

Undergraduate Learning Assistants and Mathematical Discourse in an Active-Learning Precalculus Setting

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Undergraduate learning assistants (ULAs) are becoming more popular in mathematics classrooms. With this growth, there is a need to understand ULAs' roles in the classroom. Using a four-level distinction from univocal (ULA was the only voice in the conversation) to dialogical (ULA was fostering group discussion), we investigated the discourse between ULAs and students while in an active-learning setting. Our conjecture was that much of the discourse would fall in either univocal or dialogical; however, the ULAs' discourse was an array of all four ratings. We attribute this to the ULAs recognizing the "intellectual need" of the students in the moment.

Keywords: undergraduate learning assistants, mathematical classroom discourse, precalculus

Background Literature

Undergraduate Learning Assistants

Using undergraduate learning assistants (ULAs) is becoming a more common practice in STEM departments across the US. Over 100 institutions have implemented the model created by the University of Colorado Boulder Physics program (Learning Assistant Alliance, 2016; as cited by Sellami et al., 2017). In the research on ULAs, there have been increased student performance in content assessments (e.g., Otero, Pollock, & Finkelstein, 2011), including when ULAs were employed after active learning had been fully implemented (Sellami et al., 2017). Some universities investigated the ULA model for the effects on ULAs themselves, including changes in the ULAs' physics (and pedagogical) identities (Close, Conn, & Close, 2013; Nadelson & Finnegan, 2014), as well as the effects of the model as a K-12 teaching recruitment tool (Otero, Pollock, & Finkelstein, 2011).

Use of ULAs may be on the rise because of the chance to have more faculty-student interaction. According to Pavlacic et al., (2018) "faculty-student interaction is crucial for the student and the institution" (p. 3). The authors go on to cite literature to support positive effects of faculty-student interaction (e.g., personal development and academic achievement) and negative effects of not having these interactions (e.g., increased student withdrawal rates and students as passive recipients of information). In the undergraduate mathematics education literature, Webb, Stade, and Grover (2014) described the ULA model at the University of Colorado Boulder, addressing the curricular challenges as well as implementation. In the article, the authors discussed how ULAs perceived their effects on students. The overarching theme was that the ULA acted as an intermediary: "It gives [the students] someone to ask questions to, someone they can relate to...LAs were students just like them...a class with LAs also allows students to be able to communicate with teachers who are their own age" (Webb, Stade, & Grover, 2014, p. 45). We aim to add to the growing ULA literature by investigating the ULA-student interaction in more detail, positing some explanations of student performance and

relationships with ULAs. First, we discuss what we mean by interaction in the classroom, so we turn to the discourse literature.

Classroom Discourse in Mathematics

Founded in the socio-cultural learning theory of Vygotsky (1978, 1986), the study of discourse, “or, more commonly, talk,” (Imm & Stylianou, 2012, p. 130) in a classroom is an important aspect of mathematics education. For example, Wachira, Pourdavood, and Skitzki (2013) called discourse “a crucial aspect of a [actively engaged] classroom” (p. 2), and Truxaw and Defranco (2008) cited six articles that mentioned “the *quality* and *type* of discourse [being] crucial to helping students think conceptually” (p. 489, emphasis in original).

Imm and Stylianou (2012) found that there were three classifications of classrooms: *high discourse*, which is defined as, “teachers valu[ing] an exchange of ideas with students and where rich, inclusive, and purposeful mathematical conversation happened” (p. 131); *low discourse*, defined as, “when a teacher’s talk rarely invited students into mathematical conversation or where one-directional ‘telling’ was the norm” (p. 131); and *hybrid discourse*, a mixture of the two. Imm and Stylianou (2012) utilized the notions of *univocal* (one-sided) and *dialogic* (“give-and-take communication that uses dialogue as a process for thinking” (p. 489)) discourse from Truxaw and Defranco (2008). In our study, we investigated the discourse between ULAs and groups of students, categorizing those interactions on a continuum developed by Martin (2018) influenced by Truxaw and Defranco’s notions of univocal and dialogic.

Research Question

Initially, we set out to research the effectiveness of the ULAs in an active learning classroom. One way to gauge this effectiveness is by observing what the ULA did in the class. Therefore, our research question is: *With what kinds and levels of discourse do learning assistants engage with students in an undergraduate precalculus course?*

Methods

Participants

Three ULAs participated at a large Midwest research-intensive university in Spring 2019. The mathematics department recently began a change in its precalculus program (see Authors, submitted for details) adding ULAs and an emphasis on active learning to its precalculus courses. Jack was a ULA for all six semesters that the new course structure has been used. He was with the same instructor throughout that time as well as two other instructors while working as a ULA. Phoenix has been a ULA for four semesters and worked with three different instructors. Phoenix started out as a student in the new course format and was recruited to be a ULA by her instructor. Art has been an ULA for two semesters but was a ULA for a college algebra class the first semester. Spring 2019 was the first semester for which Art served as a precalculus ULA. Like Phoenix, Art was previously a student under the new course format.

Data Collection

There were two forms of data collection for this study: observations and interviews. There were two rounds of observations performed on each section of precalculus by the first author to maintain consistency with the ratings. An initial observation was done during the 4th and 5th weeks of the semester and another during the 14th and 15th weeks (out of 16 total weeks).

The rating system used during observations was inspired by the levels of mathematical discourse from Martin (2018). These levels of discourse were for a more traditional classroom atmosphere, so adjustments were made from Martin’s definitions to fit the ULA and active-learning environment. These adjustments were mostly directed at viewing each individual group as the whole “classroom” and the ULA as the “teacher.” The system was laid out in an observation protocol and interactions between the ULA and students were rated 1-4 as they fit the criteria. Many interactions were given a combination of ratings as the interaction would transform or meet multiple rating criteria.

The rating 1 (*univocal* level) was used when the ULA was the only voice during an interaction or part of an interaction. For example, this rating was used when the ULA was explaining a problem, giving an answer, guiding a student through work, or giving formulas.

The rating 2 (*partial univocal* level) was used when the ULA was asking closed-ended questions or prompting specific answers from the students. This also included when the interaction had some input from the student, but the ULA was the primary guide of the interaction.

The rating 3 (*emerging dialogical* level) was used when the ULA was asking open-ended questions or engaging in direct discussion with *one* of the students in the group. Either the student was the main voice of the interaction, or the discussion was split evenly between the ULA and the student.

The rating 4 (*dialogical* level) was used when the ULA-student interaction resulted in group discussion between students. This does not account for all student discussions, but just the discussions that were a product of ULA intervention.

There were three different types of semi-structured interviews conducted with a) precalculus instructors, b) ULAs, and c) students in the course. There were six instructors interviewed mid-semester’ four student interviews and three ULA interviews were conducted towards the end of the semester. The first author used a common semi-structured interview protocol for all three types, adjusting questions based on the interviewee’s role in the classroom. For example, an important question asked was, “When a student asks a question, how do you (or how does the ULA) typically answer that question?”

Coding

For this study, the program Nvivo™ was used to organize the observations and interviews. The first author gave a number rating to each interaction in real time. Some interactions were given multiple ratings when the interaction reflected multiple levels of discourse. There were two types of coding used on the interviews. Each interview was coded by types of questions, and open-thematic coding was used on the responses of the interviewees.

Results and Discussion

Table 1: Total amounts of each rating by section

Rating	Sections						
	A (Phoenix)	B	C	D	E	F (Jack)	G (Art)
1 (<i>univocal level</i>)	6	8	16	14	7	24	18
2 (<i>partial univocal level</i>)	2	6	13	10	13	15	15
3 (<i>emerging dialogical level</i>)	2	5	7	11	6	19	21
4 (<i>dialogical level</i>)	3	3	10	7	10	12	12

Examples for each rating from Art's second observation in Section G follow from a single interaction with a group:

- Student asks if they are doing things right, and ULA notices they aren't. LA starts to explain (1-*univocal*) and then poses questions to that student about the process (2-*partical univocal*).
- Student asks another question, and ULA lets the student talk her way through her question to understand how to move forward (3-*emerging dialgocial*).
- ULA uses phrase "you could also think of this as $y=5$ " when talking about the limit of the function 5 to help the student understand, and student says "ohhh". (This is a different method than how the instructor explained it). LA then uses the white board to explain (1-*univocal*) and poses a question to the group and all members get involved (4-*dialogical*).

When starting the research, we had a conjecture in mind: the ULAs would skew toward either *univocal*, because the ULAs were new to the classroom, or *dialogical* because the whole class was to engage in active learning. Instead, all three ULAs demonstrated a balance of all four ratings, as shown in Table 1. We believe this is due to the ULAs addressing the intellectual needs of the students. Harel (2013) defined an *intellectual need* as a "problematic situation prior to the construction of knowledge" (p. 122). It is reflected in one of our student interviews when asked about how their ULA answered their questions:

If it's like a longer problem-I feel like if it's just a straight forward answer you know you can get without going through a lot of steps, he'll kind of give me the answer, and be like "oh, it's this instead" or he'll kind of hint at it like "you basically gave me the answer", but if it's like a lot of steps, he'll be like "okay, try it this way, and if you don't get the right answer, I'll come back".

A reason we believe the ULAs are attending to intellectual needs is because instead of relying on a uniform approach to answering students' questions, their techniques seem to vary for each situation. When Phoenix was asked about whether she directly answers students' questions, leads students to their own understanding, or facilitates discussion, she replied:

Usually a mix of all three. Because if they are super struggling, I'll at least try to get them to think about the problem in a different way. Because if the instructor teaches it one way it's like "this is the way to do it", but I'm like "but there's multiple ways to do a problem" ... I want them to think independently on their own unless if they're just completely lost. And then I'll sit down and just break it down piece by piece.

We note that Phoenix's total number of observed interactions were lower than the other ULAs because each interaction she had with students was longer than each interaction Jack, Art, and others had with their students. Jack, the experienced ULA, and Art, the first-time pre-calculus ULA, both also mentioned adjusting their questioning technique based on their perception of students' approaches.

The second reason we believe in the intellectual need motivation is that the ULAs show care for the students and were concerned about student success in the class. Jack stated that he is "paid to do something [he] would naturally volunteer for." When talking about what he hopes students take from the class, Jack talked about students' affect and well-being:

We want them to be comfortable with learning through failure... It's much less important if something is originally correct, but we want to check the understanding.

Preliminary Conclusion

By investigating the discourse of ULAs in an active-learning setting, we have introduced a new method of determining engagement. It seems as though the ULAs were balanced in their engagement overall, and that seemed to be best for students' intellectual needs. Finally, the ULAs' affect contributed to discourse; their care was influential for students and TAs alike.

Questions for the Audience

- What are other methods or approaches that could further discern dialogue?
- How much can ULA dialogue contribute to the environment of the classroom?

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