

Tools for Reflection: Video-Based Reflection Within a Preservice Community of Practice

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Abstract Current reform in science education calls for teachers to understand student thinking within a lesson to effectively address students' needs (NRC in A framework for K-12 science education: practices, crosscutting concepts, and core ideas. National Academy Press, Washington, DC, 2012; NRC in Guide to implementing the Next Generation Science Standards. The National Academies Press, Washington, DC, 2015). This study investigates how to scaffold preservice teachers with learning to attend to students' thinking for the purpose of guiding curricular decisions. The study focuses on one team teaching a science unit during their early field experience. We sought to understand how participants' thoughts and abilities changed through participation in a moderated community of practice using video of their own teaching as a reflective tool. We examined how these changes affected both their classroom practice and their decision-making for future lessons. Evidence shows growth in participants' ability to identify opportunities to elicit, assess, and use students' thinking to guide instructional decisions. Implications for use of the approach used in this study to begin developing novice teachers' pedagogical content knowledge for teaching science are discussed.

Keywords Preservice elementary science · Community of practice · Video-based reflective practice · Pedagogical content knowledge

Introduction

Preservice teachers find it difficult to effectively teach science because they often focus on classroom management and following previously constructed lesson plans (Appleton & Kindt, 2002). Attention to such managerial issues can prevent

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preservice teachers from addressing the complex skills presented in methods classes such as (a) the ability to present specific subject matter; (b) paying attention to student thinking for the purpose of guiding instructional decisions; (c) considering how lesson set-up and progression facilitate attainment of lesson objectives; (d) tying students' exploratory learning to formal scientific concepts (Appleton & Kindt, 2002). In addition, how preservice teachers' think about structuring science learning opportunities, as well as their limited experiences with effective strategies for teaching science, can make it difficult to develop their pedagogical content knowledge for providing a responsive curriculum (Levin, Hammer, & Coffey, 2009).

Shulman (1986) coined the term pedagogical content knowledge (PCK) to define an amalgamation of knowledge bases needed for teaching specific content combining subject matter and pedagogical knowledge for teaching specific topics. He claimed PCK was what distinguished teachers from content experts. Teachers draw upon this "specialized knowledge" when noticing what students are doing or saying, interpreting students' understanding and behaviors, and when deciding how to proceed with instruction (Shulman, 1986). Teachers develop this knowledge base for teaching by reflecting on practice. It is for this reason that teacher education courses (i.e., methods) need to consider PCK development as an important part of their curriculum (Abell, 2007).

Considering this need, this study investigates the efficacy of using video of preservice teachers' own teaching within a content-moderated community of practice (CoP) as a strategy for developing beginning elementary science teachers' PCK for attending to students' scientific thinking to assist them in making evidence-based instructional decisions. Both tools for reflection (video and CoP) were selected for this study because they have been shown individually to support teachers' reflective processes (Levin et al., 2009; Levin, Grant, & Hammer, 2012; Levin & Richards, 2011). Also, much of the research on the effectiveness of these strategies within inservice and preservice has been conducted in mathematics contexts (e.g., Borko, Jacobs, Eiteljorg, & Pittman, 2008; Friel & Carboni, 2000; Santagata & Guarino, 2011; Towers, 1998). Only recently have these tools been applied to science teacher education (see, e.g., Akerson, Cullen, & Hanson, 2009; Lumpe, 2007; Martin & Siry, 2012; Nilsson & Loughran, 2011; Roth et al., 2011) and an emphasis placed on their use with inservice rather than preservice teachers. In addition, from our review of the literature we also found the focus is usually on the application of one of these tools at a time with more attention being given to communities of practice than video-based reflection of one's own teaching. Considering these gaps in the literature, we developed the following research questions to focus our exploration with implementing both of these practices in a preservice elementary science context.

1. What were elementary participants' initial views about the importance of eliciting and attending to students' scientific thinking?
2. How did the participants' ideas about and *ability* to attend to student thinking *change* while participating in a video-based COP with a content specific moderator using video of their own science teaching as a reflective tool?

3. Following their participation in the COP, how have the participants' *views* of the importance of attending to student thinking *changed*?

Theoretical Frameworks

Two theoretical frameworks—reflective practice and CoP—guided the intervention investigated in our study. These frameworks also informed our research design and analysis.

Reflective Practice

Jay and Johnson (2002) assert reflective practice is paramount to learning to teach. The Council of Chief State School officers defined reflective practice within the context of teaching as teachers “who continually evaluate the effects of his/her choices and actions on others (students, parents, and other professionals in the learning community) and who actively seek out opportunities to grow professionally” (as cited in Krol, 1997, p. 96). With reflective practice, teachers grapple with questions individually and/or with others to gain insights on problems or issues within their practice. A reflective practitioner is someone who is able to focus on a dimension of their teaching, examine it from a number of perspectives, and discuss their thoughts on it with their peers (Jay & Johnson, 2002). Thinking metacognitively about an aspect of one's teaching, and then sharing those insights with colleagues, is at the core of reflective practice.

However, reflecting on practice is not an easy skill to teach. Calderhead (1989) details some challenges in the design of preservice educational programs. One major consideration is whether program tasks are within the preservice teachers' capabilities. For instance, the adequacy of lessons or planning the progression of a unit of work may require a level of knowledge and experience they do not possess. Some assignments therefore may require extensive guidance to assure success. Reflective practice assists with this process because it allows the traditionally tacit actions of teaching to be exposed so that various elements can be examined, discussed, analyzed, modified, and incorporated into one's practice.

Community of Practice

The theoretical underpinnings of a CoP are grounded in Lave's (1991) theory of situated learning, which proposes that knowledge is created through reflection with others who have similar experiences (Buysse, Sparkman, & Wesley, 2003). Thus, the use of a CoP in teacher education incorporates the view that developing one's knowledge for teaching (i.e., PCK) should be an active and social endeavor. Wenger (2011) describes CoP as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (p. 1). Therefore, members develop a shared way of dealing with problems, and as such they share resources, experiences, and tools with one another. Involvement in a CoP

supports teachers' collaboration, assisting them in adopting new forms of pedagogy. Pivotal in this theoretical framework is the tenet that knowledge is not "simply acquired, stored, and applied but rather something that is discursively constructed and drawn upon" (Edwards, 2005, p. 53). This casts knowledge as something constructed by the learner, aligning it also with a constructivist approach to pedagogy (Wenger, 1998).

A CoP also provides the advantage of drawing from a diverse knowledge and experience base (Leite, 2006). The community serves to expand one's views by providing multiple perspectives. Furthermore, as participants become integrated into membership, they are able to learn by observing and reflecting on the actions of more skilled, confident members. Their status can progress over time, promoting them to more central leadership roles. Through extended association and membership in a CoP teachers transform their status, as they develop new ways of thinking and interacting within the group. Thus, they begin to develop an understanding of the group and their place in it, allowing all members to become co-creators of knowledge (Barab & Duffy, 2000).

This study seeks to determine the effects of combining a content specific moderated CoP with preservice teachers reflecting on video of their own teaching in order to facilitate PCK development with respect to noticing students' science thinking to make informed decisions about instruction.

Review of Literature

The following review of the literature provides an overview of the use of video as a tool for supporting reflective practice, especially with regard to promoting attention to student thinking.

Many studies have demonstrated the effectiveness of using video as a tool for encouraging productive discussions about teaching and learning in mathematics (Bloomberg, Sherin, Renki, Glogger, & Sidel, 2013; Borko et al., 2008; Friel & Carboni, 2000; Santagata & Guarino, 2011; Towers, 1998). Video allows for a realistic portrayal of teaching in a way that can be viewed iteratively. It can be stopped, replayed, and manipulated to focus the teachers' attention on certain aspects of the teaching/learning process, as well as allow them time for processing and metacognition (Borko et al., 2008). Video provides a viable and in some ways superior alternative to actually observing within the classroom setting. It allows teachers to reflect on student/teacher interactions without the restrictions or distractions of real-time classroom situations (Borko et al., 2008). Video clubs add the supportive environment of a CoP in such a way that teachers tape, review, and reflect on their own and their peers' teaching. The conversations that take place facilitate the teachers' critical examination of teaching. These groups have shown to promote meaningful conversations about the teachers' own teaching (Borko et al., 2008; van Es & Sherin, 2008). In addition, Borko et al.'s (2008) findings uncovered that what teachers discuss in these types of clubs often change over time. However, open sharing by members does not usually take place automatically. To encourage

this type of discourse, a safe, comfortable environment must be established (Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008).

Santagata and Guarino (2011) submit that activities presented in correlation with video are necessary to guide preservice teachers in paying attention to significant details of how students think about mathematical ideas and in understanding how instructional moves can help elicit those ideas. The researchers incorporated elaboration activities to assist preservice teachers in realizing how instructional decisions can affect student learning. The activities, when paired with focused video reflection, helped preservice teachers create a framework for reasoning about teaching in a more integrated way. Data analysis yielded that after participation in the activities fifty percent of the participants were able to spontaneously offer alternative pedagogical moves. Santagata and Guarino's (2011) study corroborates the effectiveness of pairing focused video reflection with associated activities in helping to build preservice teachers' knowledge for teaching mathematics.

A lack of subject matter knowledge comprises another barrier in understanding student thinking. Limited understanding of the content can hinder a teacher's ability to tailor curriculum to improve students' conceptual understanding (Appleton & Kindt, 2002). The supportive nature of a CoP can assist preservice teachers in developing a solid conceptual understanding of scientific subject matter, as well as help them identify appropriate and effective instructional strategies for conveying this knowledge to their students (Cochran-Smith & Lytle, 1999). Research points to the efficacy of utilizing CoP to support teachers in improving subject matter competence. For instance, Akerson et al.'s (2009) study of a professional development featuring a CoP created to support teachers in improving their views of nature of science. Results showed sharing struggles encountered in attempting to teach nature of science within their CoP facilitated teachers' own understandings of nature of science. As this research indicates subject matter knowledge is one of many possible practical gains provided by CoP.

Marzano et al. (as cited in Lumpe, 2007) list integral factors in facilitating student achievement as, "effective feedback, cooperation, collegiality, practice-oriented staff development, a culture of shared beliefs and relationships" (p. 125). CoP fosters these ideals which are often lacking from isolated workshops. Previous research in an inservice context portrays the beneficial effects of CoP in promoting reflective practice and in supporting the adoption of new forms of pedagogy (Anfara & Angelle, 2008; Lumpe, 2007). Our study examines how applicable these effects are to an elementary science preservice context.

Research on student thinking points to the beneficial iterative quality of video. Because video allows a moment in teaching to be frozen, specific details of interactions can be viewed repeatedly to glean the importance of certain events in building student understanding (Rosaen et al., 2008). Martin and Siry (2012) also discuss the benefits of the iterative potential of reflecting with video in building progressive understandings of science teaching. Additionally, Roth et al. (2011) used video for iteratively viewing teaching through a variety of lenses, to provide a reference point both to focus discourse and to use as a source of evidence for claims. The iterative quality of video-based reflection gives attention to areas of teachers'

PCK that needs the most development and with preservice teachers this need should focus on attending to student thinking to inform practice (NRC, 2012, 2015).

Review of the research analyses uncovered that video helps to focus preservice teachers on instruction and away from management issues (Rosaen et al., 2008). Teachers also shifted from attending to their own pedagogy to attending to what their students were thinking (Sherin & van Es, 2005). Finally, the results of Rosaen et al.'s (2008) study suggest that that video-based reflection helps to create dissonance that pushes preservice teachers to confront their preconceptions and misconceptions helping them to advance their conceptions of teaching and learning.

Research Methods

We selected a qualitative case study approach (Patton, 2002) to provide an in-depth view of the participants' development with learning to attend to student thinking for the purpose of informing instruction. Specifically, this study seeks to inform the structuring of elementary science method programs to promote growth in the preservice teachers' PCK for attending to student thinking (Yin, 1994). Although data were gathered to allow for an examination of individual team members' PCK progress, findings are reported on as a group rather than as individuals because the team of five participants developed, taught, and reflected on the series of science lessons in their created unit collectively. Additionally, setting the case at the team level rather than individual level affords an examination of how the innovation affected the participants' growth collectively.

The participants of the study were in their junior or senior year of a teacher education program. They were all registered in their second of three professional clusters of coursework. The cluster consisted of math methods, science methods, and a shared early field experience course in a local elementary school. Of the five participants, four were white females and one an Indian female, all in their early twenties. The participants were given the following pseudonyms: Jane, Cora, Zoe, Lisa, and Evelyn. This group was selected based on the advice of their field methods instructor as she had the opportunity to observe the students' reflection process during their teaching of their math lessons. Additionally, when we approached these students about participating they expressed an interest in participating in the study even with the understanding that it would require time outside of their regular class time. Therefore, this particular group of preservice teachers was chosen for their propensity to engage in reflective, metacognitive discourse as observed during the math lesson study portion of their shared field experience, as well as their desire to participate.

There was a sixth participant in the intervention case, the content specific moderator. This member (Author One) was a white female in her early fifties, and at the time of the study was a PhD student in Science Education at the same large Midwestern University. Although Author One served as both the content specific moderator and researcher for this study, she balanced her roles by documenting her thoughts throughout the project in a content specific moderator/researcher journal and by using multiple sources of data in order to bracket her biases. Lastly, Author

One had previously been an instructor for the science methods course so her knowledge of the learning goals for the science methods course assisted her in her role as the content specific moderator as she knew what class activities, readings, and discussions she could draw on to support the preservice teacher participants during the CoP.

As part of their science methods course, the preservice teacher participants were required to design, teach, and reflect on a five-lesson unit. These lesson plans were created with the guidance of their methods instructor, beginning with the creation of a unit matrix that served to scaffold their understanding of the conceptual progression of science ideas. The case of preservice teachers in this study was instructed to design, teach, and reflect on a first-grade unit for the topic of properties of solids and liquids. Following instructional practices modeled for them in their science methods course the full lesson plans, which they developed after receiving feedback on their unit matrix, adhered to the 5E (engage, explore, explain, elaborate, evaluate) learning cycle format (Bybee & Rodger, 1997). Formative assessment strategies were also built in across all phases of the lessons, with the final lesson of the unit serving as a summative assessment (in addition to an elaboration) for the unit. The preservice teachers taught one lesson per week for about 30–40 min. Two different members took the lead in teaching the lesson each week, while the other members supported (as needed) small group instruction and took notes on what they observed their peers doing in their teaching with respect to accomplishing their teaching goals.

For this case study, all five lessons were video-recorded and used to guide the team's reflection following each lesson on students' thinking and how to use the information they gleaned from this reflective process to inform their instruction of the next lesson. Video-based reflection meetings were held once a week the day after instruction. This allowed the content specific moderator (Author One) to review the lessons in order to select particular areas to focus on during the CoP meeting. The CoP meetings lasted approximately 60–90 min (see "[Appendix 1](#)" for sample CoP meeting protocol). The CoP meetings, as well as the pre- and post-interviews that were conducted by Author One as a research data source, are based off of a protocol Nilsson and Loughran (2011) designed to help focus preservice teachers on specific components of their PCK (see "[Appendix 2](#)" for sample interview questions). Similar to van Es and Sherin's (2002) work with video-based reflection with preservice and inservice teachers, the content specific moderator established with the preservice teacher participants a system for "calling out" when they noticed the preservice teacher participants doing a good job of attending to student thinking or missing opportunities.

Data Sources and Analysis

Data sources include transcripts of audio-recorded pre- and post-interviews with each preservice teacher participant, a transcript of the audio-recorded preliminary CoP meeting that outlined the details of the study and the goal of using a CoP structure, transcripts of the audio-recorded CoP meetings following lessons 1–5 [note: videos of these meetings were also recorded and utilized to ensure accurate

transcription of the discussion], and the content specific moderator's/researcher's journal that included entries reflecting on each of the data sources listed above. Entries in this journal were organized according to Author One's perspective at the time she was writing. For example, if she was reflecting on something in her own instruction or planning for the next CoP she would indicate the note as written from the content specific moderator perspective. If she wrote about something she noticed changing or developing in the preservice teachers' PCK development as a result of conversation in the CoP she would indicate the entry as researcher perspective. This differentiation in perspective helped us to keep track as to what might be data from her role as the moderator versus early stages of analysis of the data from the perspective of a researcher. Finally, the preservice teacher participants' final projects from their science methods course were gathered and analyzed to understand how team members took the ideas discussed in the CoP and incorporated them into their individual revision of the lesson they taught, as this was a requirement of the final course project. As part of this project the students were required to reflect on their practice by describing and defending teaching goals, analyzing their effectiveness in assessing student learning, and detailing how the experience affected their growth as a teacher of science.

Data analysis followed an inductive format and was completed for each research question separately. For each question all applicable data sources were initially coded using an open coding format, followed by a collapsing of similar or related codes to identify consistent themes raised for each question (Patton, 2002). Although analysis employed an open coding format, special attention was given to impacts of the theoretical frameworks of CoP and reflective practice. For instance in research question 3, the interview data were organized for coding purposes into separate charts that examined the role of CoP, the role of group reflection, and attention given to student thinking.

For research question one (initial views), open coding followed by condensing of related codes was performed on all transcripts of participants' pre-interviews, as well as the transcript of the initial meeting, and five themes were identified. For research question two (changing abilities), separate charts were created and coded for the meeting transcripts following lessons 1–5 and the researcher journal entries that followed each of those meetings. These charts were then compared to uncover overlapping ideas and to provide consensus in the data. For this question, four themes were identified, designating the beginning and end of the preservice teachers' progression in their abilities to attend to students' thinking. Finally, for research question three (changing views), each data source was examined at an individual participant level to determine how each member's view changed over the course of the experience in order to discern the overall trajectory of change for the group as a whole. For coding purposes with this question, the interview data were organized into three charts—the role of the CoP, group video reflection comments, and comments related specifically to student thinking. Once the final set of codes for each of these topics was identified, the codes were examined for similarities in ideas across participants to develop an overall picture of how views for the team as a whole changed given their participation in a video-based, content specific

moderated, CoP. For a summary of all themes found according to each research question, see Table 1.

Findings and Interpretations

Throughout this section we embed our interpretations with our reporting of the findings to help illustrate how specific instances, comments (i.e., data sources) indicated development in the preservice teachers' PCK. We understand this integrated approach to reporting the findings, and our interpretations may be unorthodox. We, however, believe that to understand the influence of a content specific moderated CoP that includes participants reflecting on video of their own teaching, it is important to take time to interpret what the data are saying in relation to their PCK development as we present the findings. We begin with a summary of what we learned over the course of the six CoP meetings, and then organize the

Table 1 Themes identified by research question

Question 1	Question 2 (beginning)	Question 2 (end)	Question 3
Student thinking should be attended to throughout the entire lesson	Limited attention to and probing of student thinking	Attending more to student thinking while teaching and noticing its occurrence when viewing video, in addition to consistent contribution of suggestions on how to advance student thinking	More concrete understanding of importance of attending to and responding to student thinking to guide curricular decisions
Student thinking helps teacher understand what the students know	Framing lesson around classroom management	Framing lessons around student thinking	Realize importance of using lesson objectives as a guide to structure lessons
Student thinking assists in scaffolding students ideas	Too little time connecting exploratory learning to formal science concepts	Consciously scaffolding students to connect explorations with formal science concepts	Realize learning cycle pedagogy effectiveness in facilitating deeper learning
Concerns with managerial and planning issues	No realization of the importance of learning objectives for guiding the lesson construction	Starting to realize the importance of focusing on lesson objectives when selecting materials or guiding lessons. But still reticent to utilize appropriate material	Awareness of content specific moderated CoP and group video reflections' roles in forming PCK
Resistant to employing learning cycle pedagogy			

remainder of our findings and interpretations according to the three research questions.

Overall Findings

Over the course of the six CoP meetings (one preliminary and one following each of the five lessons taught), the participants became integral members. They developed an appreciation for the CoP's support and guidance as well as their importance within the group. Participants moved from the periphery of the CoP to take on leadership roles. They also became more comfortable with receiving and giving suggestions and ideas on improving attention to student thinking within the current lesson and in future teaching situations. The participants demonstrated growth in noticing and attending to student thinking. Their conversations reflected a switch from attention on classroom management to more consistent focusing on attention to student thinking. Also by the end of the study, participants were connecting what they uncovered about student thinking to how their lesson/unit should progress. Participants' comments also illustrated their understanding of the power of employing a learning cycle instructional model as well as maintaining a focus in their teaching on lesson objectives to support student learning. Each of these findings are further elaborated on, and supported with specific examples from our data, in the sections below.

Participants' Initial Views

Our first research question investigated the participants' views about the importance of eliciting and attending to student thinking. The data indicated that although participants realized the importance of eliciting and attending to student thinking they were not sure how to accomplish it within the parameters of a lesson at the beginning. The groups' belief that attending to student thinking helps teachers understand what students know, helps students build their own understandings and that it should be incorporated throughout all phases of the lesson is evidenced by Evelyn's response,

I think asking questions is really important. If you're teaching, you can have them (the students) look at something and they might say, 'It looks like a liquid'. You can then ask why they think that or what makes it a liquid or what kind of properties is it showing. If you're asking questions the whole time you're really getting a good grasp of what they're thinking "in the moment" rather than later. You have to ask questions all the time and get deep or else they (the students) might not get there themselves. (transcript preinterview)

Participants also started out with a primary focus on concerns ranging from how to structure individual lessons and the progression of their unit, to how to manage a whole group discussion and deal with young students' limited vocabulary and ability to read and write. Preoccupation with these issues made it difficult for them to initially frame lessons around giving attention to student thinking. This idea is illustrated in the following two quotes:

I'm nervous about getting there and trying to teach them solids and liquids and water when they haven't grasped the concepts of solids and liquids separately. (Lisa, 1st meeting transcript)

I introduce liquids at the very end of this lesson and then she jumps into pouring liquids into liquids and putting solids into liquids. Or pouring liquids into water and putting solids into water and they just learned the term liquid and are they going to be able to do that? (Cora, 1st meeting transcript)

Additionally, the data uncovered participants' naïve understanding of the set-up and reasoning behind the 5E instructional model, which places exploration before formal concept introduction. This type of learning premised on the constructivist underpinning that deep learning requires students to build their own understandings is facilitated by a learning cycle (Brown & Abell, 2007). The lack of understanding of this pedagogy was exhibited by the participants' attachment to frontloading scientific concepts shown in their initial lesson design starting with reading a book detailing all concepts to be explored in the lesson. When this issue was broached, they were at a loss for other ways to initiate the lesson (Researcher journal, preliminary meeting).

Participants' Changes in Abilities

The second research question investigated how the participants' abilities to attend and respond to student thinking progressed throughout their participation in the content-moderated CoP using video of their own teaching as a reflective tool.

Participants initially displayed limited attention to and probing of student thinking. This was documented in the first couple researcher journal entries, as well in the number of times the moderator stopped the video during the early post-teaching meetings to discuss places where participants missed opportunities to attend to student thinking. However, by the meetings following the 3rd and 4th lessons, participants were exhibiting a progression in their ability to attend to students' thinking both during the act of teaching and in reflecting on video footage of past teaching. For example, in lesson 4 as the lead teacher is reviewing what solids and liquids are with the students through questioning. When a student said, "A solid is hard," she stopped to clarify the student's thinking. Additionally, while watching the video of the lesson another participant, Zoe, noticed the interaction and realized that it as a critical incidence saying, "I like that you clarified that and didn't just let it go...and you let the other student say... I think he said, 'Carpet is soft', so I think that that was good that you clarified (the student's thinking)" (transcript meeting after 4th lesson).

Participants' focus on classroom management in the beginning interfered with their ability to attend to student thinking and hindered their contribution to the discussion of how thinking could have been probed more effectively. However, as Appleton and Kindt (2002) pointed out this hindrance is not unusual for preservice teachers. Thus, a significant part of the content specific moderator's responsibility in the CoP was to continually refocus the participants' attention on scientific ideas the elementary students were expressing. An example of this need to refocus the

participants is illustrated in the following segment of dialogue from the CoP meeting after the 1st lesson. (Note: *Text in italics provides context for the dialogue.)

[We are watching a video of the lead teacher pushing a student to extend their observational skills by asking them to describe what a ball he is describing sounds like when bounced. This demonstrates not only a realization of a critical incidence but also of using it to direct the instructional trajectory. Zoe notices this and stops the video to point out the incident]

Zoe: That's good you know what you said to bounce it. What did you say?

Evelyn: What did it sound like?

[After a short dialogue with the moderator about a possible way to improve the situation...]

Zoe: See that. He does that to me all the time, always, anything I say *[referring to the student's arguing behavior]*.

[The moderator then has to refocus the group.]

Moderator: Another way you could involve the other children in this way is if they use a descriptor ask other people to name other things that fit that descriptor. If they say, sharp...

Jane: What else is sharp?

Moderator: Then there is not so much down time (transcript meeting after 1st lesson)

As the following discussion of possible modifications illustrates, the participants progressed past framing lessons around classroom management to focus instead on student thinking. Additionally, this discussion illustrates participants' progression from the periphery of the group into leadership roles.

Moderator: Yeah so that was that you ran out of time so then you take it from there. How are you feeling about what's the next lesson?

Zoe: Alright I think. For the engage phase I don't know if I should repeat what she did. I don't know. You (meaning the moderator) said to make it like her explain phase. So how should I start that?

Cora: I think you could ask them if they remember writing down the list that Evelyn's group made and say, "What are some items that went on your solids list? What are some items that went on your liquids list?" When then maybe there's something that's on their solids list and under liquids list like the ice cream or something like that.

I could do the items I used for my lesson ...

Zoe: yeah so

Moderator: then you might even want to show them even though it could be very quick still just show them just showing them that pouring it to really distinctly different shapes and maybe the show the apple again because you've had that every time. It's just

Zoe: ingrained in them. Then for the explore part of the engage I said that we would introduce them to the stations. The stations we had were jello, lotion, powder, and Oobleck. We talked about saying, "you're going to observe it and

there is no right or wrong answer” because we said before that we don’t want them to think that it’s just one or the other because that would just be really confusing because like the Oobleck there’s no right or wrong answer so we said, “Try to figure things out” so they can try to use the properties.

Jane: We should tell them when they come up with the definition of solid and liquid, “This is a property of solid also solids have all these properties so this is how you know it’s a solid or liquid...”

Zoe: and then when they’re exploring students should be able to justify why they think it’s one or the other. (transcript meeting after 4th lesson)

Additionally, participants were beginning to show their understanding of the importance of allowing students to share their thinking with the group as evidenced by their conversations about how allowing students to share their thinking helped the rest of the class to understand the concepts better. The following quote illustrates this trend.

Zoe: I think it is really important though how we been lately calling kids to explain it because they like if they can tell their peers about it if they can tell their peers about it then they obviously understand it and then also I think that them putting it in their language and then by telling their peers that makes everyone else get it too...and it helps us explain it better too because before when I said we kept using the word shape I couldn’t think of another way to say shape but then the little girl was just like it’s thinner smaller soil was okay then tell me about the size of it does it go up or down so just having them explain it makes it easier for us to explain it too (transcript meeting after 3rd lesson)

This concept is pivotal to creating a community of scientists, an idea espoused by science reform documents. These in the moment teaching decisions demonstrate the team’s ability to facilitate science talk for the purpose of advancing students’ scientific thinking. This development demonstrates moving beyond simple understanding into the sphere of enactment of theory into practice (TERC, 2011).

As the CoP progressed participants also began taking on more central leadership roles, as evidenced by their contribution of suggestions on how to advance student thinking. For instance, when the moderator pointed out in the CoP meeting after lesson 3 that the students did not have a solid idea of what an observation is, one of the participants was able to take over and lay out how the lesson could be set up and what questions could be asked to facilitate student attainment of this goal. This then spurred a team discussion of how to best pull out and push student thinking for that concept. Additionally, during this meeting, the participants regularly contributed alternative strategies for questioning specific instances. Drawing on her own experience of teaching this topic both as a previous classroom teacher and in prior methods classes with preservice teachers, the moderator suggested they stick to simple solids and liquids in the next lesson and focus on having students state their reasoning. The participants then took the lead in construction of a new worksheet. Another example of this type of ownership in guiding attention to student thinking came after a probe of the effectiveness of the worksheet for lesson 4. All

participants contributed to an analysis of its merits and the ways various aspects applied to individual students' capabilities.

Another trend was at the beginning of the study participants spent a majority of the lesson time in the engage phase, leaving little time to connect exploratory learning to formal science concepts in the explain phase. This was revealed in early researcher journal entries, as well as in documentation of participants' missed chances to make connections to students' prior learning. For example, in lesson 2, when the elementary students brought up what they were learning in their classroom, the lead teacher moved on instead of highlighting the connections to what students had been studying. When the moderator pointed this out during the CoP meeting after the 2nd lesson, the participants raised the issue of time constraints and had to be reminded that a minute cutoff of the engage phase was one that could be spent in the explain phase.

Zoe: If we would've had 10 more minutes, we could have really focused in what he was saying there and not had to move on to another idea, because that was a really cool idea, it just wasn't what we were trying to get out in this lesson

Moderator: Yes, there is that balance. But you could take a minute. Could you cut a minute off the engage and put those minutes in places you know you could've pulled student thinking out. Because you're really starting to see where those places are and paying attention to those places (transcript meeting after 2nd lesson).

Whereas, by the time the CoP had reached the end of their unit they were consciously scaffolding the elementary students to connect exploration activities to formal science concepts. In the meeting following lesson 5, Zoe illustrates the trend by saying:

And I felt like I kept probing them because I wanted to leave them with those ideas. This is what you know about a liquid and this is why it's a liquid. He wasn't giving me an answer and I was like I'm going to get it out of you because I think that's important for everyone to hear just so like I know that they know (transcript meeting 5th lesson).

Finally, the participants initially portrayed limited abilities in selecting materials that would effectively help the elementary students to meet the objectives of the lesson. For example, the participants continued to use liquids in sealed containers even though a main learning objective was that liquids flow, pour, and take the shape of their container. This idea could have been conveyed superiorly by allowing students to pour liquids into various shaped containers. Additionally, when stating the main idea of the lesson, the way each CoP meeting was initiated, participants did not mention the lessons' learning objectives at all. For instance, in lesson 1, the lesson objectives were understanding what observations were and thinking like a scientist but when asked the main purpose of the lesson, participants only referred to making observations with the five senses. Also when discussing what to teach in the next lesson, the participants stated their main goal was solids, but had no clear idea of what exactly they wanted students to learn about solids even though they had

already constructed not only that lesson, but an entire science unit of plans. Whereas, by the meeting after lesson 3 the lesson objectives were modified to be more specific and participants started to use them to guide instruction. For instance, in the following example Cora explained the main purpose of the lesson as, “Liquids changing based on the shape of container they’re in.” When asked if there were other ideas, she elaborated on wanting to cover pouring and flowing of liquids and went on to describe how the preservice teachers had incorporated this concept into their small group discussions. She also shared how students came up with ideas the preservice teachers had not even thought of like the amount of water staying the same even though it looked different. Despite participants’ progression in using lesson objectives to guide lesson construction, they were still reticent to modify their material use. This was evidenced by the fact that even in the 4th lesson students were not allowed to pour liquids. This simple activity would have helped solidify the concept that liquids take the shape of their containers. When the moderator confronted them with this point, some of the participants described how they had pointed out the differences in shape as the containers were tilted and the liquid flowed into different parts.

Something my group did was the one that was in the bottle we were noticing the shape of the bottom being flat and then when he flipped it over it was more like a cone. So like you can flip it and it changes shape in there which is helpful but then the shampoo bottle since it is the same on both sides I just turned it sideways and showed that it went along the side. So even though you can’t pour it into different ones you can move it around in the container that it’s in and you could’ve pulled those things out. (Evelyn, transcript meeting after 4th lesson)

Additionally, this spurred the preservice teachers to consider their lesson objectives when selecting materials, resulting in a conversation focused on what types of materials could be used to set up the learning situation to more effectively scaffold the concept of liquids taking the shape of their container.

Lisa: Maybe I should have had enough empty containers at each group for them to use because maybe some students might not have even needed it they were certain that that was a solid based on other things and he just needed that extra...

Jane: because they were confused on that first one and then that when they got the Tupperware. They (the students) “We get it now!” and the rest of them pretty much (did too).

Evelyn: the one thing I would change would be: Don’t do two really hard solids because on my kids’ papers they kept writing a rock is solid because it’s hard. They also wrote the same thing for the screw and that’s fine because it is hard. This plate is hard and this is a solid but and so is the table but maybe if they had something so soft maybe it would have at least made them remember that...

Jane: like a pillow or beanbag

Evelyn: or like a fruit you know like something that wasn’t as hard

Lisa: I wanted it just to not change shape in like the container because I think it's hard to get across the point like that liquids take the shape of their container I feel like it's easier that they like change shape in different containers (transcript meeting after 4th lesson)

This conversation demonstrates that while participants hadn't yet fully incorporated this concept into their practice, they realize the importance of selection of appropriate materials in facilitating students' attainment of lesson objectives.

Participants' Views Following Participation in CoP

Research question 3 asked how participants view the importance of attending to student thinking to guide curricular decisions following their participation in the CoP. The results pointed to participants developing a more concrete understanding of the importance of attending to and responding to student thinking to guide curricular decisions. Also all participants became cognizant of the effectiveness of employing a learning cycle pedagogy and the importance of utilizing lesson objectives as a guide to structure their lessons. Additionally, the participants acknowledged having a group of their peers viewing their teaching, along with the content specific moderator was invaluable as the combination helped them to build a solid understanding of how to use student thinking to guide curriculum. Finally, the participants developed an understanding of how important learning objectives are to keep in mind when planning curriculum and designing learning experiences and activities.

By the end of the experience of participating in the video reflection within a preservice teacher CoP, the participants have started to develop a sense of how to attend to student thinking within their teaching. They also indicated they now understand what to do with information gleaned from probing student thinking as evidenced by comments such as "it can help you decide what you need to teach in the next lesson" (Lisa, post-interview). The development of this new skill was also exposed by the greatly reduced number of times over the course of the CoP that we had to stop the video to discuss how student thinking could have been probed more deeply. The participants also demonstrated their realization that what to teach next cannot be totally predetermined but must be based on what students currently understand. Participants demonstrated this through extensive modification of their unit over the course of the study.

Participants also recognized the importance of allowing students to explore on their own before formally introducing scientific concepts. This idea forms the basis of a learning cycle pedagogy of which the 5E model is a common example (Bybee & Rodger, 1997). Although tasked to create plans in this way, the participants did not start the process understanding the power of this instructional model. Jane expressed this sentiment in the following quote:

Well I think I was a little skeptical when we learned the 5E model. I guess I didn't really see how it played out in the classroom, I kind of felt like I wanted to get the students more information at the beginning rather than find it out on

their own ... We stuck to the 5E model and could see just how the children have to make their own understandings. So I think that it's really effective when you're allowing students to meet the objectives by creating their own understanding. I think that's the most effective way to teach science. (transcript post interview).

Participation in the study, however, did not result in appropriate time designation for connecting exploratory learning to formal science concepts, too much time being allotted to the engage phase of the lesson leaving an inadequate time for the critical explain phase. All participants expressed that input from the content specific moderator was important in modeling for them how to attend to student thinking, design a unit progression, and set up learning situations based on lesson objectives. They all also saw the value of the collaborative input the CoP contributed to expanding their understandings. Participants also mentioned that they learned from the constructive feedback given even if it wasn't on their own lesson. Additionally, they felt the video of their own teaching was an indispensable component of the study, allowing them to stop, examine, and discuss specific learning/teaching interactions.

I think it was really helpful to watch the videos with the group. Sometimes we would talk about the same things after teaching but it was different in the meetings because you (the moderator) would bring up things we didn't even think about. It was helpful to really zone in on where we could have asked a question or when you pointed out good examples of where we paid attention to student thinking. I think that made us think more about when we could do that. The first week we were definitely guinea pigs; we really didn't know how deep to go. So the first lesson we kept seeing so many places, but in later lessons there were a lot less times where we were stopping to talk about what could have been asked, since it was already done. I saw growth in my colleagues that's really important. (transcript post interview).

Finally, the participants realized the importance of sticking to learning objectives when planning curriculum and designing learning experiences and activities as evidenced by Jane in her post-interview (this sentiment was shared by all participants):

I think on all our lessons we knew our objectives; we knew where we wanted them to go. Our questions during our exploration were leading them down that path. Whereas we could've put objects in front of them and they could have observed them all day and could never have come up with 'Oh it's not changing its shape.' They could have never thought about that. So you really have to set it up so you know they're going to get to where they need to be. (transcript post interview).

Although this idea surfaced in all participants' beliefs, it may take more time to become cemented into the participants' practice similar to how they understood attention to student thinking in theory before knowing how to enact it into their practice.

Participants exhibited positive outcomes in their abilities to notice and to use student thinking in guiding curricular decisions. Also they demonstrated an increased focus on lesson objectives to guide lesson trajectory and material selection. Additionally, participants espoused a new found understanding of and belief in learning cycle pedagogy. Although the study yielded positive results, it is not clear whether these beneficial trends will continue when outside of the supportive environment with the content specific moderated CoP.

Conclusions

The results from this study point to the promise of utilizing a combination of CoP and video-based reflection to facilitate scaffolding preservice teachers' attention to student thinking in order to facilitate a responsive science curriculum. Our results showed that the group was initially unsure of how to enact this practice within their teaching. Additionally, at the onset of the study, the preservice teachers' exhibited a lack of understanding of the set-up and reasoning behind a learning cycle model in helping students to build an in-depth understanding of science concepts. Appleton and Kindt (2002) provide insight into this phenomenon by discussing possible distractions and framing issues frequently experienced by preservice teachers, such as classroom management or procedural concerns.

Our study uncovered a progression of growth in three main areas following participation in the video-based CoP. The participants progressed from framing lessons around classroom management to framing them around student thinking. A second area of growth was in their attention to and probing of student thinking both while in the act of teaching and when viewing video footage of themselves and their peers teaching. In addition, participants demonstrated growth in the amount of constructive criticism they contributed surrounding the advancement of student thinking. A third area of improvement revealed a progression from spending minimal time connecting learning to formal scientific ideas to consciously scaffolding students to connect explorations to formal science concepts. Finally, as the study progressed, learning objectives became the guiding force in the preservice teachers' lesson construction. Even with these three core changes, there were areas where participants still resisted change. For instance, they remained reticent to abandon originally selected materials even when evidence pointed to the benefits of doing so.

The participants in our intervention felt the experience imparted valuable skills even for lessons where they were not the lead teacher. They perceived the ideas discussed as being directly applicable to their own teaching. The weekly CoP meetings to review video footage of their lessons also assisted participants in learning to reason soundly about their teaching and helped pave the way for developing the ability to express their thoughts and concerns about teaching science (Jay & Johnson, 2002; Nilsson & Loughran, 2011).

Although usually investigated within inservice contexts, our study shows that CoP can also be uniquely tailored to preservice contexts. Wenger's (2011) definition of a group of individuals with similar interests who develop a shared way of dealing

with problems describes preservice teacher groups precisely (Buysse et al., 2003). Additionally, a preservice CoP addresses Leite's (2006) assertion that preservice "teachers need the opportunity to think with others about the teacher that want to be" (p. 7). The combination of group video viewing within a preservice CoP provides a form of teacher education that allows preservice teachers to become co-creators of knowledge (Barab & Duffy, 2000).

Our use of a content specific moderator to focus video viewing served to incorporate the recommendations of previous research stating the importance of pairing video with a focusing tool (Borko et al., 2008; Friel & Carboni, 2000; Roth et al., 2011; Santagata & Guarino, 2011; Sherin & van Es, 2005). The data from this study point to a positive trend for pairing video using a content specific moderator for this purpose. The moderator's continual focusing of the CoP on attention to student thinking scaffolds the preservice teachers in reframing their science teaching. Also the moderator modeled how to reflect on video within a CoP context, as well as how to notice and probe student thinking. Furthermore, the moderator was able to point out and challenge members about times when lessons veered away from lesson objectives. Due to the moderator's PCK for teaching science and as a science teacher educator, she was able to suggest and guide the unit and lesson trajectories to create a unified, sensible set of plans. One of the main strengths of advice and guidance provided was placement within the context of the teachers' own practice and delivered in response to a current immediate need.

The results of our study corroborate our assertion that results of studies done in inservice and mathematics contexts are applicable to science education contexts as well. Additionally, our intervention appeared to produce the situated (Lave, 1991) and proximal zone of development (Santagata & Guarino, 2011) benefits of watching video of one's own teaching while at the same time serving to combat the vicarious nature (Mulholland & Wallace, 2001) of viewing professional video of experienced teachers. Furthermore, at the completion of the intervention participants exhibited more concrete understandings of the importance of attending and responding to student thinking to guide curricular decisions, realized the importance of using lesson objectives as a guide to structure lessons, realized learning cycle pedagogy effectiveness in facilitating deeper learning, and developed an awareness of the CoP and group video reflection's role in facilitating the growth of their PCK for teaching science. These results point to the benefits of video-based reflective practice within preservice CoP and validated the application of results from studies on reflective practice in inservice and mathematics contexts (Akerson et al., 2009; Lumpe, 2007).

Implications

While this study points to the usefulness of employing video of the preservice teachers' own teaching, many questions remain. The study does not address the long-term retention of this focus; without the supportive environment of the content specific moderated CoP there is the possibility of reverting to other concerns at the expense of attention to student thinking. Additionally, preservice teachers' assertions about the importance of attending to student thinking and adherence to

a learning cycle pedagogy were not investigated to see whether these tenets were actually incorporated. Therefore, it is uncertain whether these ideas actually moved from the realm of theory to that of practice.

Given the results of our study, we recommend further consideration of including video-based reflection of preservice teachers' own teaching to help build their PCK for attending to student thinking. The use of video of preservice teachers' own teaching within a preservice CoP changes the way the learning is disseminated and aligns it with the constructivist pedagogy (Abell, 2007). The guidance and support provided by this type of guided reflection builds skills for metacognitive necessary for effective classroom practice (Donovan & Bransford, 2005). Therefore, we suggest that instituting a modified version of the tools employed in this study may help science teacher educators in scaffolding preservice teachers' abilities to attend to student thinking. Adopting this approach for helping preservice teachers build their PCK for teaching science could radically affect the way future teachers are educated, positioning teacher educators and preservice teachers as co-creators of knowledge.

Appendix 1

Sample Interview Protocols

Pre-interview

1. How will you know if your students are achieving the objectives you have for them?
2. How important is subject knowledge for effective teaching? Why?
3. What are the purposes of assessment and how important is it in facilitating learning?
4. Tell me about some different teaching strategies that you know of for teaching science?
5. What is important to know about your students in order to help them learn science?
6. In what ways can a teacher's feelings and beliefs affect their teaching?
7. Is paying attention to student thinking important? How do you think you as a teacher can effectively discover what or how a child is thinking about a science concept?
8. What do you hope to gain from participating in this research study?

Post-interview

1. How will you know if your students are achieving the objectives you have for them?

2. How important is subject knowledge for effective teaching? Why? How do you plan to go about attaining this knowledge?
3. What are the purposes of assessment and how important is it in facilitating learning?
4. Can you tell me about some different types of teaching strategies that you know of for teaching science? Why do you think certain types are useful?
5. What is important to know about your students in order to help them learn science?
6. In what ways can a teacher's feelings and beliefs affect their teaching?
7. Is paying attention to student thinking important? How do you think you as a teacher can effectively discover what or how a child is thinking about a science concept?
8. What do you feel you have gained if anything from participating in this research study?

Appendix 2

Sample Team Meeting Protocol

Meeting Agenda

5 min: Gather snacks. Conduct any necessary business.

5 min: review hard copy of lesson and mark areas where student thinking was addressed

40 min: review video tape of science lesson (session will be both video and audio taped)

10 min: Discuss possible modifications and next steps for this lessons and future lessons.

Questions Used to Guide Video-Based Reflection

Note: Questions below are adapted from Nilsson and Loughran (2011).

- What do you intend students to learn about this idea?
- Why is it important for students to know this?
- What else do you know about this idea (that you do not intend students to know yet)?
- What difficulties/limitations are connected with teaching this idea?
- What is your knowledge about students' thinking which influences your teaching of this idea?
- What other factors influence your teaching of this idea?

- What teaching procedures will you use and what are the particular reasons for using these to engage with this idea?
- What specific ways do you have of ascertaining students' understanding or confusion?

We used a call out protocol, meaning when anyone in the community noticed attention being made to student thinking someone would indicate to stop the video and we would discuss how the teacher was addressing the student's thinking. We also discussed alternative approaches to drawing out student thinking in that situation.

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