Effects of learning assistant facilitation on student in-the-moment learning

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Abstract. Introductory STEM courses are often taught with learning assistants (LAs), i.e., undergraduate students who have taken the course before and facilitate discussions in small groups of students during active learning. Using LAs leads to improved student learning outcomes, however, little is known about how LA facilitation practices influence the progression of student learning and thus lead to these improved outcomes. We combined two sociocultural frameworks to characterize LA actions as authoritative (centering the canonically correct or LA perspective) or dialogic (centering students' perspectives) and investigate how these actions influence students' in-the-moment learning conceptualized as the noticing and filling of needs in discourse. Our study reveals the following: LA actions had four similar, broader effects on student in-moment learning, while a deeper look into authoritative and dialogic facilitation demonstrates variations in how these effects played out during interactions. We provide examples of these similarities and differences to demonstrate how various LA facilitation moves can induce and fulfill similar needs within an interaction along with how the perspectives centered by LAs during their facilitation impact the ways in which these needs are met. Implications for faculty and LA training, along with course design, will be discussed.

Problem. Creating classroom environments that foster equitable learning opportunities for all students is essential to the future of science education in our world. Introductory STEM courses across universities are mostly taken by students who are not majoring in the specific subject; thus, it is important to not only teach students discipline-specific content, but also more broadly about how to identify their own needs and grapple with them collaboratively. One way to help incorporate more student-centered facilitation is to use the learning assistant (LA) model. LAs are advanced undergraduate students who facilitate discussions in small student groups during active learning (Otero et al., 2010; Otero, 2006). Studies have reported that LA implementation leads to increased student conceptual understanding, increased student retention in STEM, and decreased DFW rates, especially for marginalized students (Alzen et al., 2018; Barrasso & Spilios, 2021; Herrera, 2018; Van Dusen & Nissen, 2020). LA-supported courses also have positive impacts on student satisfaction, engagement, and attitudes (Kiste et al., 2017; Talbot, 2015). While LA implementation in STEM courses leads to improved student outcomes, emphasizing that student learning outcomes are mediated by working with LAs, not much is known about the ways different LA facilitation practices lead to these improved outcomes or how LAs attend to and influence the progression of students' needs. Thus, our research project aims at addressing the following research question: What effects do different LA actions have on student in-the-moment learning (conceptualized through the noticing and filling of needs)?

Towards the end of how LA actions influence student learning, some work has looked at how LA actions influence student discussions. For example, Knight et al. (2015) characterized five different types of LA prompts— e.g., asking prompting questions, requesting student reasoning, providing their own reasoning, making background statements, and acknowledging student answers. They accounted for the influence of these prompts on student discussion patterns, evidencing that students engage in various levels of reasoning and questioning in response to different LA facilitation. Our study moves this approach further by considering whose perspective

is centered by LA actions (the canonically correct or LA perspective vs. student perspective) and how these actions influence students' noticing and filling of needs (our definition of in-the-moment learning).

Sociocultural Frameworks. Our study utilized two frameworks that are both grounded in sociocultural theory, which views learning as occurring via a process of mediation rooted in the idea that knowledge development occurs through interactions with mediating artifacts, such as discourse, etc. (Vygotsky, 1987). To characterize LA actions, the formative assessment enactment model (FAEM) was used and adapted to the LA context (Carlos et al., 2023; Dini et al., 2020). In the FAEM, what the LA notices about student thinking, how they interpret this thinking, and the purposes they develop while working with students influence the types of actions the LA takes. These actions could be advancing, which move students thinking forward in a way that has not been explored yet, or eliciting, which find out more about what the students are thinking. LAs can enact these two different actions in authoritative or dialogic ways. Authoritative moves center the perspective of canonically correct science or the LA, whereas dialogic moves center students' perspectives.

To characterize student in-the-moment learning, practical epistemology analysis (PEA) was used to attend to how learning occurs in-the-moment during discourse (Wickman, 2004; Wickman & Östman, 2002). PEA has been adapted in our group to the LA context, with a specific focus on how students and LAs shape needs that drive learning in LA-student interactions (Karch & Caspari-Gnann, 2022). This framework's utility lies in its ability to track students' progression through an activity through the lens of how gaps (i.e., contextualized and socially situated needs to make sense of something) are noticed and filled through relations (i.e., connections between pieces of knowledge) (Wickman & Östman, 2002).

Design of Study & Analysis. Data for this study were collected from 8 chemistry and 4 physics courses from 7 professors, 37 different LAs, and 843 students across 2 universities in the Northeast region of the USA. For three lectures, participating LAs video recorded their interactions with students. These videos were used for semi-structured stimulated recall interviews with the LAs. The LAs were asked to describe what they noticed about student thinking, what their purposes were when working with students, and how they would describe what it is they did and why.

For a total of 78 interactions across all LAs (at least 2 interactions per LA), FAEM and PEA were used separately to characterize LA actions and student in-the-moment learning. FAEM analysis used both the LA interview and interaction video, whereas PEA used interaction video data only. Building on this first level of data analysis, our second level of analysis relied on the coding of LA actions with FAEM (i.e., actions coded either as authoritative or dialogic eliciting/advancing) and the characterization of how the discourse progressed during the LA-student group interactions through PEA. To identify any emergent effects of LA actions on student in-the-moment learning, we considered what function these individual utterances served in the interaction, what occurred before and after the LA utterance, which ideas were leveraged or introduced to the discussion, whose ideas were centered, and any other emergent impacts. The first author went through all 78 interactions and captured their thinking around each LA move and its effect, deeply informed by the theoretical underpinnings of both sociocultural frameworks. Following this first step, both authors collaboratively developed a primary categorization of LA actions and effects on student in-the-moment learning that focused on a meaningful connection between actions and effects. The first author then looked back at the raw data and first level

analyses to create an action-effect codebook. To establish reliability, 25% of interactions were coded amongst three coders (including both authors) independently and then discussed until consensus was reached. Both the individual analyses and codebook were revised based on these discussions. Table 1 shows a few selected examples from the codebook to demonstrate the codes and subcodes that emerged for both LA actions and their effects.

***Table 1**. Action-effect codebook examples. The full codebook includes 4 action codes, 18 action subcodes, 5 effect codes, and 15 effect subcodes.*

Action	
Code	*Subcode*
Authoritative Advancing	Directing students' attention towards a specific part of the problem
	Directing students to use an idea they have established to explicitly revisit a lingering gap/confusion
Dialogic Advancing	Opening space for students to expand upon an idea
	Looking for a relationship between two ideas

Effect	
Code	*Subcode*
Grappling	Increase grappling with an LA idea
	Increase grappling with an LA and student idea
	Increase grappling with a student idea
Revisiting an earlier need	Reconsider an old need in light of new information
	Think through an old need further

Findings. Our analysis revealed that there were four broad effects LA actions had on student in-the-moment learning: students sharing ideas and reasoning, students revisiting an earlier need, increasing student grappling, and providing closure (rounding out the discussion around an idea). Rather than just one type of LA move leading to one effect, we found that a variety of LA eliciting and advancing moves led to each one of these broader effects. This indicates that different LA moves could induce or fulfill similar needs within the progression of student in-the-moment learning given the contingent nature of LA-student interactions. A closer investigation of both the action and effect subcodes, however, revealed that the ways in which these effects played out were different across the authoritative and dialogic LA moves. For example, whose ideas were grappled

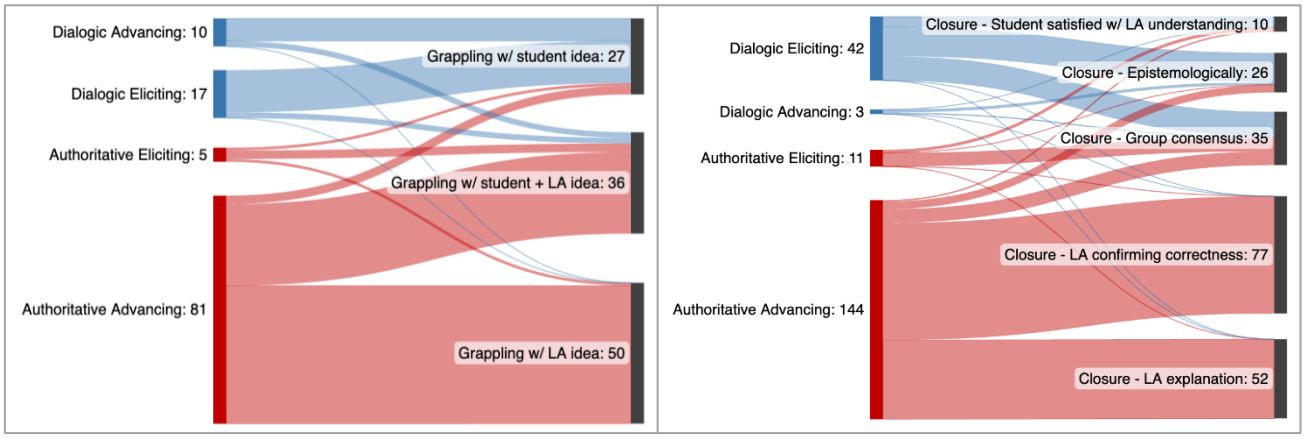

***Figure 1.** Sankey diagrams demonstrating how authoritative and dialogic LA actions lead to different effects for student in-the-moment learning. The numbers represent how often the codes were given in the data set.*

with and how closure was achieved were different comparing across authoritative and dialogic moves (Figure 1). In what follows, we will discuss these two broader effects (grappling and closure) and how their impact differed for authoritative and dialogic LA facilitation as exemplars for the similar trends found across the broad effects in our data.

LA moves led to grappling when their action led to students picking up an idea from the discussion and working towards incorporating that idea into their thinking. Typical examples of grappling included students questioning ideas, expressing confusions, or thinking critically about an idea to make sense of it. While dialogic LA actions (those centering student ideas) more often led students to grapple with their own ideas, authoritative LA actions (those centering LA ideas or canonical correct science) more often led students to grapple with the LA ideas (Figure 1). An example of each scenario can be seen in what follows.

In this first example, students were asked to consider an unbalanced REDOX reaction between aluminum and copper, and work through three questions to ultimately balance the equation. A student called LA Mango over and expressed confusion about what the question was asking for, and more specifically what was meant by "minimum number of each species." The student and LA had the following exchange:

> *Pedro: So I don't understand what it means by like what's the minimum number of each species. Like I don't understand what's on the board.*
> *LA Mango: For these species. It's an oddly phrased question. Oh, I see. So that's um, that's pretty much asking you the amount of copper and aluminum you would need to balance the equation.*

In their response to Pedro's question about what to do for this problem, LA Mango focused on the canonically correct solution to the problem and told the student they must balance the equation (authoritative) to move forward with this problem (advancing). In what immediately followed, the student wondered how to balance the equation, i.e., the idea introduced by the LA:

> *Pedro: Oh, okay. So would it be like, don't you like not need to balance it?*
> *LA Mango: You do need to balance it. So, you could see copper needs two electrons. Here you could see this aluminum needs three. We need that to be the same on each side.*
> *Pedro: Okay. So like I would put like three here [points at one of the reactants] and then two [points at one of the products] here? Like in front of the—*
> *LA Mango: Yeah, right. In front of the charged particles.*
> *Pedro: This and like this? [shows her iPad screen to the LA]*

In this excerpt, the student started off by questioning the need to balance the equation once they learned from the LA that is what the question was asking and continued to wrap their head around how to do that as the discussion went on. Considering the relationship between the action and the effect in this example, the student picked up on an idea introduced by the LA's authoritative advancing move and worked to understand it for themself.

In another example, students were asked to think about what is true regarding the enthalpy and entropy of a reaction between formic acid and oxygen that produces carbon dioxide and water. The students started discussing enthalpy and entropy by bringing in bond and phase arguments. One student, Zara, said that they tried to think about configurations, but that they didn't fully get there yet. The students and LA had the following exchange, where the LA centered the student's idea of configurations:

Zara: I also put C, and that was also my logic, the AB bonds, or AA to AB bonds, and the phase change. I didn't think about anything else. I like tried to think about configurations, but I didn't get there quite...
LA Cosog: Do you want to try to dive into configurations a bit now, or if anyone would like to dive into configurations?

In their response to Zara, LA Cosog picked up on their confusion about configurations (dialogic) and asked the entire group to think about it further in a way they had not yet (advancing). After the LA asked this question, two students shared the following:

Zara: I'm still kind of confused on configurations, so I'd like to not, actually.
Rock: I think it's like basically like, I think it's basically like, I mean, I don't know if I'm 100 percent right, cause I definitely am struggling with that too. That's one of the harder ones for me, is like the arrangement of like the subatomic molecules and particles, I think, or like, yeah.
...
Rock: I think it's just like identifying which, like if, like a compound or a molecule has, like how many configurations like each can make up, and like which ones have more and which ones have less configurations, I think. Cause sometimes like it's like hard, cause like I feel like you would like think about like the bonds, almost.

In this excerpt, the student identified configurations as something that was confusing. The LA picked up on this idea shared by the student and positioned it at the center of the conversation, inviting students to discuss their thoughts around it. Students Zara and Rock both grappled with the idea of configurations, sharing more confusions and additional thoughts about the idea they introduced earlier. Connecting the action and the effect in this example, the LA choosing to center a student's idea gave the students space and time to grapple with and make sense of their own ideas further. As seen with grappling, where dialogic and authoritative moves led to the same overarching effect of grappling but differed in the more specific account of student- or LA-centered effects, respectively, the effect of closure played out in a similar way.

LA moves had the effect of closure when they influenced the interaction in a way that led the students to leave a current need and move on to another, in other words, when discussion around one idea was finished (at least momentarily) and moved on from. Sometimes students would leave a need when they were satisfied with how the LA understood them or when they came to a group consensus around their ideas. Other times closure would play out epistemologically, meaning that although students were unable to meet their conceptual need, their need was still acknowledged and validated in some way, so that it felt okay for the students to leave that need. Closure also occurred when the LA confirmed the correctness of students' ideas or provided an explanation to the group. Comparing the different ways closure could be achieved shows that the first three types of closure are more student centered whereas the last two are more LA centered. Dialogic moves more often led to student-centered closure because the LA move centered the student perspective, which gave students the autonomy to decide for themselves when a need was sufficiently addressed to move on from. Authoritative moves more often led to LA-centered closure because they centered the LA perspective, which gave students less autonomy and rather relied on the LA to make decisions about when the need was sufficiently addressed (Figure 1).

Conclusions. Overall, we found four broader effects of LA actions on student in-moment learning. Each of these broader effects could result from authoritative and dialogic moves, however, a deeper look into authoritative and dialogic facilitation demonstrated variations in how the effects played

out during interactions. While dialogic actions more often led to student-centered effects, playing out in what students grappled with and why they moved on from needs, authoritative actions more often led to LA-centered effects. Thus, this study demonstrates that the perspectives centered by LAs during their facilitation impact the ways in which students engage in their learning in the moment.

Contribution and General Interest. To our knowledge, this study is the first to combine two different sociocultural frameworks to investigate how different LA actions have various effects on student learning. While it has been previously studied that LAs engage in a variety of different moves during their practice, influencing the levels of reasoning students engage in (Knight et al., 2015), this study uses theory around authoritative and dialogic facilitation and in-the-moment learning via discourse to explain similarities and differences in how various LA moves affect student in-the-moment learning. Namely, how authoritative and dialogic eliciting and advancing actions can similarly influence the needs that drive student learning, while also leading to differences in the ways needs are met in the interaction (i.e., student-centered or LA-centered ways). Previous research on teacher moves beyond LA facilitation has shown that maximal dialogic questioning leads to higher order thinking than maximal authoritative questioning (Chin, 2007; Van Booven, 2015). Our study, however, shows that authoritative moves can also lead to in-depth progression of student in-the-moment learning as seen for the example of grappling. The difference between the effect of authoritative and dialogic moves was not in how the learning progressed, rather in whose ideas were centered during that progression of learning. Focusing on the theme of this year's NARST conference, where the goal is to foster meaningful science education for the rest of us, the insight provided by our study can help instructors who teach with LAs reflect on whether students' learning progresses in a way that is aligned with their goals or not. An understanding of how LA facilitation affects student in-the-moment learning can help faculty leverage backwards design for learning in LA-supported courses (i.e., designing teaching based on intended learning outcomes for students) to foster learning around both discipline-specific content and general practices of science for all students regardless of intended career goals. Further, LA facilitation training can be informed by insights from our study to support these goals.

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