Methodological Advancements for Analyzing Teachers’ Learning in a Community of Practice

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Professional development that privileges teachers’ voice, equity, and the investigation of high-quality instruction is essential to the mathematics education community. However, more research is needed to understand the process, content, and depth of teachers’ learning in this setting. This paper shares our analytic method designed to capture such learning. We integrate three complementary perspectives: Communities of Practice (theoretical framework), Teaching for Robust Understanding (conceptual framework), and Frame Analysis (analytical framework). We show how this method captures changes in teachers’ participation and reification, indicating the process, content, and depth of their learning across their professional development experience. Such work iterates on Frame Analysis and advances the methodology to highlight additional tools to better understand teacher learning about components of powerful classrooms.

Keywords: Professional development, Communities of Practice, Teaching for Robust Understanding, Frame Analysis

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The Analyzing Instruction in Mathematics using the Teaching for Robust Understanding project team has developed a professional development (PD) model in which secondary mathematics teachers investigate high-quality instructional materials to deepen instructional knowledge and practice aligned to the Teaching for Robust Understanding (TRU) framework (Schoenfeld, 2015) within communities of practice (CoP)[1]. In order to leverage mathematically rich student conversations for teacher learning, our PD model focuses on a lesson's mathematical content, video clips demonstrating students engaged in rich mathematical activity, and reflective discussion questions based on the TRU framework.

The purpose of our work is to investigate mathematics teacher learning in these CoPs that focus on the implementation of formative assessment lessons (FALs) rooted in TRU. We are working to understand this learning through our methodological advancement within frame analysis. This proposal will provide readers with details about our analysis plan.

Perspectives

Our theoretical framework is based on learning within a CoP (Wenger, 1999). Our conceptual framework is the TRU framework (Schoenfeld, 2017). To understand how learning is occurring in a CoP, we utilize analytic tools from frame analysis (Bannister, 2015).

Theoretical Framework: Communities of Practice

A CoP consists of groups of people who (a) are mutually engaged in an activity; (b) are connected by a joint enterprise; and (c) have a shared repertoire of communal resources (Wenger, 1999). CoPs give voice to their members and have the ability to create reflective professional narratives that can reflect and address the challenges of teaching. Professional narratives highlight practice and professional knowledge as well as reveal assumptions allowing insight into cultural values that impact judgments (Allard et al., 2007). Collective reflection increases this impact through dialogue. Allard et al. (2007) explained, "discussion is a community activity that causes our personal assumptions to surface and be transformed" (p. 305). Within collective participation in a CoP, learning is evidenced by changes in participation and reification (Wenger, 1999). This negotiation of meaning is represented by changes in participation which are reified to give form to the meaning through the different dimensions of the CoP.

Conceptual Framework: Teaching for Robust Understanding

The TRU framework allows us to align a vision of learning in CoP to what occurs in a powerful classroom (Schoenfeld, 2015). TRU posits five interrelated dimensions: the content; cognitive demand; equitable access to content; agency, ownership, and identity; and formative assessment (see Figure 1). TRU provides a lens to view instruction as well as a common language for discussion. The framework creates an engaging and equitable education experience for the learner. Classrooms that focus on these five dimensions produce students who are powerful thinkers (Schoenfeld, 2015, 2017, 2020).

Analytical Framework: Frame Analysis

Frame analysis (Benford & Snow, 2000; Snow & Benford, 1988) is used to understand changes in participation and reification within a CoP (Bannister, 2015). Frames are co-constructed objects among the community that represent existing meanings in the group at any given time. Using frame analysis, we can capture the way teachers represent what they see as a problematic scenario (diagnostic framing), their potential solutions to that scenario (prognostic framing), and their justification or rationale of their proposed solutions (motivational framing). In our context, we use frames to classify and organize teacher conversations within the PD model and to evaluate learning over the extent of the PD.

Bannister (2015) delineated connections between key concepts from frame analysis and processes of participation and reification in a CoP (see Figure 2). Changes in framings within a community reify changes in participation occurring within a CoP. For instance, discourse between community members can evolve to reify previous conversations as single words or phrases, encapsulating complex ideas explored earlier. These changes in participation and reification are, in turn, empirical evidence of learning occurring within a CoP. We utilize frame analysis to identify reified changes in participation, which manifest themselves as participants engage with "evolving forms of mutual engagement," "understanding and tuning their enterprise," and "developing their repertoire, styles, and discourses" (Wenger, 1999, p. 95). Changes within these three processes represents evidence of learning within a CoP.

Applying These Frameworks in the Context of Our Work

In our context, mathematics teacher learning surfaces through reified changes of participation that manifest themselves as participants engage with:

- evolving forms of mutual engagement around video case studies of mathematics teaching;
- understanding and tuning their enterprise about teacher learning around high-quality instruction; and
- developing their repertoire, styles, and discourses about the TRU framework.

While teachers work as a CoP towards the goals listed above, we capture their learning utilizing frame analysis. By analyzing changes through three kinds of frames, we focus on how and to what degree teachers are learning about implementing FALs rooted in TRU. We study the evolution of their learning and engagement with the TRU dimensions throughout their participation in their CoP by focusing on diagnostic, prognostic, and motivational statements while engaging with the PD model.

Analytic Technique

In our context, we are interested in the extent to which mathematics teachers are learning about the TRU framework. The participants in this study have all voluntarily joined Professional Learning Teams (PLTs) that engage in examining video case studies focused on implementing FALs fundamentally aligned with the TRU framework (see map.mathshell.org). The PD model incorporates unpacking big mathematical ideas, watching a video case, and discussing the FAL based on one TRU dimension (Figure 1). Participants join for eight sessions throughout an academic year. Each of these sessions is video recorded and transcribed.

Using the transcripts from the PLT, we begin by separating the teacher conversations into episodes of pedagogical reasoning (EPRs). We leveraged Horn's (2005) definition to establish our own parameters for identifying EPRs as being units of talk in which multiple participants respond to the facilitation prompts post video watching. The participants discuss student thinking and participation in the video, suggest teaching moves to respond to student thinking that align with the TRU framework, and determine how their suggestions can help illuminate the big mathematical picture more clearly.

After identifying EPRs, we establish and analyze frames for a diagnosis, prognosis, and motivation. It is common, and almost expected, that there are multiple frames within each EPR. For example, during a discussion around student thinking and participation in the video, we expect that the teachers would diagnose multiple instances of student understanding, each having its own frame. To code, we first identify a diagnosis and it's attribution of causality. We then determine if the participants provided a prognosis to accompany the diagnosis. Finally, we determine if the teachers provided a motivation for their prognosis. At each stage we cite evidence from the transcript to support our coding so that we attend to teacher voices.

The next step in our coding is to align each frame with a dimension of TRU to determine what the teachers are learning based on how their frames change. To do this, we identify which dimension is being discussed. If the team can not unanimously determine which dimension, we record all considered dimensions in our field notes and negotiate which dimension best captures the conversation. We then use an internally created rubric (Figure 3), based on themes and resources from the TRU framework, to determine the depth of the teacher conversation about the aligned dimension.

Illustrative Example of Analytic Technique

The participants in this example were analyzing the video case of an Applying the Properties of Exponents FAL. This FAL was designed to focus on the *formative assessment* dimension of TRU. While analyzing the video case and suggesting teacher moves to respond to student thinking, teachers wondered if a student in the video corrected a misconception of another student based on conceptual understanding of the content or on their memorization and application of the rules for exponents. The transcript of the conversation is shown in Figure 4.

For one frame of this EPR, we defined a diagnosis as "students need the opportunity to explain their thinking to each other in order for the teacher to assess what students' understand."

This is supported by one teacher's comments about the student interaction, “we were unsure whether or not the student knew why...maybe he just memorized the rule, but he has no idea why we do that” (lines 8, 14-15). We determined this diagnosis had two separate prognoses. The first prognosis was to use intentional paired student groups (lines 1-8). The second prognosis was to invite students to return to the definition of exponents (lines 16-17). Each of these prognoses offer possible solutions to the diagnosis. For the first prognosis no motivation was provided by the teachers because there was no discussion justifying why this teaching move would address student understanding. For the second prognosis we identified the motivation through the justification of generating the rules can be generated through the definition. By returning to the definition, the students are provided the opportunity to build those rules themselves (lines 18-21).

Last, we aligned each frame to a TRU dimension and categorized it using our rubric for analyzing teacher learning in PLTs (Figure 3). For the first prognosis, the discussion aligned with the *agency, ownership, and identity* dimension because the conversation focused on providing opportunities for students to explain their mathematical thinking. We categorized this frame as a level 2 because this conversation did not explicitly discuss how students might build on each other’s ideas. For the second prognosis, the discussion aligned with the *formative assessment* dimension because the conversation focused on students refining their thinking by returning to the definition of exponents. We categorized this frame as a level 2 because the actions are leading the students in one direction. The summary of our analytic process for these frames can be found in Table 1.

Methodological Advancement

This work extends frame analysis as a tool to understand the social nature of learning within a CoP. Our advancement has been to incorporate the use of additional tools to allow us to better understand teacher learning about practices at the core of powerful classrooms. In our context, the TRU framework and accompanying resources provide teachers support to enhance student discourse and foster equitable classroom engagement through the five dimensions while centered on strong mathematical content (Schoenfeld, 2015). Through the use and analysis of FALs, teachers can develop practices that promote active and equitable participation through reflections on teaching and learning.

This advancement is possible, in part, because our work is situated within a PD model that privileges teacher voice, equity, and high-quality mathematics instruction. Our analytic method provides an opportunity to capture and study teacher learning while embracing the social discourses occurring to create the teacher learning experience. The integration of the TRU framework with frame analysis helps us move beyond documenting that teachers *are* learning in a CoP to *what* they are learning and at what *depth* they are learning. This methodological advancement is transferable to other contexts outside of mathematics because tools such as the TRU framework exist for all content areas.

Conclusion

To support our goal of understanding what teachers learn and the depth of their learning, the next step for our research is to analyze changes in teachers' participation and reification longitudinally, thus capturing their learning throughout their engagement with this PD model. By analyzing these changes, we hope to understand how teachers learn to create more powerful and equitable mathematics environments utilizing the TRU framework and FALs. Moreover, we can deepen our knowledge regarding how the PD model shapes what and how teachers are learning.

The sociopolitical turn in mathematics education calls on researchers to understand and transform mathematics education by creating more socially-just practices in the mathematics classroom (Gutiérrez, 2013). Our proposed analytic method situated in our research project assists us in understanding how this transformation to socially-just teaching practices is occurring in a CoP. Despite our work being situated within mathematics teaching and learning, this work could also be used to understand teacher learning in any CoP that follows a PD model focused on privileging teacher voice, equity, and high-quality instruction and incorporates a framework to characterize what the teachers are learning.

Notes

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Figure 1

Five Dimensions of Powerful Classrooms (Schoenfeld, 2015)

The Five Dimensions of Powerful Classrooms				
The Content	**Cognitive Demand**	**Equitable Access to Content**	**Agency, Ownership, and Identity**	**Formative Assessment**
The extent to which classroom activity structures provide opportunities for students to become knowledgeable, flexible, and resourceful disciplinary thinkers. Discussions are focused and coherent, providing opportunities to learn disciplinary ideas, techniques, and perspectives, make connections, and develop productive disciplinary habits of mind.	*The extent to which students have opportunities to grapple with and make sense of important disciplinary ideas and their use. Students learn best when they are challenged in ways that provide room and support for growth, with task difficulty ranging from moderate to demanding. The level of challenge should be conducive to what has been called "productive struggle."*	*The extent to which classroom activity structures invite and support the active engagement of all of the students in the classroom with the core disciplinary content being addressed by the class. Classrooms in which a small number of students get most of the "air time" are not equitable, no matter how rich the content: all students need to be involved in meaningful ways.*	*The extent to which students are provided opportunities to "walk the walk and talk the talk" – to contribute to conversations about disciplinary ideas, to build on others' ideas and have others build on theirs – in ways that contribute to their development of agency (the willingness to engage), their ownership over the content, and the development of positive identities as thinkers and learners.*	*The extent to which classroom activities elicit student thinking and subsequent interactions respond to those ideas, building on productive beginnings and addressing emerging misunderstandings. Powerful instruction "meets students where they are" and gives them opportunities to deepen their understandings.*

Figure 2

Connections between key ideas from communities of practice and frame analysis (Bannister, 2015)

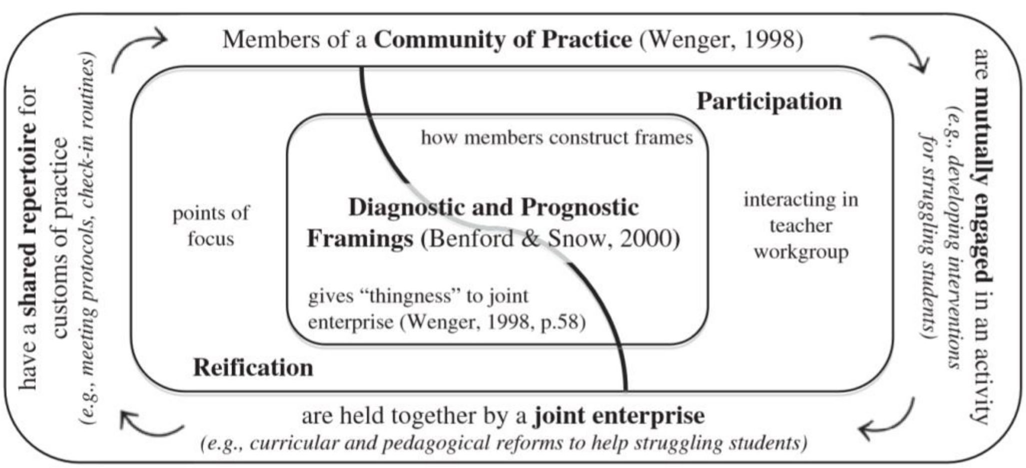

Figure 3

Rubric for TRU Talk in PLTs

The Mathematics	**Cognitive Demand**	**Access to Mathematical Content**	**Agency, Ownership, and Identity**	**Formative Assessment**
To what extent does PLT teacher talk focus on the accuracy, coherence, and justification of the mathematical content?	*To what extent does PLT teacher talk focus on classroom interactions that create and maintain an environment of productive intellectual challenge that is conducive to students' mathematical development?*	*To what extent does PLT teacher talk focus on supporting all students in equal access to and meaningful participation with the mathematics?*	*To what extent does PLT teacher talk focus on providing students opportunities to conjecture, explain, make mathematical arguments, and build on one another's ideas, in ways that contribute to students' development of agency, ownership, and their identities as doers of mathematics?*	*To what extent does PLT teacher talk focus on monitoring and helping students to refine their thinking?*
1: PLT teachers suggest and/or agree with mathematics being discussed that is not related to the discussion OR discussions that are aimed at "answer-getting" OR largely procedural explanations of content.	1: PLT teachers suggest and/or agree with classroom activity or teacher intervention that constrains students to activities such as applying straightforward or memorized procedures.	1: PLT teachers suggest and/or agree with classroom activity that leaves some students disengaged or marginalized, and differential access to the mathematics or to the group not being addressed.	1: PLT teachers suggest and/or agree with classroom activity or teacher interventions that either constrain students to producing short responses to the teacher OR do not address clear imbalances in group discussions.	1: PLT teachers suggest and/or agree with teacher actions that are simply corrective (e.g., leading students down a predetermined path) and the teacher does not meaningfully solicit or pursue student thinking.
2: PLT teachers suggest and/or agree with discussions that are about related mathematics but are primarily skills-oriented, with few opportunities for making connections (e.g., between procedures and concepts) or for mathematical coherence.	2: PLT teachers suggest and/or agree with classroom activity that offers possibilities of productive engagement or struggle with central mathematical ideas, BUT students are either left unsupported when lost, OR the teacher's actions scaffold away challenges.	2: PLT teachers suggest and/or agree with classroom activity that has all students doing mathematics, but some are not participating in the group activities; further, the teacher is not supporting students to engage in student-to-student discussion.	2: PLT teachers suggest and/or agree with classroom activity or teacher interventions that allow at least one student to talk about the mathematical content, but the teacher is still the primary driver of conversations and arbiter of correctness OR students are not supported in building on each other's ideas.	2: PLT teachers suggest and/or agree with teacher actions that solicit student thinking, but subsequent discussion does not build on nascent ideas. These teacher actions are corrective in nature, possibly by leading students in the "right" directions.
3: PLT teachers suggest and/or agree with explanations of and justifications for related mathematical ideas that are coherent.	3: PLT teachers suggest and/or agree with classroom activity in which students are supported in engaging productively with central mathematical ideas. This may involve struggle; it certainly involves having time to think things through.	3: PLT teachers suggest and/or agree with classroom activity in which all students are contributing to group or subgroup mathematical discussions, OR teacher moves have all all students making meaningful contributions.	3: PLT teachers suggest and/or agree with classroom activity or teacher interventions that allow at least one student to put forth and defend their ideas/reasoning AND, EITHER students build on each other's ideas OR the teacher ascribes ownership for students' ideas in subsequent discussion.	3: PLT teachers suggest and/or agree with teacher actions that solicit student thinking, AND subsequent discussion responds to those ideas, by building on the productive beginnings or addressing possible misunderstandings.

Figure 4
Teacher Transcript

Faith: I think I would invite maybe paired conversations, so I would not only ask the student who made one of the misconceptions-- or no, one of the students who said anything to the negative exponent would be one over that number to the positive exponent. I would invite him to maybe pair up with someone who didn't speak, and ask that person to rephrase, or restate, to reinforce that rule. Because that was a really powerful moment.

Sarah: No, no. Maybe even to push that student further and ask why, because we were discussing that-- we were unsure whether or not the student knew why. That's what Andy was talking about in our group. So we thought maybe pushing and seeing where the students would go with that too.

Josh: You mean the student who expanded the multiplication and said it works for--?

Sarah: No, actually, the student who said that-- he was the one who corrected the other student's misconception, who thought that two to the negative second, was negative four. So we were saying, maybe he just memorized the rule, but he has no idea why we do that.

Robert: One thing that I like to invite students to do is go back to the definition. How does the definition help you with the rules themselves because the definitions- I often forget the rules. And I'll go back to the definition. The definition can generate those rules. And whenever you get lost and not sure how to use the rule, try to get back to the definition and see how you can come up with the [rule].

Table 1

Sample Analysis

Category	Description
Frame Description	Teachers wonder if students who corrected a misconception knew to do that because they memorized the rules for exponents or if they understand why the rules work.
Diagnosis	Students need the opportunity to explain their thinking to each other in order for the teacher to assess what students' understand.
Prognosis 1	Teachers could use paired groups to provide more students with a voice.
Motivation	None
TRU Alignment Dimension	Agency, Ownership, and Identity
TRU Alignment Score	2
Prognosis 2	Teachers could invite students to return to the definition of exponents.
Motivation	The rules can be generated through the definition. By returning to the definition, the students are provided the opportunity to build those rules themselves.
TRU Alignment Dimension	Formative Assessment
TRU Alignment Score	2