

*Oh yes. Before, as I said, I would worry about my reputation and worry about trying to give them the right answer. So, previously, I would, usually if I remember how to do it, I would just take a pen and piece of paper and just walk down steps till I get the final answer and I show it to him and I go through it together. Now what I would do is, the first thing I would do is, I would try to get an understanding of his background. I will figure out what the concept of the problem is and how to solve the problem. And I would figure out what his background is and I would try to figure out how much direction he needs and get him through the right answer.*

On this question, there was a general agreement among the LAs that the best way to assist students was through understanding their background knowledge and using guiding questions to lead them to the correct solution.

### Advice to Instructors When Preparing Lessons

We also wanted to know what advice the LAs would give to faculty after going through the seminar. This was important because it provided us with knowledge about their sophistication. The LAs' felt that instructors must prepare their lessons to include activities that actively guide their students to understanding. For instance, LA3 indicated that instructors must assess students' understanding using active learning. Further, the faculty must keep students engaged, teach for diversity, and be aware of their learning styles. LA6 advised instructors to observe what students are struggling with, use prior knowledge, and encourage reflection among students. When asked what advice she would give to faculty as they are preparing their lessons, LA6 said:

*I think they will, definitely, need to consider where the students are with the material and what they think they know, what they think the students know, and then try to, maybe, get a little bit of input from there, saying ok, they are struggling a little bit with this and less with this. So how can I bring in this over here on the left, on the right hand, and teach... And then I would also try to think about, ask them how would they prefer to learn as students, and then, if they knew somebody else, if they were students, how would they think they would learn it best.*

Another LA (LA4) indicated that faculty need to include fun activities and visuals and break down complicated problems into understandable steps. LA1 recommended adding clickers and collaborative activities while seeking students' prior knowledge. He further advised faculty not to make assumptions about their students' prior knowledge. LA1 further indicated that the seminar had helped him to understand the importance of the advice he was giving. LA9 advised the faculty to encourage group work, real-life applications, and focus on connections among concepts. When asked what advice he would give to faculty as they are preparing their lessons, LA9 said:

*Ok, so again, the professor would start a lesson, I would start, with, again, the simpler concepts, start with the*

*simpler concepts to make sure they understand it. But along the path of the way, they should apply the concepts in the classroom, and they should have a real-life experience with the concept. They should have it in their memory as an experience. As something they have seen or something they remember doing and instead of something they remember reading or someone talking.*

### LAs' Advice to Prospective Students

The participating LAs were asked to advise prospective LAs on what they could gain from the seminar. All the LAs had positive advice for their colleagues. For example, LA3 said that the seminar could help LAs understand students in a different way, which could help how much students get from the LA. He further advised the prospective LAs to take the seminar and think about how they could apply it to their classes. LA4 stated that the seminar taught her how to communicate ideas to students and acted as a bridge for the information she was missing as a LA. LA7 advised his colleagues to be prepared to have their LAs' beliefs changed. He indicated that the seminar was important because it provided him with skills to help students. He was reluctant to take the seminar but realized later that it had important applications in his role as a LA. LA2 advised her colleagues to be serious with the seminar reading assignments. LA2 said:

*Take it more seriously at first than I did. I was like oh it is just a quarter credit class, how to be a better TA? I am not that important as a TA. It's not going to be that hard of a class. I found myself putting more and more into the reflections every week because the more you put into those the more you are going to get out of it. In the beginning, I wasn't doing any of the reading I was like, whatever it is just reading, I'll just skim it that way he knows that I skimmed it, but we had so few people that you, really, had to read it to be able to contribute to the discussion. Again, with that the more you read the more you think about it the more you are going to get out of the discussion. Which the more you are going to get out of your job later. I would definitely take it more seriously, it's not like a crazy amount of work they are asking from you.*

### DISCUSSION

Results from this study showed that attending the SES improved the LAs' sophistication in using active approaches to guide students. All participating students experienced substantial changes in their sophistication with an average change of 6.11 out of 13 questions. All the LAs also displayed no change in some of the questions with an average of 5.8 out of 13 questions. There was a small decrease in sophistication (average 1.1) among some between the pre- and post-test. The study has shown that there were still some remaining issues in the LAs' sophistication after the seminar since there were as many instances where sophistication remained the same as instances where it changed. No significant difference was observed between instances where sophistication changed and instances where sophistication did not change. The

change in sophistication observed in this study is largely attributed to the SES. This change makes sense because the seminar focused on issues that would increase the LAs' use of learner-centered approaches to guide students through their problems. These approaches include accessing background knowledge, asking students to explain how they think about their problems, and using guided questions to help students reach a solution. Further, the seminar taught the LAs to treat each student as unique. This increase in sophistication enabled the LAs to engage students effectively for understanding (Chi, 2009). According to Chi (2009) and Weinstein (2002), students must be properly guided through proper questioning techniques, effective group discussions, and providing challenging activities for the students. Therefore, having LAs who are ready to guide students is crucial for the learning process.

Of the 13 questions in the survey, substantial changes in sophistication were observed on questions 1, 5, 8, 10, and 11. Question 1 asked about their roles as LAs. Question 5 asked them about their opinion of the best faculty in terms of their teaching styles. Question 8 asked them about the explicit strategies they use to help students understand when asked a question. Question 10 asked them about their views on group work in the classroom. Question 11 asked the participants to suggest how instructors must assess students' understanding during and after a lesson.

**Table 1: Participants' summary**

TA pseudonym	Major
LA1	Physics/education
LA2	Biology
LA3	Math/Physics
LA4	Chemistry
LA5	Math/physics
LA6	Math/education
LA7	Physics
LA8	Computer science
LA9	Chemistry
LA10	Biology
LA11	Chemistry

The increases in questions 1 and 5 indicated that the seminar improved their understanding of their role as LAs and also the roles of faculty in class. Jeong (2021) argued that LAs struggle to understand their role as promoters of deeper learning and cultivators of personal connections with students. This struggle can affect how they work with students in class. The seminar, in this case, provided clarification about their role in the classroom. They had a better understanding of how an effective faculty should be in terms of how the faculty interacts with students. The increase in sophistication for question 8 showed that the SES helped them to understand how to approach questions from the students. During the pre-test, most LAs just talked about explaining the answer to the students while during the post-test, they talked about guiding the students to an answer. These findings are important because Phillip (2013) found that the LAs were able to practice the skills learned in the seminar they provided. We believe that this was also the case with the participants in this study. Further, Jeong (2021) found that LAs are afraid to use learner-centered approaches when answering students' questions due to fear of confusion and distrust. The posttest responses for question 8 showed that the seminar likely addressed this fear. Questions 3, 6a and b, 7, and 12 indicated no change in sophistication among the majority of the participants. Question 3 asked about the role of faculty in the classroom. Question 6a asked about how faculty would respond to a question from a student, while 6b asked how faculty would assign lab work to students. Question 7 asked the LAs how they know when they understand a concept. Question 12 asked the LAs if they have thought about becoming teachers. No changes were observed in questions 3, 6a, and 6b, mostly because the LAs already had sophisticated ideas based on these questions. The LAs already had an idea that the role of faculty must be to guide students through activities that will make them think about the materials. One of the aims of the LA model was to recruit teachers from science students (Otero et al., 2010). The SES did not seem to change the LAs' ideas about becoming teachers.

In terms of the perceptions of the seminar, most of the LAs believed that it helped them to understand their role in the classroom. They realized that they could do more in the classroom instead of being

**Table 2: Sample quotes depicting an observed change in LAs' perception survey**

Category	Pre-survey	Post-survey
Role as LA	My role is to grade and being backup instructor, and lab prep, carrying items for class, tutoring.	Guide students through content using techniques that allow students to understand concepts that they might not have understood when the professor taught it.
Best professor	The best professor builds on experience on what works best for most students, whether it be presenting something on the screen, giving the students activities, or something else.	I expect the professor to work through the content slowly, using visual and constructivist learning techniques to build understanding.
Role of the professor	I think the role of a professor is to introduce Concepts and materials to the class and then let students discover what it means for the current topic and the overall objectives of the class.	I think the role of a professor in the classroom is to teach material in a way that makes student question and think critically. They should help students think about how different concepts and ideas can be used both inside and outside of class.
Handling student questions	So far, I have given explicit techniques too much like an instructor. I also asked the professor way too many times for guidance. It is as if I'm almost a student myself.	I ask the student a question to guide their thinking. If they are off-track, I ask another question or explain a small part to get them back on track. Other than that, I let the student think out and process the question on their own.

observers. Based on their responses to the interview questions, we believe that the seminar increased the LAs' confidence in their roles as LAs. One of the LAs demonstrated this by stating that the seminar provided tools that helped them deal with classroom dynamics. Another LA felt that their role was like the second faculty in the class. This just demonstrates how confident the LAs were in their roles. This confidence is crucial for LAs to effectively carry out their roles. Further, this confidence can make them more active participants in the process of teaching students. As Cochran and Brookes (2013) indicated, LAs usually have challenges to help students if no proper tools are provided to them. Responses to the interview questions also indicated that the seminar helped the LAs change their approach to dealing with students' problems. The seminar helped them to actively engage the students in the learning process by asking guiding questions, seeking their background knowledge, and explaining using multiple ways. These are the issues that the seminar focused on. As observed by Sana et al. (2011), seminars like the one in our study can clarify the roles of LAs. The responses to the interview indicated that the current seminar played that role.

Finally, the participants' advice to prospective LAs who were thinking about taking the class shows that the participating LAs focused on the benefits of the class to change the LAs' perceptions. They advise their colleagues that the seminar would help them interact with students in class. This shows the satisfaction that the participant LAs had with the seminar. The advice itself shows that these participants had grown in the understanding of their roles.

## CONCLUSIONS AND IMPLICATIONS FOR TEACHING

In conclusion, this study has shown that a well-designed SES can improve LAs' perceptions about helping students. This can ensure that the LAs have the skills to better work with students. Sophistication in their perceptions of working with students can translate into applications in their classrooms. The results have also shown that LAs value a seminar that informs them about their roles. In this study, the LAs indicated that the seminar was relevant to them in their roles. Therefore, when planning a SES for LAs, ensure to incorporate content that aligns with what the LAs are doing in their classes.

### Limitations

Data from this study are obtained from a small sample of LAs based on the size of the college and the participants available from the science department at the college. More studies need to be done with a bigger group of participants.

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### Ethical Statement

The ethical standards were granted by the Institutional Review Board of Berea College. All participants signed a consent form.

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## APPENDIX

### GST 286: LAs' Perception Survey

Name: Major

B#: College GPA

1. Please, describe your role as a TA or learning assistant now. i.e., what actually do you do to support the professor in your TA/LA job?
2. Do you think there is more you could do in the classroom apart from what you are doing now? Explain
3. In your opinion, what do you think is the role of a professor in your classroom?
4. What do you think is the role of a student in the classroom?
5. In your opinion, what do you expect the best professor to do in your classroom in terms of his/her style of instruction?
6. Which professor would you rather have in your classroom? Explain a reason for each response.
  - (a) Professor A responds to your question with a direct answer but professor B responds to your question with another question to you? Why? Please write as much as possible.
  - (b) Professor C provides an explicit method that you are going to follow in your lab activity while professor D provides a research question and asks you to conduct the investigation on your own? Why?
7. How do you know when you understand something being taught in your classroom?
8. As a TA or LA, when a student asks you a question, what explicit strategies do you employ to respond to the student's question? (Or what do you do before answering the question?)
9. Suppose you find two students arguing about a certain concept in their groups (as they do group work), student A is correct, while B is wrong. What is the best way to resolve the situation so that both students understand the concept better?
10. What is your view of instruction that emphasizes group work in the classroom? Please provide reasons for that view.

11. In your opinion, how should instructors assess (find out) students' understanding during or after the lesson?
12. Have you considered teaching as a career? If yes, what made you to have that consideration? If not, would you consider it in future? Why? Why not?

### Interview protocol

TAs interview protocol: STEM Education Seminar

1. Tell me about your experience with the STEM Education seminar?
2. Could you please describe what you learned from this class?
3. What was your perception of your role as a TA at the beginning of this seminar? What is your perspective of your role as a TA now?
4. What knowledge and skills, if any, has this seminar fostered in you to effectively perform your role as a TA?
5. What is your take-home message from this STEM Education Seminar?
6. What advice would you give to other students who want to enroll in these classes?
7. Let's suppose there is a course similar to this but at an advanced level, can you take it?
8. Suppose a student came with a problem to you. Before this class how did you approach the problem? How has this class affected how you approach students' problems?
9. Suppose a professor in the class you are a TA has asked you to help in preparing a lesson? What suggestions can you give to her or him on what considerations to make in preparing for the lesson? How did you get this knowledge?
10. What suggestions would you make to a professor who wants to teach for conceptual understanding? How has the seminar influenced your thinking about teaching for conceptual understanding?
11. As a TA how do think you can approach a students' problem in a way to teach for conceptual understanding?
12. How has this seminar affected your view about the role of professors and students in a class?
13. Suppose the college wants every teaching or tutoring TA to take this seminar? How would you react to that?
14. What is your last word?