Discourse Between Learning Assistants and Calculus Students on Implicit Differentiation

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Learning assistants (LAs) are undergraduate near-peer tutors who, having previously been successful in some course, aid in the instruction of that course, typically by interacting with individual students or groups (Otero et al., 2010). It has been shown that LAs' presence in classrooms is associated with positive student outcomes (Barrasso & Spilios, 2021), but there is little understanding of how LAs contribute to such outcomes. While there are some action-focused categorizations of LA practices, e.g., providing feedback and increasing discussion time (Knight et al., 2015; Thompson et al., 2020) they are not tied to specific content areas. This study contributes a subject-specific perspective on LA classroom practice by examining discourse between LAs and students on the topic of implicit differentiation in a Calculus I course.

LAs were incorporated into the course as one part of a cross-departmental effort to transform introductory STEM courses at a large, public, northeastern university. This Calculus I course consisted of a lecture (~160 students) taught by a faculty member and recitations (~20 students) taught by a graduate teaching assistant. LAs were present only in recitations, and their role was to facilitate small group discussions during work on conceptually oriented activities. This study is focused on one recitation lesson on implicit differentiation. Data consists of 360-video recordings of small groups and students' written work on the activity. Video clips were selected for analysis based upon the presence of the LA with the small group and conversation focus on implicit differentiation. Through this process, 19 clips (~25 minutes of video data) were identified for five LAs across two semesters. LA and student speech were transcribed and analyzed at the turn of talk level for mathematical content and discursive actions. Mathematical content was analyzed using components of a hypothetical learning trajectory (HLT) for implicit differentiation (Buchbinder & Allen, 2024). Discursive actions of LAs were analyzed using Thompson et al.'s (2020) Action Taxonomy for Learning Assistants while those of students were coded using an open process under the constant comparative method (Strauss & Corbin, 1998).

Initial analysis indicates that LAs aid students in learning this topic by coordinating across multiple components of the HLT and integrating previous calculus content knowledge into these components. For example, one LA shared their conceptualization of implicit differentiation as the chain rule, rewriting y as y(x), while another LA described the implicit differentiation procedures as the "normal" derivative then "multiplying by dy/dx". While students tended to ask LAs questions about algebraic procedures, LAs reoriented these questions toward sensemaking across graphical and symbolic representations of implicit equations.

This analysis of LA-student interactions around implicit differentiation sheds light on the nuances of how LAs support student mathematical learning of that content. The study has the potential to bolster our understanding of student learning of the topic of implicit differentiation and gain insight into LAs' instructional moves as they interact with students.

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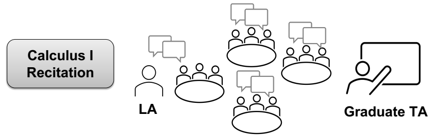
Background

The Learning Assistant (LA) Model

(Otero et al., 2010)

Learning Assistant: A current undergraduate student who has passed some course and who aids in the instruction of that course.

- **Practice:** LAs help teach students in Calculus I recitations
- **Content:** Weekly meeting with course instructor to refresh course content
- **Pedagogy:** Weekly meetings with a mentor to discuss educational topics (e.g., metacognition)



Motivation: Students in LA-supported courses show more *positive content-related outcomes* compared to students without LA support (Barrasso & Spilios, 2021), but little is known about *how* LAs facilitate positive student outcomes. Students *struggle with implicit differentiation* (Martin, 2000; Chu, 2019) offering opportunities for LAs to authentically aid student learning.

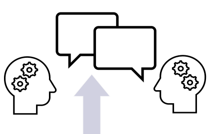
Research Question

What mathematical aspects of implicit differentiation do students and LAs discuss during their interactions in Calculus I recitations and ***how*** do they discuss them?

The Study

Setting: Part of a multi-disciplinary project for reforming introductory STEM courses at a large, public, northeastern university.
LAs teach in Calculus I recitations (~20 students each), facilitating small group discussions about conceptually rich activities.
Participants: 5 LAs and 7 different small groups of students; 3-4 students per group.
Data sources: 22 different 360°-video recordings of LA-student conversations on the topic of implicit differentiation
~25 mins of video data across two semesters.

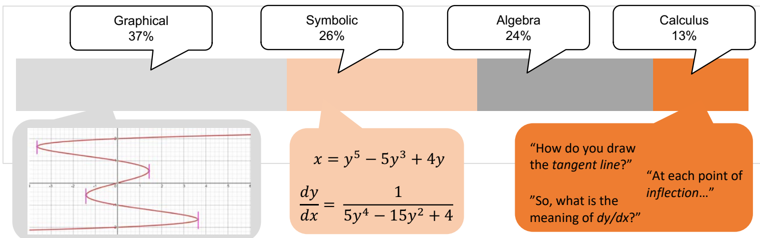
Theoretical Framework



Vygotsky's (1978) Sociocultural Theory
Learning is fundamentally social and mediated by language use

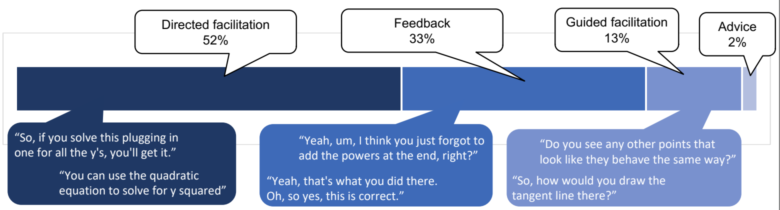
Critical Discourse Analysis (Gee, 2014)		
	Saying (Information)	Utterances coded for *topic* of implicit differentiation discussed (Buchbinder & Allen, 2024)
	Doing (Action)	Utterances coded for *student actions* (open coding) and *LA actions* via ATLA (Thompson et al., 2019)
	Being (Identity)	Speech interpreted within the context of near-peer tutoring in Calculus 1

ID Topics (N=250)



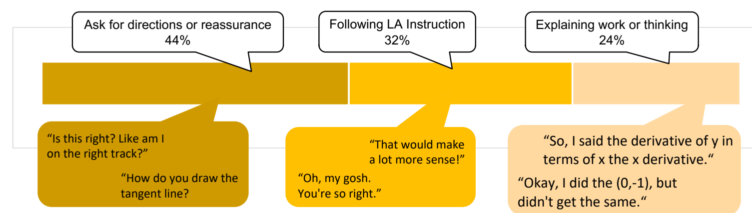
Trend: Conversations focus on prior knowledge and symbolic representations, graphs discussed in connection to computations.

LAs' Actions (N=140)



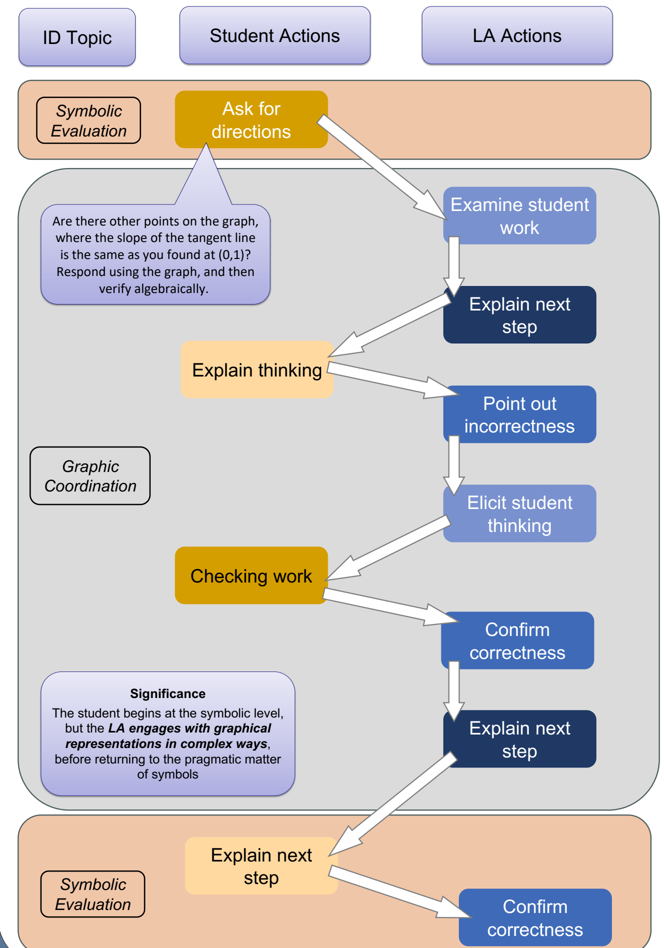
Trend: LAs tend to explain concepts and give feedback (e.g., correcting, confirming) on students' work.

Students' Actions (N= 110)



Trend: Students seek out LAs to ask questions about next steps. They follow LAs' explanations, but also explain their thinking.

Example of Discourse



Significance

The student begins at the symbolic level, but the ***LA engages with graphical representations in complex ways***, before returning to the pragmatic matter of symbols

Responding to the Research Question

- LA-Student discourse is often *pragmatic*, focusing on correctness of mathematical *procedures* and connections to *previous knowledge*.
- *Implicit differentiation* topics: graphs in connection to computations.
- Students ask LAs questions about next steps, follow LAs' explanations, but also explain their thinking.

Link to paper PDF

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