Rigorous Science Instruction: Understanding Differences Seen in Teachers' Instructional Quality Though Their Instructional Vision

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Abstract

This work follows a group of four science teachers in the second year of an intensive PD. Our analyses revealed two distinct variations in their instruction. These differences were accompanied by similar differences in their instructional vision. We argue that instructional vision can illuminate teachers' thinking about their work, insights that may be useful in helping PD facilitators better hone such experiences.

Purpose

The field is in need of additional explorations of science teachers' thinking about science learning and teaching and their instructional practices to understand better what influence teachers' instructional decisions and practices and their reactions to the reform efforts (e.g., Khong et al., 2018; Michaels and O'Connor, 2015; Sandoval et al., 2018). To address this, we argue that there is a need to focus beyond the dominant framing of teachers as only doers who practice teaching, to also consider them as thinkers who envisioned high-quality instruction (e.g., Hammerness, 2006; Horn et al., 2017). Thus, we explored, for four science teachers who participated in two years of PD, ***How do teachers' instructional visions account for differences seen in the instructional quality of their teaching practices?***

Conceptual Framework

We draw on fields of research: (i) instructional vision and (ii) instructional quality to explore how teachers' thinking interacts with their instructional practices in order to understand how teachers respond to and adopt the messages of reform and variations in their instruction. Instructional vision focuses on how teachers characterize ideal teaching practices and teachers' rationales for those practices so it provides a detailed analysis of teachers' thinking of instruction (Munter, 2014; Wilhelm, 2014). We examined instructional quality in two dimensions: (a) selection and implementation of classroom tasks considering the demand on students' thinking (e.g., Kang et al., 2016; Stein et al., 1996; Tekkumru Kisa et al., 2015; 2020a; 2021a); and (b) facilitation of productive classroom talk (e.g., Resnick et al., 2015; Tekkumru Kisa et al., 2022).

In the context of this short round table presentation, we will focus on our findings regarding characteristics of the teachers' instruction in terms of the facilitation of productive science talk and the teachers' instructional vision of productive science talk. In this study, productive science talk was characterized in two dimensions (a) accountability to the learning community and (b) accountability to the knowledge, reasoning, and process of sensemaking (Tekkumru-Kisa et al., 2023; Resnick et al., 2018). Accountable to the learning community focuses on students' and the teacher's sharing of their ideas, asking questions, listening to each other, and commenting on and building on each other's ideas. Accountability to knowledge and reasoning in service of sensemaking focuses on teachers' and students' efforts in being accountable to reasoning in science, disciplinary norms, and knowledge sharing in their classroom. A teacher's instructional vision of productive classroom talk consists of both what aspects of productive talk the teacher discusses and what rationales, and functions the teacher provides about those aspects of talk for science learning and science teaching (Munter, 2014; Munter & Wilhelm, 2021).

Study Design and Context

This study was conducted in the context of a professional development (PD) program focused on teachers' learning to foster students' engagement in productive epistemic discourse in science (Southerland al., 2017). We focused on the final lesson the teachers implemented in the context of the second year of the PD as well as the teachers' instructional vision at the end of that year. We analyzed the quality of instruction in the teachers' classrooms, and then the teachers' vision of high-quality science instruction (see Table 1).

Table 1. Information on data sources and analysis

Analysis	Data Sources	Rubrics
Instructional Quality	a. Planning materials of focal lessons b. Classroom video recordings of the lessons' implementation	*Instructional Quality Assessment-Science (IQA-S) Rigor Rubrics and Productive Talk Rubrics (Tekkumru-Kisa et al., 2021, 2023)*
Instructional Vision	c. Recordings of teacher vision interview	*Instructional vision rubrics* (Munter, 2014; Tekkumru-Kisa et al., 2021b)

Findings

Our analysis revealed variations in characteristics of talk observed in the teachers' classrooms and their instructional visions even after they participated in extensive PD. The teachers' enactment of productive science talk fell into one of two groups: teachers (Kate and Daniel) who consistently facilitated productive science talk and those (Monica and Jerry) who occasionally fostered productive science talk (see table 2). Consistently facilitated productive science talk was observed in the classrooms of teachers with a sophisticated instructional vision of classroom discourse, while teachers with a developing instructional vision struggled in facilitating such talk. **Overall, we found a congruence between the characteristics of talk observed in their classroom and their vision of the characteristics of productive talk.**

Table 2. Rubric Scores for Classroom Talk and Instructional Vision of Classroom Talk

Practice & Vision	Dimensions	Consistently facilitated talk		Occasionally facilitated talk	
		Kate	Daniel	Jerry	Monica
Characteristics of talk observed in their classrooms	Teacher linking	level-4	level-4	level-2	level-2
	Student linking	level-4	level-4	level-2	level-2
	Teacher press	level-4	level-4	level-2	level-2
	Student contributions	level-4	level-4	level-2	level-2
Teachers' Instructional vision of classroom talk	Patterns and structure of talk	level-4	level-4	level-3	level-2
	Nature of classroom talk	level-4	level-4	level-2.5	level-2.5
	Teacher questions	level-4	level-4	level-3	level-2.5
	Student questions	level-4	level-4	NA	level-2
	Student explanation	level-4	level-4	level-2.5	level-2

Group I: Consistently Facilitated Productive Science Talk

Kate and Daniel facilitated productive talk that showed keen attention to accountability, and both the teachers and their students employed a high degree of accountability to the community *(through the nature of teacher and student linking)* and accountability to knowledge, reasoning, and process of sensemaking *(through the nature of teacher press and student contributions)* as evident with high rubric scores summarized in Table 2.

For example, in Daniel's Gas Laws lessons, which extended across three days of instruction, he asked students to explain a series of natural phenomena. Daniel began the lesson by showing a video of a tanker car that imploded after it was cleaned with stem, its valves were closed, and the ambient temperature dropped. He, then, asked the students to offer an explanation of why that happened. During this launch, Daniel asked open-ended questions and constantly asked students to elaborate on their thinking by asking why and how. As exemplified in the episode given below, Daniel listened carefully to his students' thinking and used various discourse moves and strategies such as re-voicing, waiting time, and pressing for evidence and reasoning (i.e., So why do you think it's cooling down?; Why is that gonna cause it to crush?; What do you mean?) to foster productive talk. In doing so, he was fostering talk that is accountable to disciplinary reasoning, knowledge, and the process of sensemaking.

Daniel: So, what do we think is causing that [he shows the tanker imploding video again] to happen? All right. So what any other ideas?

Will: Because said the water was for, it was steam when I went in and that's really hot. So, it cooled down. There was, it was like really low pressure in the tank

Daniel: So, why do you think it's cooling down? Like we know we started at steam. So why do you think that one, that it is cooling down?

Will: Because there's nothing keeping it to that temperature.

Ammy: There's not a constant temperature.

Daniel: Okay. So, we don't have that constant inflow of energy to keep it steam. So it's gonna cool down over time. And then what's that gonna do?

Will: It's gonna cause a low pressure inside of the tank.

Daniel: Okay. So why would that low pressure inside the tank cause the tank to crush do you think?

Will: Because it's not, you know, built to, uh, hold a vacuum.

Daniel: It's not built to hold a vacuum, what do you mean?

Will: Uh, there's nothing like.

Ammy: Super, super high pressures that crushes stuff kind like in the ocean when you go farther down it would crush.

Daniel: Okay, so when things get crushed, we usually think of high pressures causing that crush. Like if you put something really deep under the ocean, it would like collapse because outside stuff's pushing in on it.

Bob: So, by removing the pressure on the inside, technically the pressure on the outside would be greater. Don't think that's enough to?

Daniel: Okay. So, we're not changing the pressure on the outside you're saying it's still the atmosphere that's pushing down on stuff, but we've changed the inside. So, like there's the difference and you think maybe the difference in the pressure is going to cause it to crush?

Bob: Maybe….

As shown in this episode, the students (all pseudonyms) shared their thoughts about how and why the phenomenon happened by using their prior knowledge about states of matter, gasses, and their daily life observations, such as crushes in the deep ocean because of high pressures. During the discussions, in addition to pressing students for their evidence and reasoning, Daniel also linked students' ideas and provided opportunities for students to comment and build on proposed ideas by using talk moves (i.e., So do we agree with that?; Did anyone else have something different, a different reason for why they think the can crushed?; Does that make sense to you?). Consistent with Daniel's efforts to build a learning community, students commented on each other's ideas, and they started to figure out how and why the phenomenon occurred through working together in their learning community. Throughout the lesson, the consistency of Daniel's and her students' efforts in promoting accountability to learning community (through the nature of teacher and student linking) and accountability to knowledge, reasoning, and process of sensemaking (through the nature of teacher press and student contributions) is reflected in the IAQ-S Talk rubrics score of level-4 (see Table 2).

In addition, Daniel clearly described characteristics of dimensions of classroom discourse (i.e., nature of classroom talk, student questions, teacher questions, and student explanation) in ways that complement each other for prompting students' thinking and learning through doing science. For instance, consistent with how he regularly asked students to support their contributions with evidence and explain their reasoning and connecting students' contributions and provided opportunities for students to build on each other's ideas, he envisioned the nature of teacher questioning as encouraging students to explaining a phenomenon, develop scientific arguments by asking questions and pressing for their reasoning, and evidence.

Group II: Occasionally Facilitated Productive Science Talk

Although both Monica and Jerry and their students showed some contribution to the generation of productive talk during the focal lessons, their efforts in building a learning community and being accountable to the knowledge, reasoning, and process of sensemaking were unstable. This is evident by the modest degree of teacher linking, student linking, teacher press, and student contribution rubric scores (see Table 2). The teachers struggled to provide details regarding their visions of instruction related to productive science talk (i.e., nature of classroom talk, student questions, teacher questions, and student explanation). Although teachers sometimes asked for students' evidence regarding their claims, they rarely asked for reasoning for their claims, and they showed minimal effort to make connections among students' ideas. For example, Jerry did not talk about student questions while describing their vision of classroom discourse. These teachers could not articulate in detail what they see as critical for classroom talk to be productive in science classrooms, especially in terms of the goal and nature of students' questions and explanations for facilitating classroom discussions in service of developing a model, or explanation for a phenomenon or solving phenomena-based problems.
sed claims and evidence.

For instance, Monica provided a broad characterization of the teacher questioning in a productive classroom talk. If students engaged in discussions, Monica as a teacher described her role as sitting in the middle of the classroom to monitor student discussions, "Occasionally I might chime in and ask them 'why' or to 'explain more' and also letting them to discuss if there are no time constraints". Monica continued by explaining that if the discussion 'is not happening,', then as a teacher, she might visit groups and do a little more probing to "get them on track". She also gave an example of some teacher questions by stating that "the follow up questions and then, why they're thinking what they're thinking and going into it." Although she talked about the "why" type of teacher questions, she did not elaborate on why it is important to ask such questions, nor did she describe the role of these questions in fostering students' thinking. Thus, her vision corresponding to the teacher questions was coded as level 2.5 as developing vision. Consistent with her vision, Monica infrequently interacted with her student, often to check their work or the evidence they used to support their claims; she rarely asked open-ended questions to foster further student thinking as we described before through characteristics of her talk in terms of teacher linking and teacher press.

Conclusions and Scholarly Significance

Our study findings revealed that the differences seen in teachers' instruction are related to differences in their instructional visions. By building on prior research (Hammerness, 2006; Munter &

Correnti, 2017), we argue that instructional vision can illuminate teachers' thinking about their work, and exploring the intersection between teachers' instructional practice and vision can help to reveal teachers' understanding and reaction to reform efforts. While there is a recursive relationship between teachers' thinking and their practices (Southerland et al., 2016), thus we can make no claims about a causal relationship between the two, certainly instructional vision can provide useful insight into teachers' thinking about their work, insights that may be useful in helping PD facilitators better hone these experiences.

Our findings speak to the complexity of enacting reform-oriented science instruction, as reflected in the range of enactments of instruction supportive of productive science talk by the teachers in this study–despite their engagement in a 2-year, intensive PD focused on such instruction. We observed that although all teachers considered the role of students' engagement in discussions in students' science learning, two of the four teachers did not articulate clearly what characteristics productive classroom talk would have and why, and what would be their functions in supporting students' learning and sensemaking aligned with the reform vision.

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References

Hammerness, K. (2006). *Seeing through teachers' eyes: Professional ideals and classroom practices* (Vol. 46). Teachers College Press.

Munter, C. (2014). Developing visions of high-quality mathematics instruction. *Journal for Research in Mathematics Education*, 45(5), 584-635.

Munter, C., & Correnti, R. (2017). Examining relations between mathematics teachers' instructional vision and knowledge and change in practice. *American Journal of Education*, 123(2).

Southerland, S.A., Granger, E., Jaber, L., Tekkumru-Kisa, M., & Bevis, T. (2017). *Learning through Collaborative Design (LCD): Professional Development to Foster Productive Epistemic Discourse in Science.* National Science Foundation, DRL #1720587

Resnick L. B., Asterhan C. S. C., Clarke S. N. (Eds.). (2015). *Socializing intelligence through academic talk and dialogue*. American Educational Research Association.

Tekkumru-Kisa, M., Akcil-Okan, O., Kisa, Z., & Southerland, S. (2023). Exploring science teaching in interaction at the instructional core. *Journal of Research in Science Teaching*, *60*(1), 26-62.

Tekkumru-Kisa, M., Preston, C., Kisa, Z., Oz, E., & Morgan, J. (2021a). Assessing instructional quality in science in the era of ambitious reforms: A pilot study. *Journal of Research in Science Teaching*, *58*(2), 170-194.