Practice What You Teach: A Video-Based Practicum Model of Professional Development for Elementary Science Teachers[1]

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Abstract: This study examines an innovative professional development program that provides teachers with an opportunity to practice pedagogical strategies in a low stakes classroom context. Elementary teachers participated in a one-week summer Institute and two-week Practicum focused on learning strategies for facilitating scientific discourse and argumentation in their classrooms. During the Practicum, teachers taught lessons in a summer program for elementary school students and engaged in daily video-based discussions to reflect on their instruction. This study identified the instructional practices that were most emphasized during the Institute and examined the extent to which teachers took up those practices during the subsequent practicum experience. A classroom vignette illustrates how one teacher engaged her students in the discourse practices, and a coaching vignette portrays her video reflection group's discussion of the episode. Findings suggest that the focal instructional practices were taken up to different degrees during the Practicum, and that opportunities for practice and reflection are potentially valuable features of professional development programs. The project illustrates the value of video as a tool for both professional development and research.

Keywords: professional development, science talk, pedagogy, science education, science instruction, classroom video

A growing body of empirical research on the structure, content and outcomes of effective professional development (PD) provides insights about the characteristics of programs that provide high-quality, high-impact learning opportunities for teachers. As Desimone (2009) argues, "there is a research consensus on the main features of professional development that have been associated with changes in knowledge, practice, and, to a lesser extent, student achievement" (p. 183). These features include: 1) a focus on subject matter content and how students learn that content;

2) opportunities for teachers to engage in active learning; 3) coherence, which includes consistency with both teacher knowledge and beliefs, and school, district, and state policies; 4) sufficient duration, in terms of number of hours and span of time; and 5) collective participation. Borko, Jacobs and Koellner's (2010) review of contemporary approaches to PD identifies two additional, related features: that PD be situated in the practice of teaching, and that PD leaders model preferred instructional strategies so that participating teachers have the opportunity to experience the strategies as learners and then reflect on their effectiveness from the perspective of teacher-learners.

Randomized controlled experiments offer some evidence that PD programs designed in accord with the features of effective PD can produce significant gains in teacher knowledge and instructional practices (e.g., Bell et al., 2010; Heller et al., 2012) and student learning (e.g., Heller et al., 2012; Penuel, Gallagher, & Moorthy, 2011). For example, Heller and colleagues compared the effects of three PD programs focused on electric circuits that used three different approaches – teaching cases, analysis of student work, and metacognitive analysis – as well as a business-as-usual control condition. Each PD program significantly increased teacher and student science test scores beyond those of the control group, and the effects held one year later.

Other studies, however, show that simply including these features is not sufficient to ensure positive impacts for either teachers or students. Two randomized controlled studies by Garet and colleagues, one focused on early reading instruction (Garet et al., 2008) and the other on middle school mathematics (Garet et al., 2011), provide a case in point. Their study of PD for early reading instruction, for example, compared a PD program that included a content-focused summer institute and school-year seminar days, a second treatment that provided the summer institute plus a half-time coach in each participating school, and a business-as-usual comparison group. The PD interventions had a significant impact on teacher knowledge of early reading content and some aspects of their instruction. However, these effects were not maintained in the year following the intervention. Further, the programs had no impact on students' reading achievement.

These mixed results suggest that existing conceptual frameworks for effective PD are not sufficient to ensure that the PD will effect change. One possible reason is that the features are underspecified. Given the lack of consistent empirical findings in research on professional development in science education, Wilson (2013) suggests that more empirical research is needed to "identify the underlying mechanisms that make some teacher professional development (PD) programs more effective than others" (p. 312). She argues for better specification of target instructional practices that are the focus of the PD, more highly theorized mechanisms of teacher learning and improved outcome measures.

One characteristic that several PD programs with some evidence of effectiveness have in common is the use of classroom video as a tool for bringing the central activities of teaching into the PD setting (Koellner & Jacobs, 2015; Seago et al., 2013;

van Es & Sherin, 2010). Like other records of practice, such as examples of student work and instructional materials, video provides an opportunity for teachers to collaboratively study their practice without being physically present in the classroom (Borko et al., 2014). Clips from videotaped classroom episodes can be viewed repeatedly and from multiple perspectives, enabling teachers to closely examine classroom interactions, as well as the content addressed in the lessons, and to discuss ideas for improvement. The Practicum Academy for Improving Science Education (PRACTISE) PD model that is the focus of this article incorporates all of the features of effective PD identified in the literature. In addition, it identifies a specific set of instructional practices to foster students' argumentation from evidence and emphasizes time dedicated for teachers to enact and refine these instructional practices in a low-stakes practicum experience. Video plays a key role in both the PD experience and the research. In the PD, teachers share video of their practicum teaching and receive feedback from colleagues and PD leaders. The primary data sources for the analyses presented in this article are video-recordings of the program's summer Institute and Practicum experience.

1 The Practicum model of professional development

Changing teaching practices involves uncertainty, room for reflection in order to understand the emerging patterns of change, a community to share experiences, and opportunities to test what works or does not work in classrooms (Jennings & Mills, 2009; Martin & Hand, 2009). During the school year, external constraints such as time, state standards, testing requirements, and instructional resources can prevent teachers from having the opportunity to practice new instructional moves or reflect on practices collaboratively with peers. The structure and constraints of schools can limit teachers' implementation of new strategies regardless of changes to their knowledge or beliefs.

Practicum experiences enable teachers to focus on changing their practice without such constraints or outside pressures. Practicums – courses designed to provide supervised practical application of previously or concurrently studied theory and methods – while uncommon in PD for veteran teachers, are a hallmark of professional preparation in teaching as well as fields of study such as medicine, nursing and social work (Ryan, Toohey, & Hughes, 1996). In the professional development program that is the focus of this article, PD leaders introduce teachers to the theory and research on the role of scientific discourse in student learning, and they model a variety of instructional practices for facilitating scientific discourse in classrooms. The practicum provides opportunities for teachers to enact the practices in authentic contexts, reflect upon their experiences and receive feedback, and then modify their practice the following day. Video clips from the practicum lessons feature prominently in the reflection and feedback sessions.

2 The Practise professional development program

The Practicum Academy for Improving Science Education (PRACTISE) project was designed to study the efficacy of an innovative model for science professional development for upper elementary (grades 3–5) classroom teachers. In an evaluation of previous practicum-based Academies, evidence from teacher surveys and interviews indicated that teachers make significant shifts in their knowledge and beliefs, and that they are comfortable with implementing new practices they have learned (Chi et al., 2011). The PRACTISE research project enables us, for the first time, to collect evidence of actual changes in practices that result from the practicum-based PD, and to compare the effects of PD with and without the practicum experience.

The PRACTISE project's goal is to develop teachers' skills in engaging students in productive science discourse and argumentation. The decision to focus on scientific discourse is grounded in theory, empirical findings and policy. From a theoretical point of view, language is an instrumental tool for constructing understanding and developing concepts (Billig, 1987; Vygotsky, 1962). Empirical research has shown that opportunities for students to engage in collaborative discourse – to advance claims, support their ideas, be challenged and challenge others – lead to improvements in students' conceptual understanding and scientific reasoning (Asterhan et al., 2007; Chi, 2009; Mercer et al., 2004; Zohar & Nemet, 2002). The policy driver for focusing on scientific discourse and argumentation is the release of the *K-12 Framework for Science Education* (NRC, 2012) that identified argumentation as a key scientific practice. Taken together, these factors shape the focus of the PRACTISE project on science discourse and argumentation.

The PD model (aka "Academy") consists of three components – an *Institute*, a *Practicum*, and *Follow-up sessions*. The intensive, week-long summer Institute focused on helping teachers learn how to facilitate scientific discourse and, specifically, argumentation from evidence, through engaging students in reading science texts and conducting inquiry-based science investigations. At the Institute, the teachers were introduced to an inquiry-based curriculum about oceans with a focus on what causes ocean currents. The PD leaders oriented the teachers to the curriculum by modeling many of the lessons and investigations. They also modeled a variety of instructional practices designed to support scientific discourse and argumentation among students.

Following the Institute, approximately half of the teachers spent an additional two weeks in a teaching Practicum. During the Practicum, they taught science and literacy in teams for approximately two hours each morning in a local summer school program. They then spent the afternoon reflecting on their instruction and planning for the next day. The Practicum experience was designed to allow teachers to: practice instructional strategies that they had learned in the Institute in a highly supported, low stakes environment; analyze videos of their teaching practice; reflect on their practice and receive feedback from colleagues, science coaches, and

literacy coaches; then adapt their instructional practices for the following day on the basis of that feedback.

Eight teams of teachers (comprised of 2–3 teachers each) were assigned to an instructional coach and a class of summer school students who were entering 3rd, 4th or 5th grade in the fall. The teams were expected to follow the ocean science curriculum that they had worked with the prior week at the Institute. The teachers decided how to pace the lessons and where to integrate science discussion. While most teacher teams planned jointly, they often took turns as the lead instructor for a particular lesson or day of instruction. Each teacher was also responsible for facilitating a discussion or activity with a small group of students each day.

In the afternoons, teachers from two teams combined into a single discussion group to discuss a video clip that one of the teachers had selected from the prior day's instruction, in consultation with their instructional coach. The goal of the discussions was to provide a supportive and safe setting for teachers to reflect on how their instructional practices were developing. The clip provided the springboard for discussing an aspect of the teacher's own practice that the teacher wanted to explore with his or her colleagues. The teacher framed the activity with a question for the group to consider as they watched and discussed the clip.

The third component of the Academy is a series of follow-up sessions conducted during the academic year, designed to provide guidance and support for teachers as they incorporated the new instructional practices into their ongoing classroom instruction.

To test the efficacy of the Academy model, professional development facilitators enacted two versions of the PD: the full Academy (Institute, Practicum and Follow-up days) and the Academy minus the Practicum (Institute and Follow-up days only). The multi-year research project is examining the impact of the different versions of the PD on teachers' instructional practices and student learning outcomes.

3 Research questions

The study reported in this article highlights one specific component of the overall PRACTISE project – the summer Institute and Practicum during the first year of the project. More specifically, we trace the instructional practices emphasized in the Institute through the teachers' enactment of those practices in the subsequent Practicum experience. The following research questions guided our analysis:
1. Which instructional practices were most prominently communicated to teachers during the summer Institute?
2. How and to what extent were these instructional practices taken up by teachers during the Practicum?

To address these questions we analyzed the discourse practices highlighted in the summer Institute and the discourse practices enacted by the teachers in their Practicum classrooms. In addition, we conducted an initial vignette analysis to begin to

explore the relationship between the Practicum's teaching experiences and reflective coaching sessions. In the following sections, we first describe the participants and data sources for the study. We then present the analytic methods and results for the analysis of the Institute, followed by analysis and results for the Practicum. We conclude with the vignette to illustrate how video was used to support teacher reflection.

4 Participants and data sources

In this section, we describe the participants and data sources we used to investigate our research questions. The larger research program included additional data sources and research methods.

4.1 Participants

All teachers in the project were recruited from a large, urban school district in Northern California. Twenty teachers in *Group 1* participated in the Institute and Practicum, and 24 teachers in *Group 2* participated in the Institute only. During the Practicum, Group 1 teachers taught in teams. The analysis in this study focuses on two teams that convened together with their coaches in the afternoon to reflect on their instruction using video. The video reflection group included five teachers: two taught as a pair in one classroom, and three taught as a trio in a second classroom. The teachers had between 2 and 11 years of prior teaching experience and all but one were female. We selected this video reflection group to analyze because one of their coaches was one of the principal investigators for the overall project, and we reasoned that he would be coaching with high fidelity to the goals of the project. Due to resource limitations, we alternated between the two classrooms during the Practicum teaching, as represented in *Figure 1*.

4.2 Data sources

To investigate our research questions, we analyzed data from three sources. First, we videotaped the summer Institute attended by all participating teachers. The video included all of the presentations, activities and discussions facilitated by the PD leaders. The second data source was video of the classroom instruction during the teaching Practicum. We analyzed instructional video from the five teachers who were in the focal video reflection group. The third was video of the afternoon video reflection discussions that these five teachers had with their coaches. We describe how these data were analyzed in the sections below.
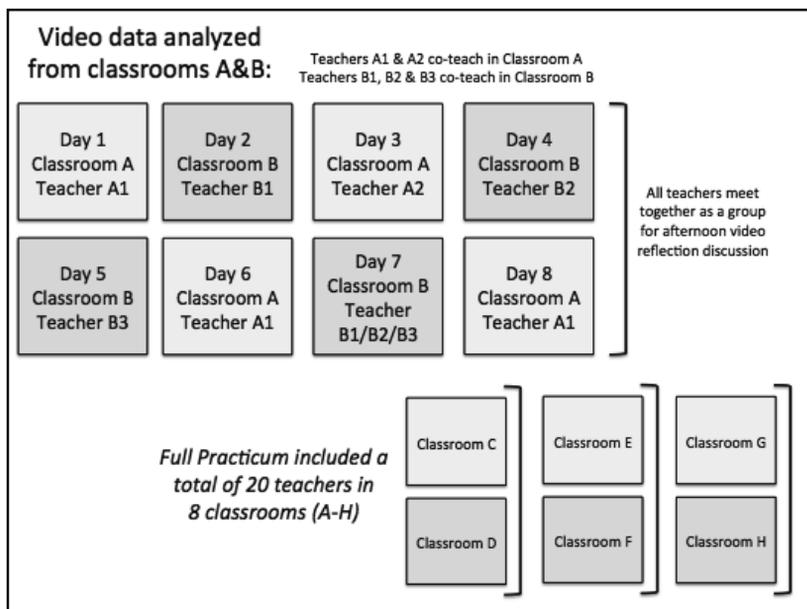
Figure 1 Practicum schematic illustrating the sample video used for analysis

5 Analysis and results

In this section, we present the analyses and results for two inquires: teacher and student discourse practices emphasized during the Institute, and practices taken up during the Practicum. We then present vignettes that illustrate the two components of the Practicum experience – a classroom vignette depicting the dialogic nature of the teacher and student practices, and a vignette depicting the nature of video reflection discussions during the afternoon coaching sessions.

5.1 Discourse practices emphasized in the Institute

The goal of the summer Institute was to teach teachers how to engage students in productive scientific discourse and, specifically, argumentation from evidence. In light of this stated goal, we sought to identify the instructional practices that were most prominently communicated to teachers during the Institute.

Analysis
Our first step in analyzing the data was to watch video of the Institute to identify and document the teacher and student discourse practices that were introduced during the Institute workshops. The PD leaders utilized a variety of presentation formats to communicate instructional practices including: 1) modeling science les-

42 sons with teachers as learners; 2) debrief sessions to reflect on the model lessons; 3) lectures or presentations; and 4) other types of teacher learning activities (e.g., jigsaw readings, creation of concept maps). In some cases, specific instructional practices were *explicitly* communicated to teachers by the PD leaders. For example, they explicitly suggested that teachers try out a particular instructional practice with their students. In other cases, the instructional practice was communicated *implicitly* by modeling the practice during the demonstration lessons. There were also instances when teachers raised particular instructional practices, often during the debrief sessions.

Our initial analysis of the Institute video records yielded a broad set of instructional practices that were mentioned or modeled at least once during the Institute. Next, we reduced the set of practices to include only those that were a) most closely relevant to supporting scientific discourse and argumentation; and b) *explicitly* communicated to teachers on one or more days of the Institute. This process yielded a set of 15 teacher practices and 5 student practices. We created a coding manual that included definitions for each of the practices in this set, which we then used in the analysis of Practicum lessons.

Results

Table 1 lists the primary teacher instructional practices. The teacher practices included practices aimed at establishing classroom norms for productive discourse such as language to use when disagreeing with other students' ideas, sentence frames, active listening, speaking loudly enough to be heard and encouraging wide participation from students in the discussion. A second set of practices involved making particular pedagogical moves to support student discourse such as pressing students for evidence, revoicing students' ideas, adding to or linking students' comments and soliciting additional student ideas. A third set of practices focused on documenting student ideas. One practice that was emphasized is the use of a T-chart which graphically organizes evidence that either supports (left column) or refutes (right column) a claim (at the top). More generally, teachers were advised to write down key student ideas such as observations or claims as a way to support discourse. The last set of teacher practices focused on the role of writing to support discourse, including asking students to write or draw their ideas before engaging in a class discussion and providing scaffolds for writing such as prompts and graphic organizers.

The only teacher practice that was part of the Institute that we decided not to include in the list or in our analysis of the Practicum was the practice of asking questions. Asking questions is central to generating classroom discussion and was explicitly addressed in the Institute. However, we excluded this practice because the primary questions that teachers were expected to use during the Practicum were provided in the curriculum materials they were given rather than generated by the teachers.

Table 1 Teacher practices communicated during the Institute

Practice	Definition
Norms for Discourse	
Language to Disagree	Teacher encourages student to use phrases such as "I agree" or "I disagree" when referring to each other's comments.
Sentence Frames	Teacher encourages students to use particular rhetorical frames (e.g., "I think____ because___") to support academic discourse in the classroom.
Active Listening	Teacher reinforces importance for students to show each other that they are listening.
Speaking Loudly	Teacher encourages students to speak loudly and/or clearly in order to allow other students to hear each other's ideas.
Wide Participation	Teacher elicits responses from different students. The teacher may use equity sticks or other devices to encourage students to participate.
Gestures	Teacher elicits gestures from students as a way of responding to a question or expressing their ideas.
Discourse Moves	
Press	Teacher asks students to elaborate, clarify or support their claims, often by asking for evidence or reasoning.
Revoice	Teacher revoices, paraphrases or otherwise summarizes a student's thought or idea.
Adding to/Linking/ Building	Teacher makes a connection between two or more different ideas that have been expressed in the discussion to show how they relate to each other.
Solicit More Ideas	Teacher asks for more ideas or thoughts from the students who have not yet shared.
Charting Student Ideas	
T-Chart	Teacher uses a T-chart that scaffolds the documentation of evidence for and against a particular claim or claims.
Recording Ideas (non-T chart)	Teacher documents students, ideas or thoughts in a public place (e.g., the board, chart paper)
Writing to Support Talk	
Writing Activity	Teacher asks students to write down their ideas (e.g., observations, claims, evidence) as a way to support discourse.
Scaffolds for Writing	Teacher provides scaffolds for writing, such as sentence frames or writing organizers, in an effort to support discourse.
Asking Students to Draw Ideas	Teacher asks students to draw their ideas in an effort to support discourse.

Table 2 lists the main student practices that were emphasized during the Institute. These practices reflect the different kinds of productive student contributions that are facilitated by the teacher practices. The student practices communicated during the Institute workshops included making initial claims or predictions, supporting claims with evidence, revising claims, critiquing the claims made by others and using prior knowledge and new resources. Taken together, these student practices are central to the goals of the professional development and at the core of productive classroom discourse.

Table 2 Student practices communicated during the Institute

Practice	Definition
Make Initial Claims or Predictions	Students make initial claims or predictions that reflect their ideas.
Support Claims with Evidence	Students support their claims with evidence. This rubric characterizes the degree to which the students are supporting their claims with evidence.
Revise Existing Claims	Students revise an existing claim based on evidence or discussion.
Critique Claims	Students critique claims by citing counterevidence or disagreeing with each other's statements.
Use Prior Knowledge & New Resources	Students use prior knowledge or resources (e.g., prior experiments, readings) to support their claims.

5.2 Practicum instructional practices

Having identified the set of teacher and student practices communicated during the Institute that fit our criteria, we then analyzed the extent to which teachers and students engaged in those practices during the Practicum experience.

Analysis
To analyze the extent to which teachers tried out the Institute practices during the Practicum, we created a rating schema based on the set of practices we identified in the Institute analysis (see Table 1 and 2). We watched video of morning instruction in one Practicum classroom during each of the 8 days of the Practicum. Since there was a team of teachers in each classroom, one or more teachers taught each lesson. Therefore, on any given day, we observed between one and three teachers enacting the strategies presented in the Institute (see Figure 1). Immediately after we watched the lesson, we rated the instruction based on how consistently the teacher engaged in each instructional practice and how consistently the students engaged in each student practice. For each practice, we evaluated each day of instruction based on the following ratings:

- "Consistently" [C]: the teacher/student engages in the target practice during the majority of possible opportunities during instruction. The practice is regularly and substantially reflected in the lessons.
- "Occasionally" [O]: the teacher/student engages in the target practice during some possible opportunities in the lesson, but does not do so consistently. There were some missed opportunities to engage in the practice.
- "Rarely" [R]: the teacher/student does engage in the target practice but the majority of opportunities in the lesson are missed. The practice is hardly reflected in the instruction.
- "None" [N]: the teacher/student does not engage in the target practice.

Due to the inferential nature of the rating categories, we conducted a calibration process with the raters to ensure a shared understanding of the meaning of each category. During the calibration process the raters independently rated and then compared ratings to refine how ratings were applied. In the process, we clarified that "possible opportunities" for a practice meant that the raters determined that the practice would have been productive at that point in the lesson. For example, typically when a student vocalizes a claim during a discussion but does not offer evidence to support the claim, there is an opportunity for the teacher to press the student for evidence. If the teacher does not press for evidence, that would be considered a missed opportunity. Because the measure required these types of inferences, we used a consensus rating method. Two members of the research team independently rated each day of the Practicum instruction. Disagreements of two steps apart or more (e.g., one rated "consistently" and the other rated "rarely") were resolved through discussion between raters and given consensus ratings. Single step disagreements were given a combination rating such as consistently/occasionally [CO]. Inter-rater agreement within one step was 96%. To facilitate analysis, we converted the ratings into a numerical 3-point scale (see Table 3). This process yielded one numerical rating for each practice on each of the eight days of Practicum instruction.

Table 3 Numerical rating scale

Practice Rating	Abbreviation	Numerical Value
Consistently	C	3
Consistently/Occasionally	CO	2.5
Occasionally	O	2
Occasionally/Rarely	OR	1.5
Rarely	R	1
Rarely/None	RN	.5
None	N	0

46 Results

Table 4 shows the average ratings of the teacher and student practices and the corresponding rating categories across the 8 days of the Practicum. These findings suggest that teachers tried out the main instructional practices communicated at the Institute, at least to some extent, during the Practicum instruction. In general, the teachers most consistently practiced the discourse moves during the Practicum instruction. The norms for discourse were also regularly reinforced although there was some variation from day to day, depending on the teacher. It is particularly important to introduce and reinforce norms for discourse during the beginning of the school year when the classroom culture is being established. Since the Practicum only spanned two weeks and the teachers were working with a set of students they had never met before, we would expect to see regular reinforcement of the discourse norms.

The instructional practices of charting student ideas and writing to support talk were practiced less consistently. This finding is not surprising given the nature of those practices. Teachers determine when it is strategic and useful to chart student ideas and ask students to write down their ideas. While potentially beneficial for supporting productive talk, we would not expect the practices to be present in connection with every classroom discussion.

The instruction engaged students in a variety of practices that were emphasized in the Institute. Students consistently made claims and supported those claims with evidence, and they occasionally used prior knowledge and new resources. The practices of critiquing one another's claims and revising claims were observed less often. It may be that these two practices, which entail following up on one's own claims or the claims of other students, are more difficult to learn than practices related to initially offering claims.

Table 4 Average ratings for each teacher and student practice

	Average Numerical Rating	Corresponding Rating*
TEACHER PRACTICES		
Norms for Discourse		
Language to disagree	1.9	O
Sentence frames	2.1	O
Active listening	2.4	CO
Speaking loudly	2.2	O
Wide participation	1.6	OR
Gestures	1.9	O
Discourse Moves		
Press	2.8	C
Revoice	2.8	C
Adding to	1.9	O
More ideas	2.1	O

Charting Student Ideas		
Recording ideas (non T-chart)	1.0	R
T-chart	1.1	R
Writing to Support Talk		
Writing activity	1.4	OR
Scaffolds for writing	1.0	R
Asking students to draw ideas	1.0	R
STUDENT PRACTICES		
Make initial claims/predictions	2.7	CO
Revise existing claims	0.9	R
Support claims with evidence	2.8	C
Critique claims	1.6	OR
Use prior knowledge & new resources	1.9	O

*Based on rounding to closest rating level

6 Classroom vignette: Dialogic nature of teacher and student practices

The analyses reported above indicate that teachers and students in the Practicum classrooms engaged in the majority of practices introduced in the Institute; however they do not illustrate the dialogic nature of the practices. In this section, we examine a vignette of a discussion in one of the teacher's Practicum lessons. We selected this particular instructional episode because it was a situation in which the discussion unfolded in an unexpected way, thus affording an opportunity to examine how a teacher adjusted her instruction based on what her students were saying in order to support productive classroom discourse. In addition, the episode is one that was discussed in the afternoon session on the following day. Thus it also provides an opportunity to consider how the afternoon coaching discussions were used to analyze teachers' use of discourse practices in their Practicum lessons.

The vignette is from classroom instruction that took place on Day 4 of the Practicum. Amanda,[2] a 4th grade teacher with three years of prior teaching experience, was one of three teachers who shared responsibility for instruction in one classroom. On this day, Amanda was teaching a lesson from the Practicum curriculum about ocean floors. The lesson was designed to engage students in argumentation about different claims about the topography of the ocean floor. Amanda showed her students four different possible representational silhouettes of the ocean floor (see Figure 2). She asked the students to select which representation they thought was most accurate. Unexpectedly, all of the students picked the same visual, the one with jagged underwater mountains, valleys, and deep canyons.

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[2] All names of teachers and students are pseudonyms.

How Is the Ocean Floor Shaped?

flat almost everywhere

mostly flat, but with small hills in some places

Small hills in most places

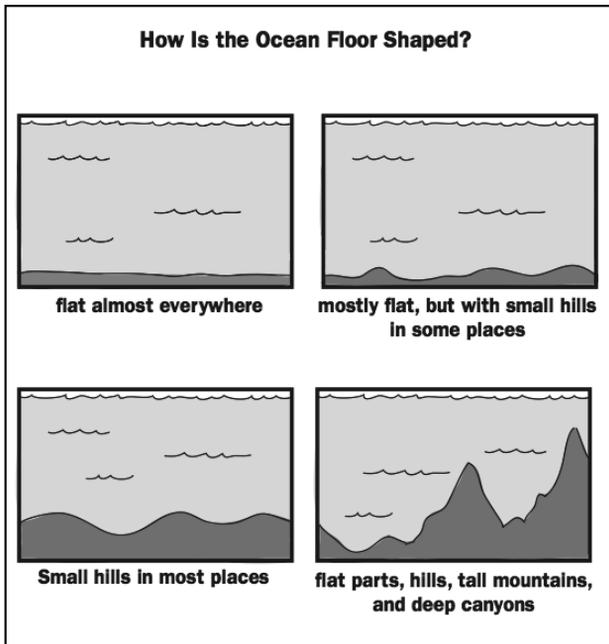flat parts, hills, tall mountains, and deep canyons

Figure 2 Ocean Floor Handout. Source: NOAA, 2011

Amanda had to quickly decide how to engage the students in productive scientific discourse since the consensus did not allow her to proceed with her plan of engaging them in a discussion about competing claims. She decided to ask the students for evidence that supported their selection. Several students suggested a variety of sources of evidence including television, movies, video games and one student's personal experience of going to a beach and stepping on a large, sharp rock in the water. Amanda was able to capitalize on their responses as an opportunity for discussion and asked the students which source of evidence they considered most reliable. The following is an excerpt from the lengthy discussion that followed:

Teacher: So out of the Discovery Channel, movie, video games, or Manuel's personal experience, which is the most reliable evidence and why? What do you think?

Alberto: I agree with Manuel because video games are fake. And some TV shows don't really show the real thing.

Teacher: So the two points that I just heard – Alberto, tell me if I'm saying what you said right. You said some TV shows aren't showing what's real, and video games are fake. [Alberto nods] Who would like to respond to what Alberto just said? Not to what I'm saying, but what do you think about his idea? I want you guys to talk to each other about what you think about what Alberto just said.

Blanca: I disagree with Alberto because in Discovery Channel when they go underwater they have cameras and you can see the ocean floor.

Teacher: Okay, so a response to Alberto or Blanca. To what one of them said.

Jose: I agree with Blanca because they can go in a submarine so much deeper.

Teacher: Okay, so what I hear Jose saying is that it's not that he doesn't believe what Manuel said, but the Discovery Channel brought cameras so if Manuel had brought a camera to the beach with him and he showed on video what he felt with his foot and what he saw with his eyes, then you would believe him just as much as you believe the Discovery Channel? Is that right? Is that what you said Jose? Okay.

In this excerpt, the students were making claims and supporting their claims with reasoning and evidence. The discussion was very fluid and animated as the students seemed to be very engaged by a topic that they found interesting and relevant. Many students wanted to participate in the discussion. While Amanda was primarily facilitating who talks next, she was also summarizing the different points being made in the discussion and pressing students for their reasoning. The students used discursive frames such as "I agree" or "I disagree," and they supported their claims with reasoning. Amanda guided the discussion and supported the students' discourse by paraphrasing points and encouraging widespread participation.

7 Video-based coaching discussion vignette

A systematic analysis of the full set of video-based coaching discussions is beyond the scope of this paper. However, to illustrate the nature of these discussions we present a vignette of the afternoon session during which Amanda, her colleagues, and their coaches discussed a video clip excerpted from this classroom episode.

Each afternoon during the Practicum, Amanda, her two co-teachers and their coach joined another pair of co-teachers and their coach for a video reflection discussion. On the day following Amanda's lesson about the ocean floor, it was her turn to share a clip for the discussion. In consultation with her coach, Amanda decided to share a clip from the discussion she facilitated with her students about the ocean floor topography. After introducing the clip and providing relevant context, Amanda posed the following question to frame the discussion:

I felt like they were starting to engage. This wasn't part of the lesson that was in the book, in the handbook, so it was just something that came up out of their own interests…. Based on what you're seeing in the video, what are the next steps that can be taken to help them to engage in a conversation that is authentic and student-generated versus what we've been doing? … We've been trying to do that but it's been more teacher – student – teacher – student. It's always very teacher directed. What can be done differently or in addition as next steps for student discussion?

Following a protocol designed to support video-based discussions, the teachers watched the video clip, spent time silently reflecting on what they saw, and then asked Amanda clarifying questions. For example, one teacher asked Amanda what she meant by "authentic." Amanda explained that she wanted to see students talking to each other in a discussion rather than just with the teacher, and she was interested in ideas about how to support this type of conversation in her classroom.

In the next phase of the video reflection protocol, the teachers shared observations about the video. During this phase, the presenting teacher's role is to listen and not contribute to the discussion. The teachers and coaches noted that the students were successful at following classroom discourse norms. They also discussed the affordances and limitations of allowing students to veer away from the intended topic of discussion. After exploring issues related to the substance of the video discussion, the teachers brainstormed ways to support student-to-student discussion (e.g., turning chairs to face each other, passing an object between students so they know whose turn it is to talk). The teachers seemed to agree that productive student-to-student discussion depended on the establishment of strong classroom norms that typically develop over time.

In the third phase of the protocol, the presenting teacher is given the opportunity to share her reflections and address any important points that arose in the discussion. Amanda explained that, in the case of the ocean floor discussion, she made a conscious decision to pause her initial plans for the lesson and to capitalize on the opportunity for authentic discussion. When all of the students agreed on the answer, she decided to press students for their reasoning and to explore their notions of reliability of evidence. She added that, in the future, she intends to do a better job at charting students' ideas and to draw attention to particular comments in order to highlight important student contributions.

The use of video in the afternoon component of the Practicum enabled teachers to reflect on their own instructional decisions and to receive input from their colleagues and coaches. As this example illustrates, the discussion of Amanda's video clip afforded her the opportunity to think about a variety of instructional options that might inform how she makes pedagogical decisions in the future. More generally, it provided an opportunity for all five teachers to consider ways of fostering student-to-student exchanges during class discussions. As a teacher, knowing when to insert oneself in the discussion and when to hold back is an important skill.

8 General discussion and implications

Engaging students in collaborative, critical science discourse is a challenging but important instructional practice. Despite research evidence for its importance, such discourse is absent in most science classrooms (Osborne, 2010). The pedagogical practices at the center of this project are intended to change this situation. They are aimed at encouraging students to express their ideas, supply evidence for their claims, and both build on and challenge one another's ideas. These discursive practices support the development of students' understanding of the science concepts (Chi, 2009). In order to encourage such dialogue, teachers must be responsive to what students are saying. They must productively insert themselves into the discourse in order to support students in reasoning with evidence (Resnick, Michaels, & O'Conner, in press).

The professional development model explored in this study was designed to support teachers in developing proficiency in instructional practices to foster productive classroom discourse. The innovative feature of the PD model was a Practicum experience in which teachers could practice instructional strategies introduced during a summer Institute, in a low-stakes classroom setting, and then have the opportunity for reflection, colleague feedback, and coaching. This study sought to better understand the relationship between the instructional practices communicated during the Institute and the practices that teachers tried out during the Practicum.

Our examination of the summer Institute identified the core teacher and student discursive practices that were emphasized by the PD leaders. Evidence from our analysis of the Practicum experience indicates that the teachers engaged in those practices in their Practicum classrooms, albeit some more consistently than others. As illustrated in the classroom vignette, the practices were used in a dynamic classroom context in which teachers needed to be responsive to their students. They had to decide when to press their students, when to link different students' comments, and how to support students in engaging directly with each other.

As with any sophisticated practice, developing proficiency in supporting scientific discourse and argumentation in an elementary school classroom takes time and experience. The summer Practicum afforded teachers the opportunity to begin to try out these dialogic practices with students in a real classroom context, an important component of science professional development (Putnam & Borko, 2000; Wilson, 2013).

Furthermore, the video-based discussions with their coaches and colleagues provided the reflective space for teachers to critically examine their instructional decisions and to explore alternatives in a safe and supportive environment. Video offered a medium for the teachers to share instructional episodes and process them together in productive ways (Jacobs, Borko, & Koellner, 2009; Sherin, 2004). By teaching in the morning and engaging in video discussions in the afternoon, the teachers who participated in this Academy had the opportunity for rapid cycles of planning, teaching, reflection, and modifying instruction for the next day.

While the Practicum may be a valuable space for trying out new instructional practices, the ongoing impact of the professional development can only be observed in the teachers' regular classrooms. In their own classrooms, teachers have more time to practice these pedagogical strategies and to establish a classroom culture that is so crucial for this type of instruction, and students have more time to engage in collaborative, critical discourse. Also, in the Academy PD model, the Follow-up sessions provide an opportunity for additional guidance and support as the teachers incorporate these practices into their instruction, again using video from their classrooms as a springboard for discussion and collaborative analysis. As part of the larger research project, we are examining whether these practices do, in fact, get carried into the teachers' classrooms. We will compare the classroom practices of teachers who attended the summer Institute, Practicum, and Follow-up sessions with teachers who attended only the Institute and Follow-up sessions. We will also compare students' science learning in these teachers' classrooms. These comparisons

will provide evidence as to the effectiveness of the Academy with and without the Practicum opportunity for developing teachers' instructional practice.

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