

# Mutual gains in STEM classrooms: Assessing learning assistant (LA) integration in forensic chemistry education

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**Abstract:** Learning Assistants (LAs) are trained undergraduate students who support student-centered learning through structured pedagogy training, preparation in advance of course interactions, and practice in the classroom. While the LA model has demonstrated positive outcomes in various STEM disciplines, its application in forensic science education remains underexplored. This study investigates the integration of LAs into a senior-level forensic chemistry course that uses a Team-Based Learning framework to promote active engagement and collaborative problem-solving. The research explores two primary objectives: (1) student perceptions of LAs in enhancing learning through student surveys, and (2) the professional and pedagogical development of LAs through structured LA reflections. The survey findings suggest that LAs are recognized as knowledgeable academic resources that make meaningful contributions to student success. The LA reflections reveal the importance of all three components of the LA model in LA development and implementation success. These outcomes suggest that incorporating LAs into upper-level forensic science courses not only supports student achievement but also fosters valuable professional growth for the LAs themselves. This study provides initial evidence for the use of peer-assisted learning in forensic chemistry and offers insights for future implementation of the LA model in similar contexts.

**Keywords:** Peer-Assisted Learning, Forensic Science Education, Reflective Practices, Learning Assistant Training, Active Learning

## Introduction

Peer-Assisted learning models, such as Learning Assistant (LA) programs, have gained traction in STEM education for their ability to foster active engagement and collaborative learning (1). LAs are undergraduate students who are prepared to assist their peers in learning approaches that emphasize student-centered learning activities (2). While implementation of the LA model varies, programs consistently include three components: pedagogy, preparation, and practice. LAs take a pedagogy course in which they learn fundamental teaching and learning principles as well as effective instructional strategies. They also meet weekly with the instructor of the course they support to prepare for upcoming activities. The majority of LAs' time is spent in practice - interacting directly with students to support their participation in active learning activities. LA practice can involve facilitating in-class activities, leading recitation sections, or holding office hours or study sessions.

The LA model has increased in popularity since it was first described in 2010 as a strategy for preparing K-12 science teachers (1). More recent research reveals its benefits to student success in large introductory STEM courses (3,4) and potential to increase students' sense of belonging and persistence in STEM (5). There is some

evidence that LA impact is higher in upper-level courses, possibly because LAs and students are likely to be closer in their academic paths than they would be in introductory courses (6). Incorporating LAs may offer a unique benefit to forensic science instructors implementing student-centered approaches since these courses are typically upper-level.

In addition to promoting student success, satisfaction, and sense of belonging, experience as an LA has emerged as a benefit to LAs, themselves. There is some evidence that K-12 teachers with experience as LAs use more evidence-based teaching practices than their peers with no LA experience (7). LAs also have common experiences, like navigating discussions with students who have different understandings of concepts, that provide opportunities to learn how to better facilitate learning. These experiences makes them more thoughtful during discussions both in learning and other disciplinary contexts (8).

So far, there has been no reported implementation of the LA model in forensic science courses. Given the apparent unique benefit to students in upper-level classes as well as the opportunities for professional growth for LAs, incorporating LAs to help facilitate student-centered teaching into forensic science courses seems promising.

### *Purpose*

The purpose of this paper is to explore the impact of peer-assisted learning through the use of LAs in a senior-level forensic chemistry course. While peer-assisted learning has demonstrated positive outcomes in various STEM disciplines, its application in forensic chemistry remains underexplored. This study aims to address that gap by examining the experiences of LAs and the perceptions of students enrolled in a Team-Based Learning forensic chemistry course. Specifically, the objectives are to 1) assess the student perceptions of LAs in supporting student learning, and 2) analyze the professional and pedagogical development of LAs through structured reflection. By investigating these objectives, this paper seeks to provide evidence for the value of integrating LAs into forensic chemistry education and inform future pedagogical practices.

### **Methods**

#### *Ethics and Transparency*

The research presented in this paper adhered to the ethical guidelines outlined by the Institutional Review Board (IRB: STUDY00008049) approved by the author's institution. The first author was a learning assistant in the forensic science course, the second author was the instructor of the LA pedagogy course, and the third author was the instructor of the forensic science course presented in this work. These three authors are uniquely positioned to provide expertise related to this project.

#### *Forensic Science Course*

This study took place as part of a senior-level forensic science course at a large, public, research-intensive institution. The course is required for all undergraduate forensic science majors and has a laboratory component in which students must be co-enrolled. The lecture portion of the course met twice per week (75 minutes each meeting), and the laboratory portion of the course met once per week for 165 minutes.

Students enrolled in the course have completed introductory forensic science courses, calculus, organic chemistry, and analytical chemistry. The course learning objectives and goals emphasize scientific and instrumental methods used in the analysis of different categories of forensic samples; discipline-specific writing related to laboratory experiments and journal-style research reports; team collaboration to develop conceptual understanding and problem-solving related to course content; and development of a novel research idea, analyses to address the research question, and preparation of oral presentations to disseminate findings. Content delivery is achieved using the flipped classroom model in which students are provided readings and videos prior to

lecture meeting times. More information on the flipped course structure can be found in previous work related to a similar course at our institution (9). Weekly lecture meetings are reserved for activities that are facilitated using the Team-Based Learning (TBL) model (10). During the first lecture meeting each week, students completed summative assessment quizzes both individually and within their teams, followed by a discussion to address knowledge deficits and misconceptions. Remaining lecture time is earmarked for team problem-solving sessions in which students are provided formative assessments (i.e., problem sets). More information on the TBL course structure can be found in previous work related to a similar course at our institution (11). The TBL activities, designed to promote critical thinking and the development of problem-solving skills, are enhanced with the integration of learning assistants.

Learning assistants attend all lecture meetings. During TBL activities, the LAs provide support to the instructor by circulating the classroom to ensure students are participating in the TBL activity and to assist with problem-solving. The LAs address students' questions through effective questioning, which promotes critical thinking and independent problem-solving. In addition, LAs provide additional support to the instructor by identifying concepts that are difficult for the students, which allows the instructor to address knowledge deficits and misconceptions in real-time. The course presented in this paper is the instructor's ninth time teaching the course and the third time integrating LAs into its structure; two LAs were part of the course presented in this paper.

#### *LA Pedagogy Course*

The LA pedagogy course was developed using resources available on the Learning Assistant Alliance website and the instructor's background in faculty development and education research. All new LAs at this institution enroll in a pedagogy course to prepare them for their roles. The course prepares students to assist in a variety of courses (general chemistry, organic chemistry, biochemistry, and forensic chemistry). The LAs in the pedagogy course meet once per week with the pedagogy course instructor for 50 minutes in addition to their time spent in weekly prep sessions with the forensic science course instructor and with students in the course they are supporting. The pedagogy course covers topics including questioning strategies, error framing, facilitating discussions between students, and mental models. LAs are given opportunities to practice their pedagogical skills in role-play activities and simulations. They submit a reflection each week on their experience with students, observe each other working with students, and present a poster at the institution's semesterly High Impact Practice showcase.

This study took place in the sixth year of the LA program at this institution. It was the fourth time the instructor taught the pedagogy course.

### *LA Pedagogy Weekly Preparation*

LAs for forensic chemistry courses must have completed the course in a previous semester and earned an A or B letter grade. LAs are granted observer-level access to the course’s learning management system (Canvas), which allows them to review assigned readings, instructional materials, and videos provided to students enrolled in the course. LAs participate in weekly one-hour preparatory meetings with the course instructor. These sessions are a foundational element of the LA model, designed to prepare LAs in the content knowledge needed to effectively engage with students in the classroom (1). At the beginning of each session, the LAs for the forensic science course are provided practice packets comprising problems for the upcoming weekly topic. The practice packets are the same problem sets provided to students each week. During the session, LAs complete the problems without guidance from the instructor and time is reserved to refresh and reinforce critical concepts. The LAs are instrumental in providing feedback and suggestions about how to improve the problem sets to enhance student understanding.

### *Survey Dissemination*

To understand the students’ perceptions of LAs in supporting student learning (objective 1), a survey was designed and disseminated through Qualtrics to all students enrolled in the forensic science course. Completion of the survey was anonymous, voluntary, and no course credit was earned for participating. A total of 17 students completed the survey. The survey contained one multiple-response closed-ended question presented below in **FIGURE 1** and six Likert-type questions presented on a scale of 1 (strongly disagree) to 5 (strongly agree) presented below in **TABLE 1**.

### *LA Reflections*

To analyze the development of the LA, we conducted a thematic analysis (12) of the LA’s weekly reflections submitted as part of the pedagogy course as well as a comprehensive reflection after the conclusion of the semester. During the semester, the LA reflected by responding to prompts that changed weekly. Prompts included:

- Your role as an LA is to “assist learners”. If you were to rate yourself on a scale of 1-10 (10 being the highest) where would you rate yourself right now? Why?
- What teaching skills or strategies did you use this week? Were they effective? If so, how do you know? If not, why not?

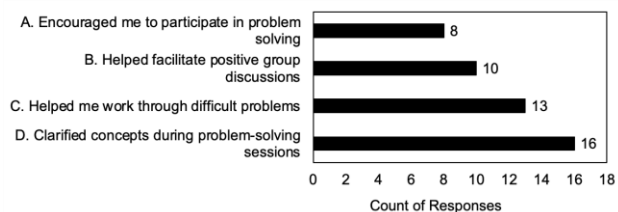
- How are your weekly content preparation meetings with faculty and other LAs for your course helping you to anticipate student ideas?
  - Without using a reference, what do you think it means to LA?
  - If you could go back in time and give yourself advice at the beginning of your LA experience, what would it be? Why?

After the conclusion of the semester, the LA engaged in post-semester reflective practice using the scaffolds described by Machost and Stains (13). The second author read all reflections, making note of recurring ideas and development of pedagogical knowledge that could help describe the LA’s personal and professional development. After identifying themes, the second author used member checking with the LA to ensure the analysis was reasonably well-aligned with the LA’s experience.

## **Results**

### *Survey Analysis*

Multiple-response closed-ended questions allow students to select all applicable options from a predefined list. These types of questions capture the variability in student experience related to specific aspects of LA support (i.e., understanding of course material). The survey contained the prompt: In what ways did the LAs contribute to your understanding of course material? (Check all that apply) followed by a list of four options a student could choose that included (A) encouraged me to participate in problem solving, (B) helped facilitate positive group discussions, (C) helped me work through difficult problems, and (D) clarified concepts during problem-solving sessions. Students could choose more than one item, resulting in a total number of chosen responses that exceeds the number of students who completed the survey.



**FIGURE 1** Responses for survey question “In what ways did the LAs contribute to your understanding of course material? (Check all that apply)”

Results presented in **FIGURE 1** indicate that approximately 50% (8/17) of the students felt that the LAs encouraged them to participate in problem solving, and over 50% (10/17) of the students felt that the LAs helped facilitate positive group discussions. Encouraging

active problem-solving and facilitating positive group discussions promotes collaborative learning, builds confidence, and strengthens critical thinking skills. LAs who foster participation and guide group dynamics help create environments where students feel supported in exploring course concepts. Approximately 75% (13/17) of the students felt that the LAs helped them work through difficult problems, and nearly all (16/17) of the students felt that the LAs were able to clarify concepts during problem-solving sessions. Working through difficult problems and clarifying concepts during problem-solving sessions are essential for overcoming learning obstacles and reinforcing understanding. LAs who provide targeted support and timely explanations help students build confidence, correct misconceptions, and deepen their understanding of the course material.

The survey contained six Likert-type questions aimed at understanding the students' views of the LAs' qualifications, demeanor, and readiness to assist, which are foundational to their instructional role. Results are presented in **TABLE 1**.

**TABLE 1** Results from six Likert-type survey questions; columns for strongly disagree and somewhat disagree are not included as the counts (and percentages) are zero.

Survey Question	Neither agree nor disagree count (%)	Somewhat agree count (%)	Strongly agree count (%)
Q1 - The LAs for this course were approachable.	0	2 (12%)	15 (88%)
Q2 - The LAs for this course were helpful when I needed assistance in class.	0	2 (12%)	15 (88%)
Q3 - I feel comfortable asking LAs for help in class during problem-solving sessions.	0	3 (18%)	14 (82%)
Q4 - Having a LA in this classroom made me more likely to ask questions during problem-solving sessions when I was confused about course content.	2 (12%)	3 (18%)	12 (70%)
Q5 - The LAs for this course were knowledgeable about course content.	0	0	17 (100%)
Q6 - I feel that if other forensic science courses had LAs available to me, I would be more likely to succeed in those courses.	1 (6%)	5 (29%)	11 (65%)

The first four Likert-type questions (Q1-Q4) focus on the student-LA interaction and the classroom climate that the LAs help foster. The questions assess how the LAs contribute to a supportive learning environment by being approachable and helpful, and encouraging student engagement. All survey participants agreed that they felt comfortable asking LAs for help, that LAs were approachable, and that LAs helped provide assistance during problem-solving sessions. Nearly all of the survey participants (15/17) agreed that having LAs in the classroom made them more likely to ask questions when they encountered confusion about the content of the problem-solving activity. The last two Likert-type questions (Q5-Q6) focus on the academic competence of LAs and their perceived impact on student success. They reflect students' recognition of LAs as valuable academic resources and their potential to enhance learning. All survey participants agreed that the LAs demonstrated knowledge about course content, and nearly all participants (16/17) agreed that having LAs in other forensic science courses would positively contribute to their academic success.

#### *LA Reflections*

The LA's reflections help give insight to the positive student perceptions of her role in the course. Three major themes emerged that, taken together, describe the development of the LA and reveal the importance of the role of each of the components of the LA model in this development. Here, we describe each theme and give examples from her reflections throughout the semester. The timing of each reflection is indicated in parentheses. For example, "Week 3" refers to the LA's reflection in the third week of the semester, during which the LA was concurrently enrolled in the LA pedagogy course and actively participating in the forensic science course. "Post-semester" refers to the exercise the LA did using the scaffolds for reflective practice (13).

The first theme, *intentional engagement*, emerged in the LA's reflections about her eagerness to engage with students from the beginning of the semester. In her first reflection, she said, "I made sure to go around the room, even to tables the other LA had been at, to ask them if they had any 'questions, comments, concerns?'" (Week 3) This was a consistent theme throughout the semester as well as in the post-semester reflection. The LA mentioned making a "concerted effort" (post-semester) to engage with students rather than waiting for students to approach her. She would even "circle back" (post-semester) to check on students she had helped who were struggling. This theme is notable because it demonstrates a quality with which the LA entered the experience. Whether a personality trait or an artifact of the upper-level or small enrollment nature of the course, intentional engagement with students indicates intentional engagement in the *practice* component of the LA model.

The second theme described the LA's minimization of apprehension about being able to explain *challenging content*. There was some "anxiety" (post-semester) in the beginning of the semester about being able to answer student questions, but the weekly prep meetings were an opportunity to clarify concepts. In the beginning, there was a "paradigm shift of being the learner vs being the supporter of learning" (post-semester) as the LA anticipated needing to answer questions about concepts she either may not have remembered or remembered struggling with when she was in the course. However, the weekly prep meetings helped mitigate the "fear of the unknown" (Week 13):

*These meetings are also helpful to clarify reasoning for certain concepts that I may have forgotten since I have taken the class, which allows me to strengthen my confidence for responses when students ask me the logic behind content. (Week 5)*

The third theme, *pedagogical knowledge and skills*, emerged because the LA's reflections were focused heavily on her use of pedagogical knowledge and skills developed through participation in the pedagogy course. The semester reflections show a clear progression from didactic approaches, "I still feel new to this role, and sometimes I feel that sometimes I am too quick to lead them to the answer" (Week 3) to attempts to use pedagogical skills like guiding questions, "I prioritized letting students explain to me how they reached an answer using guiding questions and asking students to provide elaboration for their answers and explained how they reached a conclusion" (Week 5), to more advanced pedagogical skills involving considerations for how students conceptualize a concept and how to guide them:

*I am working on helping students make connections to past content, in order to reach the correct answers. This also isn't easy, because it can be challenging to help them apply previous knowledge, especially when the students may not have strong background information, (they don't remember foundational concepts, don't have a strong foundational background, etc.) so sometimes it can be hard to meet students on their level. This is a skill I have had to develop however. I consider this skill a method of trying to figure out how to find common information that both of us know, and work up from there. (Week 10)*

These reflections demonstrate the LA's experience of the three components of the model and emphasize the importance of all three in any implementation of the model. She considered the positive feedback on the survey as an indication of a positive outcome in her LA **practice**. The minimal reflections on apprehension about answering students' questions could, in part, be attributed

to the LAs preparation before becoming a LA, but she explicitly attributed it to her opportunity to clarify content in the **weekly prep meeting**. Most of her reflections focused on the use of pedagogical skills, which clearly improved over the course of the semester. Again, she explicitly attributed this to her participation in the **pedagogy course**. Asked what she thought it meant to be an LA in one of the last reflection activities, she referred to all three components:

*I think being an LA means that you are willing to learn how people learn, and **apply productive pedagogical skills** to help create success **in the classroom**. Being an LA is extremely hands-on, and being an LA means you are working closely with other students, and feel **ready to answer questions** and make connections. Being an LA requires knowledge of the class you are assisting, preparation outside of class, and an understanding of how students learn to provide the classroom with the best outcomes. Being an LA means your presence is a resource for students to lean on. (Week 12, emphasis added)*

## Discussion

The implementation of LAs in this forensic science course was guided by the three essential elements of the LA model: pedagogy, preparation, and practice. The student survey results show that the LAs positively influenced the learning environment and student outcomes in each of these three areas.

### Practice

The first element of the LA model, practice, involves the application of pedagogical strategies in an authentic classroom setting. The LAs' ability to foster a supportive and approachable classroom was seen in the survey results. All survey participants reported feeling comfortable asking LAs for help (Q3, **TABLE 1**), and that LAs were approachable and helpful during problem-solving sessions (Q1, **TABLE 1**). Nearly all survey participants indicated that the presence of LAs made them more likely to ask questions when they were confused (Q4, **TABLE 1**). These findings highlight the LAs' ability to create safe spaces where students felt comfortable engaging, asking questions, and seeking clarifications. Reflections showed that the LA entered this role with an interest in intentionally engaging students. Nonetheless, her confidence in supporting students was reinforced by the strong implementation of the other two components of the model (pedagogy and preparation):

*Based on the survey results from the students in the class, I believe that the positive outcomes may be attributed to ULA content competency, and application of pedagogical skills.*

### *Pedagogy*

The second element of the LA model, pedagogy, focuses on the development of LAs. The impact of LAs was most evident in their ability to encourage active participation, facilitate group discussions, and clarify complex concepts. Over half of the survey participants reported that LAs encouraged them to participate in problem solving (8/17, **FIGURE 1**) and helped facilitate positive group discussions (10/17, **FIGURE 1**). These findings align with the pedagogical goal of promoting student-centered learning. Nearly all students (16/17, **FIGURE 1**) indicated that LAs clarified concepts during problem solving sessions, highlighting their role in supporting conceptual understanding. By guiding students through difficult problems and encouraging peer-to-peer interactions, LAs helped foster a collaborative learning environment that supports deeper engagement with the course material. Successful use of these skills seems to be attributable to the LA's participation in the pedagogy course. Her use and reflection on these skills developed significantly over the course of the semester.

### *Preparation*

The third element of the LA model, preparation, focuses on the importance of equipping LAs with the contented knowledge needed to support student learning. The survey responses suggest that students perceived the LAs as prepared and knowledgeable. All survey participants agreed that the LAs demonstrated strong content knowledge (Q5, **TABLE 1**), and that LAs were helpful when they needed assistance during class (Q2, **TABLE 1**). These results reflect the effectiveness of the LA preparation process, which included structured training and ongoing support from the forensic science course instructor. Students' confidence in the LAs suggests that the weekly preparation sessions were successful in positioning LAs as credible and capable instructional partners. Regardless of having completed the course successfully, the LA's reflections indicated some apprehension about answering questions in the beginning of the semester. However, weekly prep meetings supported the LA in feeling and being prepared to answer those questions.

## **Conclusions**

These results show that the integration of LAs into the forensic science course supported student learning across all three essential elements of the LA model. The LAs not only contributed to the conceptual understanding and problem-solving but also fostered a positive classroom culture of inquiry and collaboration. Nearly all survey participants felt that having LAs in other forensic science courses would contribute to their academic success (Q6, **TABLE 1**). Additionally, the LA experienced notable growth in her ability to reflect on and respond to student difficulty with concepts. Her reflections indicate that these skills will be transferable to professional settings:

*I have found that this course has been helpful in understanding how other people think. There is so much diversity in how people's brains work, and how everyone processes information. This pedagogy course has helped me learn about ways to meet people from different angles, to best deliver information. As a resident assistant, sometimes students come to me with issues and problems that they are facing in their lives, and ...I employ some of the pedagogic strategies we use in class. When a roommate group recently asked me for help with conflict, I used team-based strategies to help them solve a problem, I did this by asking them to explain to each other how they best thought to solve a problem, which allowed them to collaborate to reach a compromise.*

Future research should explore the scalability of the LA model across multiple forensic science courses to assess the broader impacts on student learning and engagement. This should include perspectives of multiple LAs and course instructors.

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